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MANAGING IT IN LARGE ORGANIZATIONS AS PLATFORM-ORIENTED INFRASTRUCTURES. A NORWEGIAN E-HEALTH CASE

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Managing IT in large organizations as Platform-oriented Infrastructures. A Norwegian e-Health Case

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Abstract:
The degree of complexity of the portfolio of IT solutions within organizations has been continuously growing since the advent of computing. This growing complexity is in many organizations experienced to be costly and virtually impossible to adapt to changing organizational structures, strategies and user needs. IS research has so far failed to address this issue in full theoretical and practical breadth. Two approaches to developing and managing software has become dominant during the last two decades: Enterprise Architecture and Agile Software Development. These approaches are focusing on different and complementary issues, and both approaches are found insufficient – both need to be extended and modified to deal with the issues and challenges focused by the other. So far, neither the challenges of doing so have been sufficiently analysed, nor has a synthesized approach so far emerged. We will in this paper address these challenges drawing upon recent research on platform ecosystems, and information infrastructures and suggest a framework for a promising approach; Platform-Oriented Infrastructures. Our research question is; *how can concepts from and research on information infrastructures and platform ecosystems contribute to the management of IT solution portfolios in large organizations enabling both coherent integration and information flow as well as flexibility and innovation?* The empirical evidence is a case study of a large e-health initiative in Norway, where we analyse the emergence of platform-oriented infrastructure. We offer several contributions; we give an outline of the key elements of a platform-oriented infrastructure, we provide more theoretical analysis of the limitations of EA and Agile and how the concept of platform-oriented infrastructures help overcome these limitations.

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1. Introduction

The degree of complexity of the portfolio of IT solutions within organizations has been continuously growing since the advent of computing. Currently, large organizations have often thousands of applications running – each being integrated with a number of others within the same organizations, and increasingly with external ones. This portfolio of solutions is usually developed, maintained and operated by a huge variety of vendors, consultancies and internal IT units operating in a correspondingly complex mix of collaborative arrangements. This growing complexity is in many organizations experienced to be costly and virtually impossible to adapt to changing organizational structures, strategies and user needs. To help organizations cope with this complexity, new frameworks such as Service Oriented Architecture (SOA), Enterprise Architecture (EA), IT Governance models, etc. have been developed and adopted. In spite of the fact that EA, and in particular the TOGAF[1] framework, has achieved the status as more or less "best practice," results have often been disappointing – making some argue that EA is "completely broken" and should be modified and become Agile EA to deal with the dynamics of user organizations (Alzoubi and Gill 2015, Bloomberg 2014).

The popularity of EA has been growing in parallel with a similar growth in popularity of a very different approach to software: Agile Software Development – hereafter called just Agile (Beck 2001, Collier 2011). Agile has for a long period been used in small projects and proved to work weel in this context (Dybå and Dingsøyr 2008). However, the last decade the need for adapting Agile to larger projects and more complex contexts have become widely accepted in the Agile community (Dingsøyr et al 2018, Zaitsev et al. 2020). This illustrates that both EA and Agile focus on very different issues and challenges – issues and challenges that are crucial for successful IT development and management. However, both approaches are found insufficient and need to be modified to address the issues and challenges focused by the other. The question, then, is if and how this may be achieved.

Some researchers have argued that radically new approaches are required, suggesting conceptual umbrellas like ultra-large-scale systems (Northrop et al. 2006), coalitions of systems (Sommerville 2012), and digital or information infrastructures (Star and Ruhleder 1996; Monteiro and Hanseth 1996, Ciborra et al. 2000, Hanseth and Lyytinen 2010, Henfridsson and Bygstad 2013) as a basis for developing such approaches.

An important strategy to deal with complexity has been standardization. However, research on information infrastructures has documented that information infrastructures, just like software systems in general, also have to be flexible to adapt to change user requirements as well as the rapid change of digital technologies in general. Accordingly, a critical issue in the development and evolution of information infrastructures is this *tension* between standardization and flexibility. Actually, research on information infrastructures has pointed out that their evolution is more fundamentally driven by tensions, like those between standardization, integration, centralized control and stability on the one hand, and variety,

[1] TOGAF is described in Wikipedia as follows: The Open Group Architecture Framework (TOGAF) is a framework for enterprise architecture that provides an approach for designing, planning, implementing, and governing an enterprise information technology architecture. TOGAF is a high-level approach to design. It is typically modeled at four levels: Business, Application, Data, and Technology. It relies heavily on modularization, standardization, and already existing, proven technologies and products. https://en.wikipedia.org/wiki/The_Open_Group_Architecture_Framework See also https://www.opengroup.org/togaf

flexibility, modularization, autonomy, and change on the other, and, further, that such tensions are outcomes of specific combinations, of architecture and governance structures, here called *architecture/governance configurations* (Hanseth and Monteiro 1996, Tilson et al. 2010, Lyytinen et al 2017, Hanseth and Modol 2021).

Emerging complex socio-technical arrangements have also been researched under the label of platforms or *platform ecosystems* (Tiwana 2014, Parker et al 2016). The term platform has become very popular also among practitioners and users and is currently used to characterise almost any successful IT solution. Platform ecosystems have a lot in common with infrastructures (Tilson et al. 2010; De Reuver et al., 2017). They both involve a large number of technological and organizational elements, and evolve and grow over long time, extensively driven by network effects. What makes platforms different from infrastructures as they are portrayed in the IS research literature is the fact that all platform ecosystems are based on one specific architecture/governance configuration: a stable core, the platform, controlled and owned by a single organization, and a dynamic periphery consisting of a large number of "apps" developed by a correspondingly large number of autonomous app developers. Although the architectural principle of splitting a platform ecosystem into one stable core and a dynamic periphery is shared for all platform ecosystems, just as in the case of infrastructures, platform research also focuses on how platform ecosystem evolution is driven by various tensions which again are shaped by specific architectures/governance configurations at more detailed levels (Tiwana 2014; Wareham et al. 2014, Rolland et al. 2018, Hanseth and Modol 2021).

Research on platforms has focused on platforms primarily providing services for consumers like Facebook, Uber, Airbnb, Android, and iOs/iPhone. The enormous success of some platforms and their owners has, however, inspired also vendors of ordinary software for commercial organizations to try to imitate the strategies of the successful platform owners and open their applications for third party developers in order to expand their market and user base. Important examples of this are EPR vendors which have succeeded in growing large ecosystems of apps and app developers around their ERP software (Wareham et al 2014). In parallel with this, many user organizations now see their IT solutions as platforms and restructure their application portfolios towards platform ecosystems (Rolland et al. 2018, Gregory et al. 2018, Hydle et al. 2021). Further, public sector agencies are also increasingly seeing the IT services they are developing for citizens as platforms – even adopting concepts like "Government as a Platform - GaaP" (Brown et al. 2017).

Based on this we will in this paper address the following research question:

> *how can concepts from and research on information infrastructures and platform ecosystems contribute to the management of IT solution portfolios in large organizations enabling both coherent integration and information flow as well as flexibility and innovation?*

We will address this research questions through a longitudinal case study of the long-term evolution of the IT solution portfolio within a regional hospital organization in Norway (involving about 5.700 applications used by about 80.000 users in 11 hospital trusts (including around 40 individual hospitals)) up to 2018 with a focus on a large program aiming at transforming the region's IT portfolio running from 2012 to 2018. Our contribution adds to EA and Agile as well as infrastructure and platform research. We do so by theorizing the concept of *platform-oriented infrastructure* as a specific architecture/governance

configuration and demonstrating how this configuration can help large-scale organizations managing their IT solution portfolio through what we call a combination of *platformization* and *infrastructuring* processes. Platformization denotes both the process of transforming, i.e. platformizing, an existing silo-oriented application towards platform ecosystems at the same time as the platforms (and platform ecosystems) are integrated with each other to become components of, i.e. infrastructured into, a platform-oriented infrastructure.[2]

2. Related research

We will first assess the Enterprise Architecture and Agile research, then we review the information infrastructure and platform research, and introduce our key framework combining the issue of tensions and their relations to what we call architecture/governance configurations.

2.1 Enterprise Architecture

Enterprise Architecture aims to deal with the complexities of IT solution portfolios, and to align business and IT needs, through a holistic view on business processes and IT systems (Zachmann, 1987; Open Group, 2011; Ross et al.,2006). The ideas and principles behind EA has a long history. Kotusev (2016) sees IBM's Business Systems Planning (BSP) methodology as the first known framework. Later Zachman's framework, primarily ontology oriented and classification focused, became popular before the Open Group's TOGAF quickly became the dominant framework, partly because it provided a full process for implementation and use. The current version is 9.1 and a significant number of the world's largest corporations are users. An influential contribution was also the framework of Ross et al. (2006), Enterprise Architecture as Strategy, which focused more on business perspectives, and established the operating model as a foundation.

Most research on EA has been normative and the whole EA field has been criticized for being atheoretical (Schilling 2018, Kotusev and Kurina 2020). However, some empirical research does exist and presents the results of EA initiatives as less compelling (Kotusev, 2019). While there are some documented successes (Schmidt, C., and Buxmann, 2011; Foorthuis et al, 2015) many EA initiatives have been disappointments; they are not necessarily outright failures, but they seem to go on forever, without concrete results (Dang and Pekkola, 2016). One line of empirical research has investigated possible improvements to the frameworks (Banaeianjahromi and Smolander, 2016). Similar studies have pointed to issues such as EA quality as a key enabler of EA benefits realization, (Niemi and Pekkola, 2016), the inconsistent use of the EA artefacts in practice (Kotusev, 2019), and the need for two-way communication between the EA team and the various projects (Hylving and Bygstad, 2018).

A more fundamental critique has been raised by other researchers, such as Kemp and McManus (2009), who pointed out two fundamental problems; first, EA is based on a top-down strategy that assumes that it is analytically and managerially possible to control everything at the operative level. Considering the overall complexity of current IT portfolios, this is not a realistic assumption. Second, the long-term view of EA is incompatible with a rapidly changing world. In the same line Bloomberg (2013; 2014) called for a more agile approach instead of the traditional modelling focus:

[2] On parallel platformization and infrastructuring processes, see also (Constantinides at al. 2018). The notion of infrastructuring has in particular been explored and articulated by (Pipek and Wulf 2009). Their use of the term is slightly different from the use of the term in tis paper as they are emphasizing the role of users in infrastructuring processes.

> *"Enterprise Architects have used various frameworks and other tools to document how their organization operates, often with meticulous detail. But to what end? (…). Common to most definitions is the notion that such architects must drive business transformation in their organizations. But the practice of EAM has become all about documentation rather than effecting business change. (...) The field of Enterprise Architecture must itself transform into a new, Agile Architecture in order to drive digital transformation effectively in today's increasingly wired world" [15].*

Bloomberg's call for an agile EA approach has become quite popular within the EA field and among EA researchers the later years. (Alzoubi and Gill 2015, Hanschke et al. 2015, Thummadi et al 2017, Fürstenau and Woo 2019, Masuda and Viswanathan 2019, Canat et al 2018). However, the research in Agile EA is also mostly normative proposing modifies EA frameworks which are supposed to make EA more dynamic. While some research reports optimism among IT manager about the prospects of combining EA and Agile approaches, careful analysis of whether these two are "friends or foes" are still hard to find (Canat et al. 2018).

