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PLATFORMIZATION, INFRASTRUCTURING AND PLATFORM-ORIENTED INFRASTRUCTURES. A NORWEGIAN E-HEALTH CASE

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Platformization, Infrastructuring and Platform-oriented Infrastructures. A Norwegian e-Health Case

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Abstract:
The degree of complexity of the portfolio of ICT 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. Building on current research we suggest a framework for a promising approach; *a platformization process. Our research question is*, *how can a platform-oriented architecture/governance configurations help managing tensions between stability and change in the evolution of corporate infrastructures?*
The empirical evidence is a multilevel study of a large e-health initiative in Norway, where we analyse an emergent platformization process. We offer three contributions; first we give an outline of the key elements of a platformization strategy, second, we propose a new platform-oriented infrastructure configuration, and third we show how a multi-level configuration can resolve the inherent tensions of corporate infrastructure evolution.

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1. Introduction

The degree of complexity of the portfolio of ICT solutions within organizations has been continuously growing since the advent of computing. Currently, large organizations have typically hundreds, if not thousands, of applications running – each being integrated with a number of other applications 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, IT Governance models, TOGAF, ITIL, etc. have been developed and adopted.

However, the results have often been disappointing – making some argue that Enterprise Architecture, for instance, is "completely broken" (Bloomberg 2014). Some researchers have argued that radically new concepts and approaches are required (Northrop et al. 2006; Hanseth and Ciborra, 2007; Sommerville 2012). A significant part of this research sees complex portfolios of integrated IT solutions and the organizations developing and operating them as information infrastructures. Hanseth and Lyytinen (2004) call such portfolios of integrated IT solutions within single organizations *corporate information infrastructures*[1] (here called *corporate infrastructures* or *just infrastructures*).

Information infrastructure research has focused on issues like how their evolution is driven by the nature of their complexity and how existing constellations of technological and organizational arrangements - the installed base - shape infrastructures' trajectories. Recently, more focus has been directed towards how the evolution of infrastructures are driven by various *tensions*, like those between standardization, integration, centralized control and stability on the one hand, and variety, flexibility, modularization, autonomy, and change on the other, and how such tensions are outcomes of specific combinations, or configurations, of architecture and governance structures (Lyytinen et al 2017; Rodon and Hanseth, in review).

Emerging complex socio-technical arrangements have also been researched under the label of platforms or *platform ecosystems*. 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 they evolve and grow over long time. What makes platforms different from infrastructures in the way they are portrayed in the IS research literature is the fact that platforms 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 app developers. Although the architectural principle of splitting a platform ecosystem into one stable core and a

[1] This is one of three categories of infrastructures they identify, the others being business sector infrastructures (for example an infrastructure supporting a supply chain in car manufacturing), and universal service infrastructure (like for instance the Internet).

dynamic periphery made up of a (growing) number of apps 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 combinations of architectures and governance structures at more detailed level (Tiwana 2014; Wareham et al. 2014, Rolland et al. 2018).

Research on platforms, as well as the wider interest and public discourse, 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. An important example of this is SAP, which has succeeded in growing a large ecosystem of apps and app developers around their ERP software (Wareham et al 2014). In parallel with this we have experienced a change in how many user organizations talk about their IT solutions - large-scale applications are now often called platforms. So far, however, research on the role of platforms in organizations is lacking (with Rolland et al. (2018) as a notable exception).

Even though most platforms are connected and operate together with others[2], platform research has also focused only on individual platforms in isolation from each other. Larger organizations have hundreds, if not thousands, of IT solutions where each of them is integrated with many others. (The organization presented in this paper has recently counted their solutions and identified 5.700 different ones.) So if many IT solutions are changed to become mere platforms, within larger organizations there will be a huge number of such platforms integrated with each other. This makes research into how to integrate and manage the co-evolution of a multiplicity of platforms within an organization, which we will call a *platform-oriented corporate (information) infrastructure*, an important research issue.

The specific architecture/governance configuration of platforms (i.e. a central platform governed by a single corporate owner, as the centre of an app ecosystem with numerous apps in the periphery, where the app development are controlled in by distributed structure of autonomous app developers) has proved to be very powerful for managing tensions in ecosystems around individual platforms. Based on this we will in this paper explore how platform-oriented architecture/governance configurations can be utilized to manage the tensions involved in the evolution of large-scale corporate infrastructures.

We see the various tensions addressed in the infrastructure literature as closely related. We see integration, centralized control and standardization as presupposing stability while modularization, autonomy, and variety facilitates change. Accordingly we see, in line with Farjoun (2010), the tension between stability and change as the fundamental one. This leads us to a more specific research question:

[2] Programmatic (or personalized) advertising where media organizations' publishing platforms are connected to so-called supply side platforms that again are connected to demand side platforms (used by those buying space for advertising) through ad exchanges. Through the interactions of these platforms real time auction processes are taking place.

> *how can a platform-oriented architecture/governance configurations help managing tensions between stability and change in the evolution of corporate infrastructures?*

We will address this research questions through a longitudinal case study of the evolution of the infrastructures 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)) over a period of 5 years (2012-2017). Our contribution is an extension of the current infrastructure and platform research, where we show that the insights from both fields contribute to understand and theorize more complex structures than pure platform ecosystems. 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 infrastructure 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 applications 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[3].