Summing-up, while the basic idea of EA may have its rationale, there is an urgent need to reconceptualise it, based on documented large-scale projects and organisational insights. We aim to do so by addressing two key assumptions EA is based on and which are found not to hold.

First, we should acknowledge, as Bloomberg (2013) points out and in line with Kemp and McManus' (2009), that organisations are not "architected", rather they grow and change organically as they adapt to outer and inner pressures and changes. EA should be a means to enable this process, not hindering it; it should be flexible enough to include change, but stable enough to work as a foundation. Second, in line with the digital business strategy literature (Bharadwaj et al., 2013), we should exploit the options of modern digital technologies, not as tools, but as organising principles. This means that it is too limited to ask how IT can support the business. Rather, we should ask how the organisation could leverage the unique possibilities of modern infrastructures and platforms to achieve its goals.

2.2 Agile Software Development

The growth in popularity of EA has taken place in parallel with a similar growth in popularity of agile software development approaches. And, as illustrated above, the importance of agility is increasingly recognized also in the EA community. EA and agile practices represent competing approaches to software development running through the whole history of IT: top-down, holistic and specification driven development versus bottom-up, iterative and more experimental development - both approaches always having had their strong advocates.

Agile practices approach discovering requirements and developing solutions through the collaborative effort of self-organizing and cross-functional teams and their customer(s)/end user(s) (Collier 2011, Dybå and Dingsøyr 2008, Dingsøyr et al. 2012, Acharya and Colomo-Palacios 2019). It advocates adaptive planning, evolutionary development, early delivery, and continual improvement, and it encourages flexible responses to change. It was popularized by the Manifesto for Agile Software Development (Beck et al. 2001). The values and principles espoused in this manifesto were derived from and underpin a broad range of software development frameworks, including Scrum and Kanban.

While, just like in the EA case, discussions around agile have been mostly normative, research documents several positive outcomes of following an agile approach. An extensive review of empirical research on agile development concluded that agile works very well for small co-located teams, and it facilitates smooth collaboration between developers and users or customers (Dybå and Dingsøyr 2008). However, important limitations have also been identified. This include the introduction of agile into large and complex organizations and larger software projects as well as taking into account architectural issues (ibid). Agile approaches concentrate on organizational issues facilitating agility, i.e. a learning oriented and experimental or iterative software development process, the key elements being self-organized co-located teams. And this has also been the core issues in research on how to scale up agile approaches to large software projects while architectural issues remain ignored (Dingsøyr et al 2018). Originally agile approaches were based on oral communication within individual teams. This worked fine as when the members of the teams were collocated. However, projects with a large number of teams require coordination and communication between teams at different locations. Research on how to scale up Agile has been searching for appropriate institutions, mechanisms, and coordination artefacts and tools facilitating the required needs for coordination between a larger number of self-organized teams that also might be distributedly located (Dingsøyr et al. 2018, Zaitsev et al. 2020, Qureshi et al. 2018.).

To summarize: Agile and EA address different issues: flexible and learning oriented software development versus organizing large scale portfolios of software systems. And they have focused on different aspects of software development. Agile focus on communication and organizational issues facilitating learning and agility while EA focus on architecture in a way that requires a top down and specification driven process. However, both EA and Agile is based on one central shared assumption of "in-house software development," i.e. they assume, implicitly, that the software organization involved has control over the totality of the software they are dealing with (Rolland et al. 2016). This assumption is clearly due to the fact that user organizations' software portfolios are primarily composed of commercial products, some of which may be very large and complex and based on an architecture which cannot be modified by a user organization. And in the case of Agile, as software systems become more complex, they easily become more rigid – depending on their architecture.

However, EA and Agile communities share one experience: both approaches are increasingly seen as insufficient and that the issues addressed by the other need to be accounted for. EA must become more agile, Agile must adapt to address issues related to large scale – even though architectural issues remain unaddressed. The question is, then, if or how EA can be combined. They are certainly complementary, but are they also contradictory (Canat et al. 2018)? Or what can an approach addressing the issues focused by both look like? And can research on platform (ecosystems) and information infrastructures help us in this taking on this task?

2.3 Information infrastructures and platform ecosystems

Platform ecosystems and information infrastructures have become increasingly focussed research objects in recent years - within IS as well as related fields like Management Research, CSCW, Science and Technology Studies, and Media Science.[3] Regarding IS research on infrastructures, Henfridsson and Bygstad (2013) identify four streams. First, complexity models highlighting the complexity of digital infrastructures as a multitude of actors simultaneously enact their own goals. Second, network models assuming that networks of

[3] For a broader discussion of similarities differences between platform and infrastructure research across the different research fields mentioned here, see (Plantin et al. 2018).

human and technical elements drive digital infrastructure evolution, typically grounded in Actor Network Theory. Third, relational models presuming that infrastructure should be appreciated through the sensemaking of its users and stakeholders. Finally, strategic asset models viewing infrastructure evolution as the process by which managers initiate and implement changes in an organization's portfolio of systems and tools for increasing the alignment between its information technology resources and strategic imperatives.

While the last strand of research is closely related to EA, the three first streams were motivated exactly to address the challenges emerging due to the growing complexity of IT solution portfolios in large organizations and the limitations of EA and other exiting approaches mentioned above. Hanseth and Lyytinen (2010, p. 4) define an information infrastructure "as a shared, open (and unbounded), heterogeneous and evolving socio-technical system (which we call installed base) consisting of a set of IT capabilities and their user, operations and design communities."[4] Further, infrastructures are recursively composed of other infrastructures, platforms, applications and IT capabilities and controlled by emergent, distributed and episodic forms of control (ibid p. 1). Infrastructures' evolution is to a large extent driven by network effects creating self-reinforcing processes. For this reason, it is suggested that the focus should be on how to improve existing technological and organizational arrangements, "cultivating the installed base" (Hanseth et al 1996, Hanseth and Lyytinen 2010, Aanestad et al. 2017) rather than designing new solutions "from scratch."

The concepts of platforms and platform ecosystems have become popular due to their success in providing attractive services for large groups of users across more or less the whole planet. And because of the demonstrated power of these concepts, they are also being adopted in the management of IT solutions within user organizations (Rolland et al. 2018, Gregory et al. 2018). Just like information infrastructures, platform ecosystems are seen as evolving through organic growth and involve a large number of autonomous actors. Accordingly, also the concept of platform ecosystems embeds an approach to overcome the problematic assumption of EA at the same time as both infrastructure and platform ecosystem research take large scale solutions as their starting points.

A number of reviews of research on platforms and platform ecosystems have been published the later years, including Gawer (2014), Thomas et al. (2014), and McIntyre and Srinivasan (2017). Gawer (2014) reviews what she calls the engineering stream seeing platforms as technological architectures and the economic stream seeing platforms as (multi-sided) markets, synthesizing these into a perspective seeing platforms as organizations, or meta-organizations. McIntyre and Srinivasan (2017) organize the platform research literature into three streams: technology management, industrial organization economics, and strategic management where the two first corresponds to Gawer's engineering and economy perspectives. Thomas et al. (2014) also include a fourth research stream: organizational platforms. They note that this stream includes a significantly smaller sample of publications, pointing to Ciborra's (1997) seminal paper on the "platform organization" as the key contribution.

The popularity of platforms has also triggered more efforts aiming at theorizing platform ecosystems and ecosystems in general (Dattée et al. 2015; Adner 2017; Jacobides et al. 2018; Autio and Thomas 2018; Autio et al. 2018; Autio and Thomas 2019). Jacobides et al. (2018) combines research on platform ecosystems with research on "business ecosystems," which

[4] See Lee and Schmidt (2018) for a review and extensive and critical discussion of various definitions of information infrastructures.

centres on a firm and its environment, and "innovation ecosystems," which focus on a particular innovation or value proposition and the constellation of actors that support it, defining an ecosystem a "set of actors with varying degrees of multilateral, non-generic complementarities that are not fully hierarchically controlled" (ibid. p 2264). While Jacobides et al. primarily draw upon strategy and management research, Dattée et al. (2015), Autio and Thomas (2018), and Autio and Thomas (2019) theorize ecosystems by also building upon IS and Service Marketing literature, pointing to generativity and Service-Dominant Logic as the key characteristics of ecosystems. Adner (2017) characterizes both of these approaches as ecosystem-as-affiliation which he contrasts to ecosystems-as-structure focusing on different structural relations between elements of an ecosystem.

Platform ecosystems and infrastructures are similar in the sense that they include a huge number of technological components as well as developers and development organizations, they both evolve and grow over long time, and their evolution are to a large extent driven by network effects. But there are also significant differences: platform ecosystems are all based on one specific architecture in terms of the split between platform and apps, and a specific governance structure where one single actor owns and controls the platform while autonomous app developers control the apps. In addition to this, IS research within platform and infrastructure streams sees both infrastructure and platform ecosystems as primarily driven by tensions which again are shaped by specific combinations of technological architecture and governance structures. We will review this research below.

2.4 Tensions

Research on both infrastructures and platform ecosystems has elaborated on the idea of tension as a conceptual lens towards understanding their evolution (Hanseth at al. 1996; Edwards et al. 2007; Reimers et al. 2014; Tilson et al. 2012; Wareham 2014, Rolland et al 2018). Regarding platform ecosystems, their evolution is seen as driven by the tensions between openness and generativity, i.e. facilitating innovations among third parties, vs. control (Tiwana 2010; Eaton 2012; Foerderer et al. 2014, Wareham et al. 2014, Ghazawneh and Henfridsson 2013); between standards and variety and collective and individual (Wareham et al. 2014); and between technological debts and technological options (Rolland et al. 2018).

A central theme in infrastructure research has been the tension between the need of standards and stability on the hand and the need for flexibility and change on the other (Hanseth et al. 1996). But a broader range of tensions have also been identified and analysed. Examples include the top-down demands for integration versus the persistent, bottom-up reliance on the installed base of systems and practices (Hepsø et al. 2009), and the sensitiveness to local contexts versus the need to standardize across contexts (Rolland and Monteiro 2002).

Building on extensive historical and social research Edwards et al.'s (2007) pointed out three basic tensions in infrastructures' evolution. These are related to time (short-term decisions vs. the long-time growth), scale, (such as between global interoperability and standardization vs. local optimization) and agency (such as between planned vs. emergent change).

Lyytinen et al. (2017) has developed a more detailed and sophisticated framework of how tensions determine infrastructures' generativity and evolution. They define generativity as "from –within, inherent recursive growth in the diversity, scale, and embeddedness associated with digital infrastructures" (Lyytinen 2017). First of all, they see an infrastructure's evolution as shaped by interactions between its underlying technologies, architected

technologies, physical context, and socio-economic context. Within each of these domains they identify one dominant tension determining an infrastructure's generativity: fixity vs. variety of underlying technologies; stability vs. change/flexibility of architected technologies; between local and global within physical context; and between control and autonomy within the socio-economic context.

2.5 Architecture-Governance Configurations

Research on how to deal with the tensions mentioned above has focused on their conditioning by the combination of the platform ecosystems' and infrastructures' architectures and governance structures (Ghazawneh and Henfridsson 2013; Henfridsson and Bygstad 2013; Tiwana 2014; Hanseth and Modol 2021). In this research architecture is broadly defined as a description of technical components, their function (i.e., what they do), and how they are arranged and interact to provide the overall functionality of the system. Governance broadly refers to how activities related to the platform ecosystems and infrastructures are organized and the distribution of decision rights.

The concept of software platform as defined by Tiwana (2014) represents in itself a specific architecture and governance structure explicitly aimed at managing tensions between stability and change (or flexibility) on the one hand and between centralized and distributed control on the other: the stable part of an ecosystem is integrated into the platform which is controlled by the platform owner while the dynamic and unstable parts are distributed across the apps which are also controlled in a distributed fashion, i.e. independently by the individual app developers. Tiwana (2014), however, goes further by suggesting that what shapes the different evolutionary outcomes of platform ecosystems is the alignment of the more detailed architecture and governance structures. Accordingly, Tiwana argues for a co-design and co-evolution of architecture and governance so that they can be mutually reinforcing.

The close relationship between a platform's architecture and governance structure is well reflected in Ghazawneh and Henfridsson's (2013) boundary resource model as illustrated in figure 1. This model split a platform into two modules: the platform core and its boundary resources. Further, a platform owner will according to this model control or govern the platform through two processes: resourcing, i.e. making boundary resources (typically APIs) available for apps and app developers, and through securing the integrity of the platform.

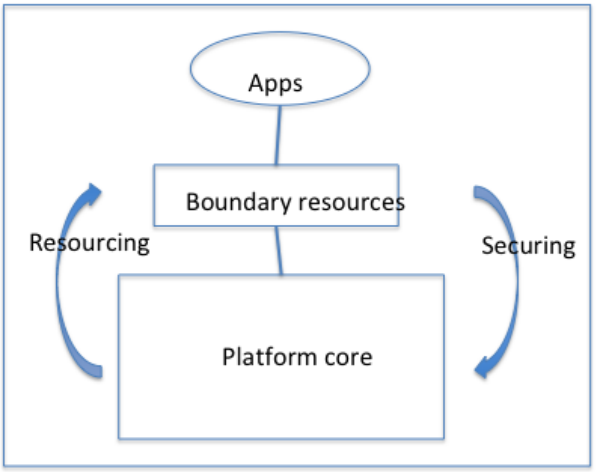

Figure 1: *The Ghazawneh/Henfridsson boundary resource model*

Infrastructures are not based on a specific overall architecture or governance structure as platform ecosystems are. And so far, research in this domain has been limited to conceptualize and analyse architecture in terms of trade-offs between opposites or extremes of a continuum –e.g., modular vs. monolithic and tightly vs. loosely coupled architecture. Henfridsson and Bygstad (2013), for instance, find evidences that a modular architecture combined with a decentralized control structure is a valuable trigger for the attraction of new users, new services, and the expansion of the scope into new domains of use, while tightly coupled (or integrated) architectures and centralized control structures are conditions enabling the attraction of new users and scope expansion but not the establishment of new services. Based on their framework covering the relations between a range of tensions Lyytinen et al. (2017) propose a set of principles for how to balance them in the various domains to maximize generativity. Among these are: loose coupling to physical components, modularity, loose coupling across layers, abstractions across domains, distributed technical control, etc.

2.6 Summary

This literature review reveals that platform ecosystems and infrastructures have a lot in common. It also demonstrates that platform configurations represent a specific and widely successful way of managing the tensions between stability, integration, centralized control, and standardization and universality on the one hand and dynamics, modularization, autonomy, and variety and adaptation to local needs on the other. Further, we see infrastructures and platform ecosystems to be related according to Hanseth and Lyytinen's (2010, p. 1) definition of infrastructure, saying that a number of platforms or platform ecosystems may be integrated, and, hence, constituting an infrastructure.

We synthesize the tensions driving the evolution of information infrastructures and platform ecosystems as illustrated in table 1 below. In doing so, we concur with Farjoun (2010), seeing the tensions between stability and change as the fundamental one. We also concur with him seeing the relation between stability and change as a duality and not a dualism. That means that we do not see stability and change as opposite ends om a continuum where one need to find the proper balance, but as "fundamentally interdependent - contradictory but also mutually enabling" (ibid, p. 202). Tensions between stability and change are primarily condition by the infrastructures' and platform ecosystems' architectures and governance structures. Further, architectural and governance structures need to be aligned as illustrated in table1below. We will use this framework to analyse the various strategies for evolving HSE's IT solution portfolio.

	Stability	**Change**
Architecture	Integration (efficiency) Uniformity, standardization Centralized	Modularization (flex) Variation Decentralized
Governance (strategy, organizing)	Consolidation Long term focus Planned change Centralized control	Local optimization (adapt.), innovation Short term focus Emergent change Distributed control

Table 1: *Architectural and governance tensions*

Using this framework, we see that EA assumes stability and that a coherent architecture covering "everything" requires centralized control. Agile, on the other hand, emphasizes change and distributed control in terms of autonomous teams at the same time as architectural issues are ignored. Platform ecosystems is based on a rather holistic perspective, balancing the

tension between stability and change by means of aligning architecture and governance structures where the stable parts of the ecosystem are put into a tightly integrated and centrally controlled platform while the components that need to be dynamic are built as autonomous and distributed controlled apps.

3. Research method and setting

We will her describe our research approach and setting. We develop our concept of Platform-Oriented Infrastructures in the context of a particular class of large-scale IT solutions: e-health infrastructures. E-health infrastructures are extremely complex, both in terms of the clinical processes they support, as well as in terms of the number of systems and applications (usually silo systems) in use, leading to a several tensions (Bygstad and Hanseth, 2016; Aanestad et al, 2017). They are therefore extreme cases (Gerring, 2006) and well suited for developing new theory.

3.1 Research setting

Our object of study is the evolution of e-health infrastructures in Norway with a focus on the transformation of the application portfolio of a health region in Norway from 2012 to 2018 – namely the South-Eastern Norway Regional Health Authority, normally called Health South-East, here abbreviated HSE.

Norway is a Scandinavian country with 5,2 million inhabitants who enjoy a high standard of living and public health services. Historically hospitals have been owned by the19 counties. From 2003, however, they have been owned by the government and organised into four health organizations called Regional Health Authorities given the names Health North, Mid, West, and South-East respectively. Individual hospitals are organized into larger structures called hospital enterprises.

The health regions get instructions from the government once every year about how to run and develop their medical services. This includes also some instructions about how they should develop their IT portfolio.

HSE may be regarded as a governmental "holding company" for 11 legal hospital organisations, here called hospital enterprises.[5] Health South-East serves a population of 2,8 mill and had in 2017 app. 80,000 employees. IT Services is centralized, run by the company HospitalPartner,[6] which is wholly owned by Health South-East and has around 1.300 employees.

HSE has without doubt a complex IT solution portfolio. In first half of 2018, more then 5700 different applications were identified, each of them integrated in various ways with a number of other solutions (Sigurdsen 2018). Some of the solutions are small and simple ad used by a few users within an organizational unit, some are big "silos" used by most users at a hospital or across the regions, while yet others are national solutions used by the more or less whole health care sector.

[5] In Norwegian they are called "helseforetak." Each hospital enterprise includes several local hospitals. Before the government taking over the hospitals in 2003 there were about 50 independent hospitals within the region.
[6] The South East Health Authority was established in 2007 as a merge of the East and South regional organizations. Hospital Partner was established as the central IT organization of the South Health Authority in 2003. After the merge, the IT personnel from the other regional organizations were transferred to Hospital Partner.

3.2 Research approach

The research reported here is a part of on-going research on e-health infrastructures in Norway since 1988 with a focus on the period 2012-2018. Since 1988 we have followed a large number of projects and initiatives aimed at establishing and improving e-health infrastructures. A key theme for all our research has been strategies for integration and standardization. Our research started in 1988 when one of the authors was working at an applied research institution and was hired by Telenor to work on a project aiming at contributing to the development of international standards for exchange of health information. After this, the same author was working for two years (1990 – 1992) for a software company developing solutions for exchange of patient related information between health care institutions. Since 1992, data has been collected from a number of initiatives and projects, including:

- Establishment of standards and solutions for information exchange between health care institutions, for instance lab orders and reports, prescriptions, admission and discharge letters, etc. 1992 – 2012.
- Development of a national Electronic Patient Record solution. 1995 - 2003.
- Integration of patient related information systems in hospitals by means of web portals. 2005 – 2015.
- Development of a national e-prescription solution. 2008 – 2016.
- Development of a solution giving patients access to patient record information and interaction with hospital doctors. 2010 – 2012.

Data were collected through interviews with project participants and managers, and users as well as from various project, strategy, and national policy documents. (Results from the research have been published in a number of papers, the most relevant of which will e included in the final version of this paper.)

During the period 2012-2018, we followed HSE's ambitious program, called Digital Renewal, aiming at transforming its IT portfolio. Our research interest was in how such a complex portfolio of applications, many of them big and rigid silos, could be restructured into a generative infrastructure, i.e. an infrastructure enabling smooth information flow at the same time as the infrastructure was flexible enough to adapt to changing user needs as well as allowing further innovations utilizing new technologies like smartphones and Internet-of-Things.

We embarked on this based the combination of an infrastructure perspective focusing on issues like integration, standardization and tensions and an open and exploratory approach where we were following the evolution of Digital Renewal and its projects directed by emerging challenges and outcomes, zooming in on issues we considered important both from research and practice perspectives. Due to events and the directions Digital Renewal was taking, we became increasingly focused on how concepts from infrastructure and platform research could be combined.

Based on this approach, several papers have been published on issues that have emerged. This paper draws upon the results published in these papers in trying to theorize about our overall interest: what a generative e-health infrastructure could look like and how to transform an application portfolio into such an infrastructure as well as enable its further evolution while maintaining its generativity.

We investigated the evolution and transformation of the complex application portfolio. We studied the governance and development of HSE's IT portfolio at three levels:

- *The national level*: we interviewed top executives and IT managers at the Ministry of Health and Health Directorate, analysed plans and initiatives, and we followed the governance and development of a national e-health service, the ePrescription solution, from 2009 to 2015.
- *Regional level*: we investigated the development of a regional IT architecture and governance structure in the South-Eastern Norway Regional Health Authority from 2013 to 2018, organised as a mega-programme, "Digital Renewal".
- *Project level:* we followed a portfolio of key projects from 2013-2018; the regional EPR, lab, radiology, and a separate initiative at Østfold Hospital.

3.3 Data collection

This article draws partly upon data collected between 1988 and 2018. Here we will describe in more detail our data collection related to the Digital Renewal program during 2012-2018. In the early phase we collected data about Digital Renewal's strategy and the scope, aims, and plans for the individual project. The most important data sources were various official documents. We were also collecting data from various documents describing national strategies. We collected more detailed data about the strategies and plans, and in particular the perspectives and motivations behind, through interviews with managers at different levels and IT architects.

As Digital Renewal unfolded, we moved our focus towards the evolution of the individual projects as well as their relations and (social/organizational as well as technical) dependencies. During this phase, we used similar data sources as in the first: documents like status reports, quality assurance reports and documents describing risk assessments, combined with interviews giving more detail. In his phase we also interviewed software developers. We were also examining product documentation from vendors and interviewing vendor representatives. During this phase we gradually zoomed in on emerging challenges and issues and also solutions or projects we found particularly relevant and interesting. Two such were particularly interesting and important for this article: a sophisticated patient logistics solution at the new Østfold Hospital which was developed as a set of independent modules, or "apps," accessing a number of silos, and the Integration Factory, responsible for all integrations between applications and the Integration Platform they built and operated supporting the integrations.

In the last phase we focussed on outcomes of the projects, and finally on discussion about a new strategy. In this face various documents were key data sources, in particular documents presented for HSE's Board of Directors and minutes form board meetings. In this face we also collected data through interviews with health care personnel.

In total, we collected data from a large number of documents and by interviewing 77 informants, many of them twice or more. Interviews were mostly open, focusing on their experiences in programs and projects. The main informant groups were managers at different levels, IT architects and developers, and medical personnel. See Table 2 below.

Level	**Interviews**	**Documents**
National 2009-15	*Ministry of Health*: Senior managers and executives	Ministry of Health: White paper: "One citizen, one journal"

	Directorate of Health: Senior managers, E-prescription project managers and architects Consultants	National ICT: A National SOA architecture Directorate of Health: The ePrescription project plan and ePrescription architecture
Regional 2011-15	South-East Health Region: - Vice chairman of the Board - Programme manager - Regional CIO - Project co-ordinator - Regional IT architects - HospitalPartner managers - HospitalPartner developers - Vendor representatives	The Digital Renewal Programme: Plans and status reports IT architecture documents Requirements specifications Minutes from Board Meetings
Projects 2013-18	The key clinical systems implementation projects: - Project Managers - Sub-project managers - IT architects - IT developers and consultants - Lab personnel - Medical doctors and nurses - Vendor representatives	Project documents: Plans Status reports User requirements IT architecture documents and blueprints Vendor documents: Product specifications Evaluation reports

Table 2: *Data sources*

3.3 Data analysis

Our analysis of the data related to Digital Renewal was iterative and interleaved with our data collection. As our project evolved, we zoomed in on various issues of interest and relevance and published a number of papers on these issues. The present article builds on all of them in trying to theorize on the challenges related to the management of complex and large-scale IT portfolios where. Our concept of Platform-Oriented Infrastructure is the outcome of a quite extensive process where we tried to conceptualize what a generative infrastructure cold look like consistent with both the failures and the achievements of Digital Renewal. In doing so we first identified the tensions present during the evolution of HSE's IT portfolio and how these tensions were tried managed or shaped by various architecture-governance configurations. Based on this analysis, we were tinkering with concepts related to information infrastructures and platform ecosystems. In the later part of our project, project participants as well as architects inside HospitalPartner were gradually adopting a perspective where applications could be seen as platforms. HSE's overall information infrastructure would then be seen as a combination of a huge number of platforms (or platform ecosystems). What finally made it possible for us to put the various pieces of the puzzle together into a picture of a platform-oriented infrastructure, was the idea of considering HSE's Integration Platform as a boundary resource between apps and the multiplicities of application.[7] See Table 3.

Step	**Task**	**Output**
Identify events and issues	Identify key events and issues in the data	Case description

[7] This idea actually emerged when one of the authors were tinkering with how to combine concepts related to platform and infrastructure with Digital Renewal outcomes over a galss of wine before having dinner with two international collegues.

	material, focusing on IT architecture and governance.	
Analyse tensions and platformization	Analyse the tensions of the case, and reposition the study as the emergence of a platformization process	Analysis (interleaved with the case description)
Propose solutions by interpreting the data from an infrastructure and platform perspective	Propose an architectural and governance configuration	Discussion section

Table 3: *Data analysis*

The analysis was iterative, and included feedback from our informants; in analysing the process we carefully assessed the overall architecture documents and then discussed their implications for local clinics with doctors and lab personnel. Their views were again discussed with central architects. At the end of the research process we also discussed draft versions of this paper with key informants.

4. Case: Transforming an e-health infrastructure

We will here present our case: – the evolution of the application portfolio, of a health region in Norway - the South-Eastern Norway Regional Health Authority, normally called Health South-East, here abbreviated HSE. We will first present the evolution of the IT portfolio since IT was first introduced into hospitals during the 1970-ies, but with focus on the period from 2012. The evolution will be presented as a series of phases, and for each phase we will point out how stability and change were emphasized in the strategies as they were reflected in the architecture and governance structures adopted, and the outcome of the strategies. The outcome of this analysis is summarized in Table 4.

	Focussed issues	**architecture**	**governance**	**Tension strategy**	**outcome**
1970-1990	Innovation, developing solutions supporting new use areas	Stand-alone systems	Distributed control local hospital, department	Emphasizing change only	Growing variety
1990-2003	New distributed solutions supporting new collaborative structures	Variety of solutions connected through standardized interfaces	Centralized control of standards development, and distributed control of the development of solutions	Balancing stability and changge	More solutions, increased variety, very slow progress in standardization
2003-2012	Increased number/variety of solutions, lack of integration/support of information flow	Tight integration of solutions of the same kind, loose coupling of different kinds of applications	Centralized governance; strategy and key decisions controlled by the regional administration	Reducing variety through standardization of applications	Failed standardization, growing variety
2012-2018	Increased number/variety of solutions, lack of integration/support	Consolidation of the same kind of applications, loose coupling	More centralized control	Reducing variety by consolidating applications	Failed consolidation, drifting towards POI

	of information flow	between applications of different kinds			

Table 4: *The evolution of HSE's IT solution portfolio.*

4.1 Evolution of IT strategies and the IT solution portfolio before 2012

When IT arrived in the health care sector in the early 70-ies, the focus was on the development and adoption solutions supporting new use areas, i.e. innovation and local adaptation. In terms of architecture then, the growing overall portfolio of solutions was highly modularized as it consisted of stand-alone applications governed according to a distributed model where individual hospitals or smaller units within hospitals, in collaboration with local IT departments, controlled the IT activities. The different solutions were only integrated through manual transfer of data between them. In terms of tensions then, dynamics and change, i.e. innovations, were emphasized.

1990-2003: combining development hof more solutions and message standardization

During the period until 1990, a huge number of solutions were developed and adopted, generating an assumed need for automatic information sharing. The emergence of communication technologies during the 1980-ies also created huge opportunities for information sharing, both within and across hospitals, and new services, in particular telemedicine services like transmission of real-time multi-media data related to, for instance, minimal-invasive surgery. Further, new medical knowledge and technologies (instruments) were leading to increased specialization of the medical profession which again generate a need for more collaboration among medical specialists and health care institutions.

Against this background, the development of standards for information exchange between solutions became a focussed task at the same time as the development and adoption of new solutions supporting new use areas should continue. This strategy represented a change in architecture by integrating solutions based on standards. However, the solutions would still be only loosely coupled. The governance structures also changed in a corresponding way: centralized control of standards combined with distributed control of the development and adoption of individual solutions. This strategy was, then, one where one tried to balance stability and integration on the one hand and change and innovations on the other.

2003-2012: Standardizing solutions and centralizing control

When HSE was established in 2003, a central administration and IT unit was set up, quickly concluding that the existing strategies had been successful in terms of leading to a huge number of different solutions. The standardization strategy, however, had failed. They decided to go for a centralized IT governance structure and transfer all IT personnel into a new regional organization, Hospital Partner. Further, they decided that not only the information to be shared, but also applications should be standardized, i.e. all hospitals should implement the same lab system, patient record system, patient administrative system, radiology system, etc. Applications should, then, be standardized in a process where HSE signed a so-called framework contract with vendors after a tendering process while the hospitals decided when they wanted to replace their existing solutions.

The new strategy represented a significant step towards a more tightly integrated architecture and centralized control. The main focus was definitively on stability by reducing the variety among solutions, and certainly not innovation and change.

2012 ->: Centralization and consolidation/The Digital Renewal Program

In December 2011 a new Director of Technology and E-health was hired. He did a review of status of the IT domain and existing strategies. This was leading to a consensus saying that the strategy focusing on standardizing applications had not delivered. Each product had been configured and adapted to local needs differently among the hospitals making information sharing just as challenging as if the hospitals had different products at the same time as many hospitals were still using their old systems. The number of IT systems and applications in 2012 was reported to be around 4000 (in early 2018 5.700 different applications were identified). This situation was seen as a major obstacle for patient-oriented services and innovation, and was widely criticised by politicians and media. The answer from the top health executives to the challenge was to establish a new governance regime and standardization strategy. A top-level manager commented:

> *"The main problem is the fragmentation of solutions, which has a historical explanation. Each hospital, each clinic – and even each clinician – has had the freedom to choose any solution that was available, during the past 30 years. These choices have often been made arbitrarily, dependent on which vendors were knocking on the door, or other local conditions. The result is hundreds of different solutions, which cannot exchange data, because of the lack of standards, and cannot communicate, because of the lack of integration. Today, this is an obstacle for both patient oriented care and evidence-based medicine. It is also expensive. There is only one solution, which is an overall consolidation to shared systems, and a standardization of data and processes. This requires the courage to establish a top-down governance structure, an integrated architecture, and well-financed programmes to implement the strategy".*

In line with this view, HSE worked out a new strategy according to which all applications, in principle, should be "consolidated," i.e. there should be one single patient record installation, one single lab system installation, etc. shared by all hospitals. A large programme, called Digital Renewal, was launched in 2012 to implement this strategy. [8]

Digital Renewal was planned to run from 2012 to 2017 with a budget of 7 bn. NOK (around 750 mill Euro), initially organized as six sub programmes:

- *Regional Clinical Documentation*: Standardizing and consolidating electronic patient record and other clinical systems within 2016, including chart and medication system, solution for chemotherapy treatment of cancer, and "birth record" system.
- *Radiology:* Consolidating from several to one shared radiology[9] solution in 2016.
- *Medical labs:* Consolidating from several to one single shared lab system within 2016 supporting the four most important kinds of lab (medical biochemistry, pathology, micro-biology and blood bank).
- *Digital co-operation*: Information exchange with hospitals outside the region and primary care, and the implementation of national solutions for information sharing like the national ePrescription and Summary Care Record solutions.
- *Enterprise Management Support:* Shared enterprise system and data warehouse.

[8] A slightly modified and updated version of the strategy can be found here: https://www.helse-sorost.no/Documents/Digital%20fornying/086-2015%20Vedlegg%201%20-%20IKT-strategi.pdf

[9] A radiology solution consists of two main components: RIS and PACS. RIS is abbreviation of Radiology Information System and supports the management and performance of radiological examination. PACS is abbreviation for Picture Archiving and Communication System and is storing all kinds of radiological images like X-ray, CT, MR, ultrasound, etc.

- *Infrastructure:* Shared IT platform and data centre.

The mega-programme was organised and governed in a top-down structure, with a central Programme Board, and a board for each sub-program. All program boards were populated with top-level managers securing a very strong top-level management commitment and involvement. The many projects were run by professional project managers, and with tight reporting routines and continuous risk management. External consultants regularly produced audits. The CEO of Oslo University Hospital (OUH), acting as the head of the Programme Board, commented:

> *"The IT solutions have become extremely important for the whole health sector. We can see a parallel with the banking sector 20 years ago, which has dramatically changed the whole industry. It is very important to standardize our systems: A shared EPR system, together with shared lab and radiology systems will be operationally very important for patient safety, but also contribute to make OUH into one unified organisation."*

The Digital Renewal program was generally well received in the press and in the sector. There were however some critical voices, primarily among hospital clinicians, among whom many felt left out of the process. One profiled doctor expressed it this way:

> *"The overall thinking in the programme is dominated by economists and consultants, and ignores the perspectives of the clinicians. In my view, they use the IT programme to implement a centralised corporate model in the region, instead of supporting the clinicians that actually produce the medical services".*

The overall strategy had, and still has, a very strong focus on individual applications. Integration of and information sharing between different applications is hardly mentioned at all, and definitively not addressed as an issue that matters.

After some time, challenges emerged and all IT activities related to the new Østfold Hospital, which was under construction, were taken out of the individual projects and merged into a separate project outside Digital Renewal. The interdependencies of physical and digital structures in the building project, delays in Digital Renewals projects - and a non-negotiable start-up date in 2015 - allowed the local management to run the project independently from Digital Renewal.

In spite of a strategy focussing on integration and reducing variety through applications standardization combined with centralized control, during the period 2003-2011 variety had increased. The response to this fact was to prescribe stronger doses of the same "drug:" more focus on reducing variety through tighter integration of applications in terms of consolidation and more centralized control. This means increased emphasis on stability and even less on innovation and change.

4.2 Digital Renewal projects

We will now turn our attention towards the projects given highest priority. For each we describe key aims, challenges met and responses to these, and outcomes.

4.2.1 Electronic Patient Record

All hospitals except Oslo University Hospital (OUH) were in 2012 using the same EPR system. A shared, consolidated EPR solution was planned as a two-step process: first implementing the system used by the others at OUH, then consolidate all installations into a regional one. The existing EPR systems at OUH had 12,000 users. No additional functionality or adaptations were added, and only the most important existing integrations between the old EPR system and others should be included in the project.[10] The project delivered on both time and budget - on October 20th 2014 the new solution was successfully set into production.

The highest risks were considered to be integration and data conversion. These were also the most resource demanding tasks. 65 different systems should interact with the new EPR, through 345 interfaces, while about 2.5 M patient records should be converted from the existing EPR into the new data base and its structures.

In the following year (2015), the effort to transform all the 11 different EPR installations into a consolidated one started. By Summer 2017 the costs estimation work was completed: consolidation of all EPR installations was estimated to be in the area of 125 to 195 M Euros. Integration with other systems was the most resource demanding effort, estimated to cost between 35 and 55 M Euros. These huge costs made the hospital managers question if the benefits that would be achieved was proportional to the costs, and project participants started to discuss alternative strategies. The main elements of an alternative strategy were stepwise standardization of the data bases and development of APIs for queries across all installations. The project drifted towards the latter. By end of November 2017, 7 of the 11 hospitals enterprises have implemented a first version the data base standard,[11] and some new APIs,[12]for instance one API providing access to all existing medical record documents (like lab reports and admission and discharge letters) for one patient across all installations in the region, were developed.

The estimation of the costs of consolidation as originally planned, disclosed huge variety among the different installations and the overall complexity of the ERP domain. The new emerging strategy accepts this variety, and try to achieve the aims of consolidation, i.e. data sharing, based on a different architecture and governance structure: a distributed architecture and control structure where the individual installations remain independent while data sharing is facilitated through APIs implementing queries across all installations. The new strategy also focuses on consolidation as an ongoing process where APIs are established one by one where the most needed APIs are developed first. Accordingly, this strategy, and its architecture and governance structures, represent a change where the tensions between stability and change are tried balanced.

[10] The budget was estimated to 685 MNOK (around 75 mill Euro). The implementation project was organised with a steering group, project manager and project office, and eight sub projects. Around 400 participants were involved - a mix of employees of HospitalPartner, external consultants, vendor employees, and many doctors, nurses and lab personnel from OUH. The project was very tightly run, with detailed activity planning and reporting at all levels, and continuous risk management. The steering group, headed by the CEO of OUH, was following the project closely.

[11] http://hsorhf.prod.fpl.nhn.no/hso_nyheter_/Sider/Ahus-innførte-regional-journalstandard-som-det-7.-foretaket-i-.aspx

[12] Based on the IHE XDS standard https://ehelse.no/standarder-kodeverk-og-referansekatalog/standarder-og-referansekatalog/ihe-xds-metadata-norsk-profil-av-ihe-xdsb-his-11692016

4.2.2 Second project: Medical labs

Across the region many different solutions were in use for each of the four major lab types, i.e. medical biochemistry, pathology, microbiology, and blood bank.[13] The Lab program specified one solution covering all the four types of labs, and after a tendering process a contract with the selected vendor was signed in 2012. A preliminary version of the new lab system was implemented in Østfold Hospital in 2015. This version did not include functions for the blood bank and covered only the basic functionality that the hospital needed.

When this solution was up in running, the project started analysing the gaps between this one and the requirements of the other hospitals in the region. Based on this analysis the board of Health South-East decided in April 2017 to build a regional solutions by addressing the needs one kind of lab at the time, starting with pathology.[14]

Like the ERP, also the lab project was also confronted with the unmanageable variety and complexity of the lab domain, and changed their strategy towards one where they would develop four more separate solutions for each type of lab. Further, they also accepted that consolidating each of the four solutions would take a long time, accordingly taking one step towards a more process-oriented approach to consolidation. This, then, also represented a change regarding approach to the tensions between stability and change.

4.2.3 Third project: Radiology

Within radiology, products from five different vendors were in use. After a tendering process, the contract with the selected vendor was signed during the spring 2013. This solution was planned to be implemented first as a pilot in the Innlandet Hospital.

The acceptance testing started in October 2014, but was quickly discontinued due to the huge number of errors discovered. Several new versions have been tested, but an acceptable solution remained looking far away.

In parallel with the pilot testing at Innlandet, gap analyses have been on the pilot solution. This analysis revealed that there was huge variety regarding the work processes at the various radiology departments. This variety was primarily due to differences between the departments. Some hospitals are rather small and need support only for a few rather simple and standardized procedures while others need support for high volumes of a rich set of procedures. Further, the Radium Hospital, the national and most advanced cancer hospital (a part of OUH), needs support for rather complex packages of radiological examinations tailored to the needs of individual patients. It turned out that a solution satisfying all these requirements would be unmanageably complex.

Due to the continuing struggles the adaptation and implementation of the selected solution faced, during the winter 2017/18 alternative options were analysed. In April 2018 the board of Health South-East decided to cancel the contract with the vendor, and instead concentrate on

[13] In total 11 different products were implemented among the eleven hospital enterprises. Six different products were in use within medical biochemistry, four within microbiology, and two within each of pathology and blood bank. Four hospitals used the same product within both medical biochemistry and microbiology.

[14] The total cost of the project is estimated to 100 M Euros and to be completed by 2025 (the original estimate when the decision to go for one shared lab system in 2012 was taken was 13 M Euros and that the project was assumed to be completed by 2020). https://www.helse-sorost.no/Documents/Styret/Styremøter/2017/20170427/042-2017%20Saksframlegg%20-%20Innføring%20av%20regionalt%20laboratoriedatasystem%20-%20status%20og%20videre%20planer.pdf
The detailed specification of a regional pathology solution started in November 2017.
http://hsorhf.prod.fpl.nhn.no/hso_nyheter_/Sider/Nå-starter-konfigurasjon-av-patologi-til-regional-standard.aspx

establishing shared radiology solutions at each of the 11 hospital enterprise in parallel with a stepwise development of a regional solution by developing APIs for accessing information across the hospital enterprise solutions similar to what they have started doing for the ERP systems.[15]

This project met the same challenges as the ERP and lab projects, and came to the same conclusion, i.e. that they had to adopt a different architecture and governance structure to manage the tensions between stability (uniformity) and change (variety) in a more appropriate way. The overall strategy, architecture, and governance structure adopted were more or less exactly the same as in the ERP project.

4.2.4 Digital co-operation

The digital co-operation project has been rather small compared to those presented above. It has, however, reached most of its important aims. These include the implementation of the national e-Prescription and Summary Care Record solutions in all hospitals in the region. The e-Prescription solution is used to share prescription information between all relevant actors in the health care sector, while the Summary Care Record solution give the same group access to the most critical and relevant information in urgency situations. In addition, the project has implemented a solution enabling the exchange of discharge letters from OUH to GPs in all (i.e. about 420) municipalities in Norway. Further, all Health South-East hospitals are accessing a huge number of national registers used for management, quality control, and research. Examples include a national register with information about all cancer patients, and vaccination and birth registers.

This project illustrates the fact that IT solutions are increasingly integrated not only with solutions within the same hospital or region, but also nationally. This implies that architectures and governance structures within a region need to be connected to and aligned with architectures and governance structures of other regions, primary care, as well as at the national level, that regional architectures and governance structures need to be flexible to adapt to external changes.

4.2.5 The Østfold Hospital and lightweight technologies

The portfolio of integrated solutions developed and running when the new Østfold Hospital opened in 2015 is the most advanced hospital enterprise wide integrated portfolio of IT solutions within the region. A number of new services was made available, in particular supporting patient logistics and coordination of patient related activities. These services were implemented, based on technology from a smaller Norwegian vendor, as a number of independent modules running in mobile phones, notepads or accessible through whiteboard touch-screens that visualised and supported the control of patient flow through the hospital. This included services supporting activities related to patients arriving at the at the emergency department, allocating patients to wards, transferring patients between wards, ordering lab and radiology services, and supporting the discharge of patients, etc. Personnel preparing the meals for patients and cleaning patients' rooms also made their services more efficient by getting access to information about patients' dietary requirements and when patients were planned discharged respectively. Mobile phones were used extensively to co-ordinate actions between different units, and to inform patients and their families. The individual modules of the solution were accessing information in a number of applications - including EPR, lab, radiology, chart and medication solutions, etc. The hospitals also collaborated with a couple

[15] https://www.helse-sorost.no/Documents/Styret/Styremøter/2018/201804/040-2018%20Saksframlegg%20-%20Radiologi-løsning%20for%20Helse%20Sør-Øst.pdf

of start-up companies in developing new services for monitoring and treating cancer patients at their homes after being discharged from the hospital. The IT solutions developed for this purpose included various sensor and instruments operated by the patients and tools for communicating with doctors, were integrated with the IT solutions in the hospital in line with a platform/app model.

The development and use of this solution stimulated and contributed to a rapidly growing interest in the use of new mobile and Internet-of-Things technologies. Most health as well as IT personnel believed this technology would enable the development of a broad range of new and improved medical services. This triggered the establishment of a new project, called MediCloud, to address these issues. This project aimed at providing a cloud-based platform where software companies could test applications that needed access to data stored in various software solutions, in particular the ERP system, but also lab, radiology, chart and medication solutions, etc. MediCloud also served as a communication channel between the HospitalPartner and software vendors related to the development of appropriate APIs for the vendors. This activity contributed to a growing awareness of the importance of platforms and platform ecosystems as a way of organizing the development of new and innovative solutions enabling new and improved medical services. This made HSE's CEO request a report from the central IT unit outlining a strategy related to "lightweight" technologies[16] like the patient logistics solution in Østfold. A proposed strategy was worked out during the spring 2017. Further the experience with new solutions and services for monitoring and treating patients at home has become a foundation for a new regional strategic initiative aiming at developing and implementing the concept of "Home Hospitals" which is expected to contribute substantially to cost containment as well as better patient services.

The Østfold case, and the activities it triggered, represents a strategy for coping with tensions different from that of Digital Renewal. First of all, it focused on vertical integration, i.e. integrating different kinds of system within the hospital enterprise, as opposed to the focus on horizontal integration, i.e. integrate each kind of solutions across all hospitals. Further, in this case stability and change was balanced by developing new functions as independent modules, or apps, on top of the existing solutions, while keeping the existing solutions stable. The latter strategy was then further elaborated through the MediCloud project and the development of the Research and Innovation Platform.

4.2.6 Summary and status by the end of 2018

At the end of 2018 the Digital Renewal program is officially brought to an end. The consolidation strategy has not delivered and is abandoned. No new official strategy has been announced, but a consensus is established that a new approach is needed. The new approach will focus and improving the existing IT portfolio through small steps rather that giant leaps which the consolidation strategy aimed at (Kvan 2018). The new Director of Technology and E-health has declared that "the era of large projects is over." The new approach will draw upon the positive achievements of Digital Renewal and the new strategies that have been decided for the EPR and radiology solutions. The challenges Digital Renewals were confronted with as well as the achievements have been interpreted in relation to the growing popularity of platforms and platform ecosystems which were in particular promoted in the MediCloud related projects.

[16] The distinction between heavyweight and lightweight IT is discussed in Bygstad (2016).

More smooth information sharing is still seen as important as previously, but now this will be tried achieved through the development of API in line with the strategy they have embarked upon in the EPR and radiology projects. Further, they will capitalize on the positive experiences and achievements in Østfold, in particular the patient logistics solution and give higher priorities to innovations as outlined in the "lightweight" technology strategy requested by the HSE's CEO. This means that they are giving up the one-sided focus on stability in terms of standardization and reducing variety combined with centralization of control, and changed towards a strategy and architecture and governance structures trying to balance the tensions.

4.3 Integration strategies and technologies

Integration of IT solutions emerged as an issue during the (late) 1980-ies. Its importance and the challenges involved have grown continuously ever since. We will here look more closely at how integration issues have been dealt with within HSE.

Before the establishment of HospitalPartner (in 2003), many hospitals within the region independently adopted BizTalk, Microsoft's Enterprise Software Bus product. They also adopted specific middleware products supporting exchange of radiological information based on the DICOM standard. In this domain three different products were adopted among the Health South-East hospitals.

When Hospital Partner was established, they were taking over the responsibility for the operations of the middleware solutions as well as further integration work. Personnel involved became organized into a unit called the Integration Factory. For both practical (or technical) as well as legal reasons the Integration Factory has developed and operates in total 13 instances of the Integration Platform – one for internal communication within each of the 11 hospital enterprises, one for communication between the enterprises, and one for communication between hospital enterprises within the region and national solutions, hospitals in other regions, and primary care institutions. The Integration Factory is responsible for all integration efforts within HSE and all information sharing and integration between IT solutions take place through the Integration Platform. This includes, then, all projects and solutions described above.

Over the years the middleware solutions in use as well as the additional integration software have been growing. All this is named the region's Integration Platform. Due to emerging needs, the Integration Platform has been continuously growing in terms of basic functionality at the same time as the Integration Factory has focussed on harmonizing the middleware installations as well as the additional existing integration software across the hospitals. A major enhancement of the Integration Platform was the inclusion of Microsoft's Internet Integration Server (Microsoft's web services middleware product). More recently they have emphasized implementing new APIs.[17] To facilitate this the Integration Platform is also extended with a so-called API Gateway and IAM (Identification and Access Management) solution. The first supports secure access and the latter management of access rights of different users and apps. The overall architecture of the Integration Platform is illustrated in figure 2.

[17] These APIs are based as far as possible on the PHIR implementation of the HL-7 standard

A separate group of programmers, fifteen in total, has worked on integration of lab and other systems. 1st of January 2018 this group was included into the Integration Factory, bringing the number of employees in the Integration Factory up to 40.

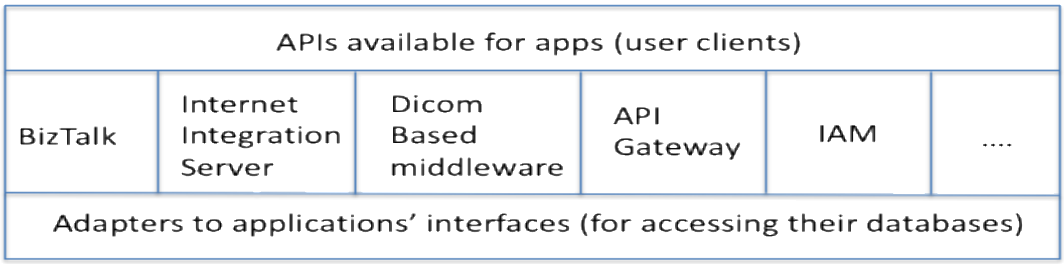

Figure 2: *The architecture of the Integrated Platform*

Before 2002, the hospitals also hired architects to work on integration issues in parallel with the implementation and use of middleware solutions. When HospitalPartner was established, architecture section was set up and all architects were transferred and given the title Enterprise Architect. All of them were TOGAF certified.

When the Digital Renewal program was launched, the architects argued that an overall architecture should be worked out based on the TOGAF framework and which the solutions should be based upon. However, it quickly clear that this approach had to be abandoned. First of all, specifying such an architecture would take a long time while the projects were all seen as urgent and could not wait. Second, it quickly also became clear that such an architecture would become unmanageable complex. Finally, the acquisition of all new solutions should take place through tendering processes as regulated by the EU directive on public procurement as this is implemented into Norwegian legislation. The solutions chosen would all have their own architecture and could not be redesigned to fit a specific architecture made for HSE.

However, as Digital Renewal evolved, new roles for architects emerged. All projects included at least one architect, and soon the architects saw that architectural decisions in one project had implications for other projects, leading to frequent meetings among the architects to coordinate across projects. Further, a crucial issue for all architects was related to the fact the data stored by the various solutions overlapped. Important decisions that had to be taken, then, was which solution should be the official source of which data and rules relate to which data in which solutions should be updated when the "master solution" is updated. The performed these tasks in close collaboration with the Integration Factory. This means that the role of the architects evolved from focusing on developing a holistic architecture "from scratch" following the TOGAF framework towards solving architectural issues related to the integration and management of larger numbers of solutions delivered by different vendors.

The Digital Renewal strategy had a very strong focus on individual applications. Integration of and information sharing between different applications is hardly mentioned at all, and definitively not addressed as an issue that matters. In our view, however, The Integration Platform and the Integration Factory have been absolutely critical elements in HSE's overall IT portfolio. They are key explanations why this portfolio of more than 5700 integrated applications work as well and evolve as smooth as they actually do. The Integration Factory and the Integration Platform has evolved more or less "under the radar" of the managers responsible for the Digital Renewals strategy. However, the combination of these two has worked as an important vehicle for managing the tensions between stability and change – it

has facilitated standardization and integration at the same time as it has enabled the modifications of individual solutions as well as innovation and the development and adoption of new ones.

4.4 Summary

Since the advent of computing within health care, new kinds of IT solutions supporting new kinds of work processes and tasks have continuously been developed and adopted, leading to a constant growth in variety of IT solutions and complexity of the overall portfolio. Since the late 1980-ies, managing this variety and complexity has been the key issue addressed by the various strategies. As the complexity has been growing, the strategies have since 2003 increasing been characterized by a one-sided focus on stability in terms of standardization and integration on the one hand and centralized control on the other. These strategies have failed to achieve its goals regarding integration and standardization at the same time as it has not addressed nor controlled innovation. This fact has become increasingly recognized within HSE the later years, and a new strategy focussing on balancing the tensions between stability and change is emerging. The dominant strategy during the 1990-ies also did so. The key element of that strategy was the development of standards, which, actually, turned out to be much more difficult than anticipated. The key difference between the strategy of the 1990-ies and the one we see emerging, is illustrated by the role played by the Integration Factory and the Integration Platform. The strategy followed during the 1990-ies was that when standards were agreed upon, the vendors would implement them, and then the solutions would be interoperable. Experience proved, however, that the settlement of standards was much more difficult than anticipated, at the same time as significant integration work had to be taken care of by user organizations even if the solutions were implementing relevant standards. These tasks have been the responsibility of the Integration Factory and supported by the Integration Platform. In addition to the technical integration work, managing security and access rights are important responsibilities for the Integration Factory.

5. Analysis and discussion

We will now analyse the evolution of HSE's strategies and the evolution of its IT solution portfolio and in particular the failures and achievements of Digital Renewal program

5.1 HSE's IT portfolio as a generative Platform-Oriented Infrastructure

We will now turn our attention towards concepts from and research on information infrastructures and platform ecosystems, and how they can contribute to an approach to the management of tensions related to large-scale and complex IT solution portfolios – in particular how they can help moving beyond the limitations of EA. We will emphasize the positive achievements of Digital Renewal, the lessons learned, and the crucial role of the Integration Factory and the Integration Platform. Based on these concepts, we will elaborate an interpretation of the overall portfolio as a Platform-Oriented Infrastructure that evolves through a mix of platformization and infrastructuring processes. We will do so by describe the different elements of the overall concept and how each such element emerged throughout our data collection and analysis process which took place in parallel with the evolution of the Digital Renewal projects and HSE's overall IT portfolio.

5.1.1 Information systems as platforms and platform ecosystems

Since Digital Renewal was launched, the concepts of platform and platform ecosystem have grown in popularity – among health care as well as IT personnel within HSE, in the whole health care sector as well as other sectors and the IT industry, and, not the least, among IS scholars. Within HSE and Digital Renewal the concepts of platform and platform ecosystem

was most explicitly and extensively adopted in the MediCloud project. MediCloud evolved towards a focus on enabling new software solutions to interact with existing (mostly large scale) applications similar to the interactions between apps and platforms, and between app developers and platform owners, in platform ecosystems, i.e. conceptually consistent with Ghazawneh and Henfridsson's (2013) boundary resource model of platforms as illustrated in figure 1. The Research and Innovation Platform, for instance, was developed based on this view.

When looking at (large scale) applications, like for instance Electronic Patient Record systems, from a platform perspective, we see that they include more than just a platform core and boundary resources that give other applications access to the patient record system's data. Such solutions also include a range of functions available to users, normally implemented by a number of rather separate modules, i.e. user clients, that may be seen as apps accessing the platform. This implies that a large-scale application can, in a technological sense, be seen as structured like a platform ecosystem in itself.[18] This model of applications is illustrated in figure 3.

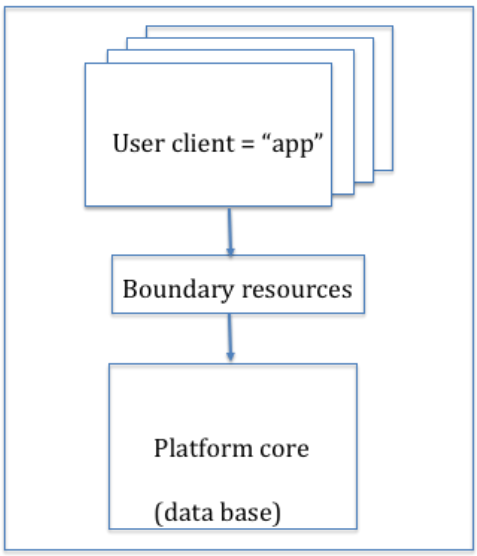

Figure 3: *Applications (silos) seen as platform ecosystems*

The 65 applications that were integrated with the ERP solution during the implementation of DIPS at Oslo University can, according to this model, be seen as 65 apps accessing the DIPS platform core through DIPS' boundary resources.

5.1.2 Multiplicity of information systems, multiplicity of platform ecosystems

The health care sector, as most sectors, is populated with a huge number of applications. Most applications are exchanging information with others in various ways. This means that, if we see the IT solutions as platforms, the overall portfolio of IT solutions can naturally be seen as an infrastructure composed of a multiplicity of platform ecosystems. In this infrastructure, many apps, including user clients of silo systems, will access a number of other of platforms (i.e. the platform core of silo systems). The patient logistics solution at Østfold Hospital is a god example of this.

All interactions between different solutions within HSE take place through the Integration Platform which provides the various apps with appropriate and coherent resources to interact

[18] This means that the software product is delivered by its vendor as a platform combined with a basic set of apps just like iPhone and Android phones.

with the totality of vendor platforms within an organization at the same time as it takes care of security and access control issues, i.e. it is playing the role of a shared boundary resource towards all individual platforms. This boundary resource takes care of both roles described by the Ghazawneh/Henfridsson model: resourcing and securing. The securing gives the HSE, and user organizations in general, control over which resources each user client get access to and under which conditions, i.e. securing the totality of vendor platforms. Securing was facilitated by the Integration Platform's API Gateway and IAM modules.

The Integration Platform interacts with the individual platforms through their boundary resource. Accordingly, we see the Integration Platform as an example of what we call an *organizational boundary resource* while we call the platform part of an application (provided by a vendor) *vendor platform* composed of a *vendor platform core* and *vendor boundary resource* respectively. This model is illustrated in figure 4.[19]

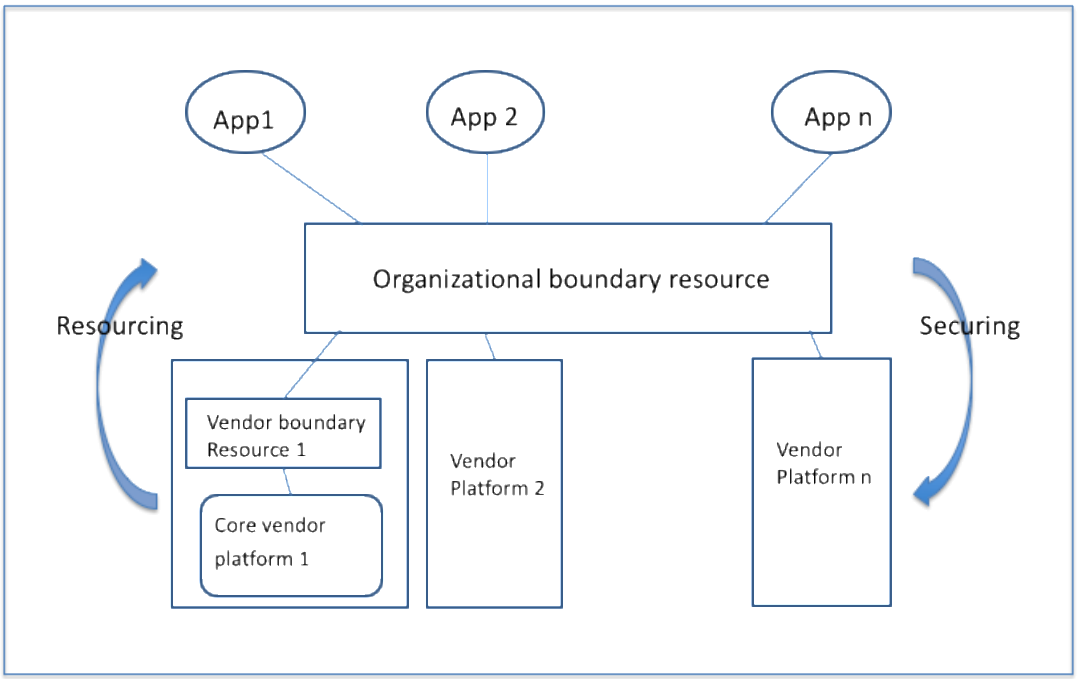

Figure 4: *The role of organizational boundary resources in multi-platform infrastructures.*

5.1.3 Multi-level platforms and multi-level boundary resources

Currently, most of HSE's IT solutions belong to and are used by one hospital enterprise only (several of them different configurations of the same software product though). This means that most (vendor) platforms are today found at the hospital enterprise level, while the consolidation strategy can be seen as aiming at establishing regional (vendor) platforms (and also standardized user clients for all users within the region). While the original consolidation strategy failed, the change towards development of APIs providing access to all EPRs and radiology solutions within HSE represents, then, and alternative strategy to consolidation and

[19] The user clients of an application (silo) will usually be tightly integrated with its data base, i.e. it will access its data base without going through the boundary resources used by other user clients. Further, while the total portfolio of IT solutions in an organization is dominated by applications, there will also be some "pure" user clients that are only running on top of platforms provided by other vendors while there may also be some "pure" platforms that provided by vendors without any user clients. An example of the latter from our case is a multi-media platform that stores data produced and retrieved by all user clients operating on multi-media data in the organization while the patient logistics solution at Østfold Hospital is an example of the former.

the establishment of shared regional solutions in terms of *regional platforms*. The Summary Care Record, ePrescription, and national registers, etc. are also seen as *national (vendor) platforms* (where the actual vendors are in fact different government agencies). The 13 instances of the Integration Platform, then, represents one organizational boundary resource for each of the 11 hospital enterprises for accessing the hospital enterprise platforms locally, one for accessing regional platforms, and one for national platforms. This is illustrated in figure 5.

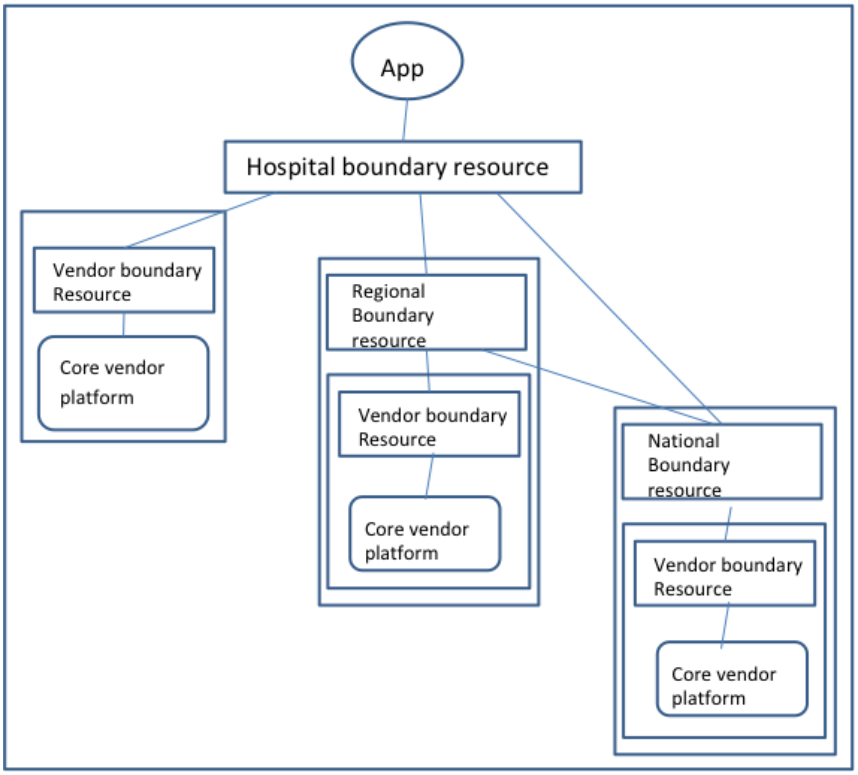

Figure 5: *Multi-level platform-oriented infrastructure*

5.2 Platforms, infrastructures and platform-oriented infrastructure

We call a portfolio of IT solutions integrated in line with the model above a *Platform-Oriented Infrastructure*. Such an infrastructure shares many features, quite naturally, with platforms, platform ecosystems, as well as infrastructures. They can be seen as consisting of a high number of connected and overlapping (i.e. infrastructured, see below) platform ecosystems.

We have called an instance of the Integration Platform an organizational boundary resource. This means that we see the totality of an organizational boundary resource and the vendor platforms it gives access to as an organizational platform and correspondingly the combination of an organizational platform and the apps accessing it may be called an organizational platform ecosystem.

In the IS research literature, two aspects of has been focussed: as an on-line market place (a two- or multi-sided market); or an architecture, combined with a governance structure, to manage a software system extended by third parties. In our case, seeing HSE's portfolio of IT solution as a platform-oriented infrastructure is primarily a strategy (and architecture/governance configuration) for managing Health South-East's total IT solution portfolio, in particular enabling and managing the required flow and sharing of information between applications delivered by different vendors. It is also a strategy for managing the

complexity and evolution of existing applications at the same time as further innovations, for instance based on lightweight technologies, are supported. The latter issue, then, means that the platform established in terms of the various boundary resources (the Integration Platform) plays both roles focused in the IS literature: it represents both a way of allowing third parties to develop add-ons, and it that sense it also established a (kind of) market place for developers of new software and users.

The "boundary resources model" (Ghazawneh and Henfridsson 2013) fits perfect to our purpose. While in the case of traditional platforms, the boundary resources are a part of the platform developed and controlled by the platform owner, within user organizations, like in our case, it is crucial that the user organizations also have control over the boundary resources made available for third party developers. Regarding resourcing, the boundary resources provided by platform vendors (vendor boundary resources) are too complex and inadequate for many app developers. At the same time, to manage the overall portfolio of applications properly, it is essential that app developers and apps are provided coherent boundary resources towards several vendor platforms. Securing is an even more crucial issue. Which data and services an app gets access to must be controlled by the user organizations and not only by vendor platform owners.

A distinction between platform ecosystems and infrastructures focused in the IS literature is the fact that platforms are owned and controlled by one single organization, while infrastructures are not. Further, platform ecosystems are, in the research literature at least, seen as separated from each other, while infrastructures usually come in multiplicities, i.e. they are layered upon as well as connected to each other. In our case, HSE as a regional authority is a key actor. However, the individual hospitals still have significant autonomy, for instance when it comes to how they perform their diagnostic and treatment services. In addition, HSE has to collaborate with national authorities and agencies, primary care institutions, not to mention all IT vendors.

Wikipedia provides a definition of infrastructure which is god example of how infrastructures are understood in general: "Infrastructure is the fundamental facilities and systems serving a country, city, or other area, including the services and facilities necessary for its economy to function."[20] HSE's IT portfolio is obviously in line with this definition. It is indeed a fundamental facility. And, this definition points to an important distinction between platform ecosystems and infrastructures: a platform ecosystem is a business model or strategy for organizing some innovation or value creation activities (Jacobides at al. 2018, Autio et al. 2018), while the purpose of an infrastructure is to serve all members of a society or some economic activity. In our case, HSE's IT portfolio may be seen as having some similarity to a marketplace for patient information sharing, but it is definitively not. First of all, patient information is not traded. It is rather the straight opposite: medical personnel are obliged to register and make information available for others at the same time as they also are obliged to access and use relevant information in their work. For these reasons, in our view, HSE's IT portfolio is primarily an infrastructure, at the same time as its development and operations are organized according to a platform ecosystem model - it is a platform-oriented infrastructure.

5.3 Managing tensions in platform-oriented infrastructures

The emerging platform-oriented architecture-governance configuration in the case reported here embeds a strategy for managing the tensions shaping the evolution of an infrastructure

[20] https://en.wikipedia.org/wiki/Infrastructure

similar to that of platform ecosystems. In the case of platforms like Android and iPhone/iOS, tensions between stability and change are managed by including what is or may be stable in the platform core and unstable elements are located "at the periphery" as apps; the platform is centralized controlled by the platform owner while app developers develop their apps autonomously; etc. On a rather abstract level, the case reported here is similar. The various vendor and organizational platforms are in general rather stable while the user clients are more unstable. What we have observed, however, is that data structures are rather stable and can be organized into shared platforms while the functions supporting user procedures and work processes are less so and should be organized into separate "apps." But also, platforms change. This happens partly as the vendor add new features and functions to its platform, develop a new version of the platform, or, more significantly, when the user organization decides to replace, for instance, their patient record or lab system with new ones delivered by another vendor.

In our case, however, the role the multi-level boundary resources are playing makes a difference compared to cases like Android and iOS/iPhone. First of all, the organizational boundary resources may also be stable. Actually, we see them as the most stable elements of platform-oriented infrastructures! For instance, they will to a large extent be based on national or international standards and such standards are changing very slowly.

A platform-oriented architecture also represents a quite powerful and flexible tool for managing the tensions between standardization and uniformity on the one hand and variety and local adaptation on the other. IT support for work processes unique for one hospital, for instance, is implemented as a part of a hospital platform while what is equal for all hospitals within a region or a nation is located as a part of a regional or national platform. While data structures in general are more uniform and stable than work processes and the functionalities needed to support them, also some user clients can be rather stable and shared among all hospitals.

Just as in the case of traditional platform ecosystems, the structure of platform-oriented infrastructures also reflects how related activities are organized and governed. But because platform-oriented infrastructures are more complex, so are also their organizational and governance structures. While vendors normally have the property rights of their software, the actual installations are controlled in various collaborative and contractual arrangements between vendors and user organizations. Further, the user organizations that share a solution, whether this is a platform or an app, have to manage the solution collectively involving the organizations constituting the unit (hospital enterprise, region, national) sharing the solution. This is so partly because of the complexity of the health care sector, but also for legal reasons. According to Norwegian legislation each individual hospital is legally responsible for the treatment they are giving to patients and also the quality and management of their patient information (Fossum et al. 2019).

The organizational boundary resources play an absolutely crucial role in giving the user organizations control over their platform-oriented infrastructures. In our case, these boundary resources, the Integration Platform, are primarily controlled by the central IT organization, Hospital Partner. The organizational boundary resources are the "heart" of the infrastructures linking all vendors and user organizations together. Hence, the boundary resources have to adapt to and fit the vendors' and users' needs – they have to evolve in a "distributed tuning" (Eaton et al. 2015) process.

The concept of Platform-oriented infrastructures represents a strategy for combining Agile and EA. It does so not fusion them into one single universal strategy, but rather by establishing a "division of labour" between them based on a recognition of the fact that everything is not or does not have to be equally dynamic. An Agile approach is, then, appropriate for developing apps supporting new and innovative services while architectural issues will be in focus in managing the totality of vendor platform in an organization – decide on the role of each platform where they overlap, their integration, and establishing coherent and consistent organizational boundary resources.

5.4 Platformization and infrastructuring

Research on both platform ecosystems as well as infrastructures tends to assume tensions to be stable (Tilson at al 2010, Tiwana 2013, Lyytinen et al. 2017; Ghazawneh and Henfridsson's Henfridsson and Bygstad 2013). In our case, however, we have seen that tensions change over time. Accordingly, there is a need for an approach that also addresses stabilizing and destabilizing processes (Henningson and Hanseth 2011; Hanseth et al. 2019). The overall focus and aim of the Digital Renewal program were to replace different local systems with shared regional ones. When the program started, the hospitals had fairly stable EPR, lab and radiology solutions as well as work processes aligned with the solutions. Starting developing and implementing regional solutions implied, then, destabilizing existing solutions and processes, then establishing new ones and stabilize these. How challenging such a change will be depends on the variety and total complexity of systems and processes involved. For instance, experience so far shows that the variety among PACS systems, supporting storage and retrieval of images, and work processes related to these is modest and establishing both a regional PACS platform as well as a PACS user client demands only a modest effort. The variety among the overall work processes within the radiology domain as well as the solutions supporting these is, however, much, much bigger. Accordingly, replacing all existing local Radiology Information Systems, supporting work processes in radiology departments, with a regional one seems to be huge task that will take a long time – at the best. We find it quite likely that the variety within the radiology domain will or should stay at a quite high level because of the differences among the departments in terms of size and range of examinations. On the other hand, we believe a significant part of patient data stored in RIS systems could be standardized across the region, and accordingly a regional RIS platform could be established while the RIS user client, i.e. the functionality supporting the radiological work process should remain local. This would, then, be a strategy very close to the one the Digital Renewal program is adopting regarding EPR systems.

We see, then, that tensions related to the evolution of infrastructure are not static, but interacting and dynamic. Managing tensions, for instance by increasing the degree of standardization and reducing variety, decreasing autonomy and increasing centralized control, reducing modularity and the degree of integration, requires a dynamic approach where multiplicities of tensions are managed through a multiplicity of destabilizing and stabilizing processes. This is a rather different picture from the rather static approach to tensions reported in the infrastructure and platform literature so far (Tilson at al 2010, Tiwana 2013, Henfridsson and Bygstad 2013). And we see the multi-level platform model presented in this paper as a specific architecture-governance configuration that represents a powerful model for managing such dynamics of tensions in order to make a corporate infrastructure evolve is required directions.

6. Conclusion

In this article we make four contributions to IS research. First and foremost, we theorize from our case developing the concept of Platform-Oriented Infrastructure as an architecture-governance configuration as a framework for managing complex and large-scale portfolios of IT solutions in complex organizations. This framework recognizes tensions a critical issue in the management of such portfolios, and that tensions are managed through architecture-governance configurations. Further, the framework recognizes the fact that tensions are dynamic and changes over time. Hence, the specific architecture-governance configurations of Platform-Oriented Infrastructures need to be dynamic as well. They evolve through processes of platformization and infrastructuring. In other words, Platform-Oriented Infrastructures evolves through cultivating the installed base.

The multiple layers of platforms incorporating a multitude of vendor platform and the role of organizational boundary resources between apps and vendor platforms are the key characteristics of this concept. The organizational boundary resource enables user organizations to control their infrastructures and make them evolve in a coherent manner at the same time as they get the benefits from the individual vendor products in the market place. We also believe the platform-oriented infrastructure concept portrayed here can successfully be seen as generally valid for large-scale distributed corporations at large. IS research literature has described organizations in many different sectors with IT portfolios and challenges having much in common with that of Health South-East. This includes companies in the oil sector (Hepsø 2009), financial industry (Gregory et al 2018; Bygstad and Pedersen 2012, Osei-Joehene and Ciborra 2000), and the media sector (Saastad 2017; Lindskov 2016). It is a fact that most of the world's digital infrastructures looks much more like the Health South-East silo architecture than the clean-cut platforms of Apple or Airbnb. We therefore believe that the platform-oriented infrastructure concept portrayed here can successfully be seen as generally valid for large-scale distributed organisations at large. We believe our concept of platformization shows a way forward for organisations in similar situations, and that the emerging platform-oriented strategy appears to be powerful both in terms of enabling a more controlled future evolution of the infrastructure and a smooth path to the new architecture.

Second, we contribute to EA research and Agile by demonstrating the fact that both lack of awareness of the tension between stability and change, which fundamental to the management of larger IT solutions and the portfolio of such, and accordingly their lack of "tools" for dealing with this tension. Further, we illustrate how the concept of Platform-oriented infrastructure combine Agile and an architectural by establishing a "division of labour" between them.

EA's blindness for tensions, which are ubiquitous in complex portfolios of IT solutions, and hence EA's lack of tools for dealing with them. Further, our concept of Platform-Oriented Infrastructures can be seen as an alternative to exiting EA frameworks like TOGAF, and, accordingly, an important addition to exiting EA frameworks.

Third, we make contributions to research on platforms and platform ecosystems. We do so by demonstrating how these concepts can successfully be applied within organizational contexts, adding to the research by Rolland et al. (2018) and Gregory et al. (2018). Gregory et al. (ibid) describe how the IT solutions portfolio of the bank is transformed, in the bank's own terminology, into a (single) platform offering services to their customers. This platform is, actually, described as a three-layered ecosystem consisting of what they call an infrastructure,

consisting of the core banking systems, a set of services, and a "glue," linking the infrastructure and services layers. This means that what they call a platform corresponds perfectly Ghazawneh and Henfridsson's (2013) boundary resources model. What we do in this paper then, is to give a far more detailed description of how the IT solutions portfolios of large organizations may be organized according to such a model, how existing portfolios, can be transformed to fit the model, and how they can continue evolving.

We also contribute to platform research by describing how platforms and platform ecosystems are integrated into information infrastructures. In doing so, we point to an important gap in IS research on platforms. This research is based on a focus on individual platforms and platform ecosystems as isolated phenomena. In reality, however, platforms are connected to each other. For instance, all on-line shopping platforms are integrated with payment platforms. Another example of this is programmatic advertising, were a large number of platforms are tightly connected and interacting (Alaimo and Kallinikos 2018). To our knowledge, there is no research on how platforms and platforms ecosystems are integrated and their impact on each other's evolution. Such research is in high demand.

Finally, we contribute to information infrastructure research in demonstrating how they can be composed of a multiplicity of interacting platforms and platform ecosystems. In doing so, we demonstrate the power of one specific architecture-governance configuration composed of integrated platforms and platform ecosystems for managing tensions in infrastructures.

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