2. Related Research

As mentioned above, infrastructures and platform ecosystems share the characteristics of evolving and growing over long time, and include or involve a huge number of technological components as well as organizational and individual actors. In the IS literature there are two definition of platforms frequently cited. Tiwana et al. (2010, p. 675) define software-based platforms, defined as "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate." This definition, then, focuses on a platform as an architectural construct where the whole ecosystem is split into a stable core and a dynamic periphery of apps. In addition, this definition also represents an organizing principle or business strategy for attracting third parties to extend and enhance and expand a vendor's software system, i.e. expand its user base.

Parker et al. (2017) define a platform as "a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and sets governance conditions for them. The platform's purpose is to consummate matches among users and facilitate the exchange of goods, services, or some sort of social currency, thus enabling meaningful value exchanges between all participants." This definition sees a platform as an on-line marketplace, typical examples being PayPal, Über, Airbnb, and mobile payment platforms. These platforms are not, however, extensible codebases. On the other hand, some popular and platforms satisfy both definitions. Android and iOs/iPhone can be extended by apps developed by third parties and represent in that way also open marketplaces where app developers can sell and app users can buy apps.

[3] 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 o fusers in infrastructuring processes.

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] Infrastructures are seen as complex socio-technical systems that are developed, operated and used by larger numbers of vendors and heterogeneous users groups, where neither the development activities, nor the use are controlled by one single actor while platform ecosystems are seen as controlled by a platform owner/controller.

We will below review IS research on the evolution and growth of platform ecosystems and information infrastructures, how their evolution is shaped by tensions which again are shaped by specific architecture/governance configurations.

2.1 Evolution of infrastructures and platform ecosystems

Network effects (or externalities) creating self-reinforcing processes are widely held to be at the centre of infrastructure evolution. Such network-effects are generated because the value for users of an infrastructure depends on the number of users, i.e. the size of the network. Henfridsson and Bygstad (2013) identify three different self-reinforcing processes through which infrastructures evolve: innovation, adoption and scaling. Innovation means extending an infrastructure with additional services, adoption points to growth of new users, while scaling denotes the integration of more partners and applications into the infrastructure; Drawing upon critical realism, Henfridsson and Bygstad (2013) theorize these three processes as mechanisms driving infrastructure evolution. Self-reinforcing processes (or mechanisms) like these three work for already established infrastructures. However, the role of network-effects has broader implications for infrastructure evolution. Hanseth and Lyytinen (2010), for instance, argue that such effects create two important design problems that they call the take-off and the adaptation problems respectively. The first problem points to the fact that when the value for users of an infrastructure depends on the number of users; it has very little value for the first user. This creates challenges regarding bring the first users on board and establishing an initial situation where self-reinforcing mechanisms start driving the further evolution. The processes leading to this situation has been described as the bootstrapping of an infrastructure (Hanseth and Aanestad 2003; Hanseth and Lyytinen 2010; Skorve and Aanestad 2010; Rodon and Chekanov 2014). The adaptation problem points to fact that complex systems where network effects are present often evolve towards a state where they are locked-in (Arthur 1989).

Turning to the evolution of platform ecosystems, most research sees this as a process of growth in number of apps running on a platform or the adoption of a platform by a growing user base (Tiwana, 2014, Parker et al. 2016). As in the case of research on infrastructure evolution, network-effects are considered central to the evolution of platform ecosystems. In particular, research focusing on the interdependencies and network effects between different groups related to a platform has become popular (Rochet and Tirol 2003; Tirol 2017; Parker et al. 2016). This research mostly draw upon theories of two- or multi-sided markets to describe and analyse self-reinforcing processes where the availability of apps attract more users to a platform which again attract more

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

developers to develop which again attract more app developers. An example is Uber; as more car owners making offering their services through Über, it attracts more taxi users to book services through Uber, which again attract more car owners, and so on.

Some research exists on the early phase of platforms' history. Islind et al (2016), for instance, have inquired into the initial development of a platform while Evans and Schmalensee (2016) have explored conditions determining whether a platform reach critical mass and its self-reinforcing diffusion process "ignites," similar to the bootstrapping infrastructures. In addition, Helmond (2016) has analysed how applications are modified in order to become "platform ready," i.e. adapted so they can share information with platforms like Facebook.

Platform research within IS has also elaborated further on the concept of platform by making a distinction between the core platform and its *boundary resources.* Boundary resources determine how apps can interact with the platform core (Ghazawneh and Henfridsson 2013). This conceptual split of the platform core and its boundary resources has triggered research into the separate evolutionary paths of these two. While the platform core still is seen as stable and strictly controlled by the platform owner/controller, it does change. It changes in terms of growth of functions, both also in more radical ways, for instance in terms of incorporating one platform into another a process, which Tiwana (2014) calls envelopment. Platforms' boundary resources are evolving along trajectories shaped by interactions between the platform owners and their users and app developers in a process Eaton et al. (2015) call distributed tuning. This process involves a mix of activities from app developers' direct requests to platform owners for new boundary researches to "jailbreaking."

2.2 Tensions

In addition to network effects, scholars within both the infrastructures and platform research domains elaborate on the idea of tension as a conceptual lens towards understanding evolution (Edwards et al. 2007; Reimers et al. 2014; Tilson et al. 2012). 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). Ghazawneh and Henfridsson (2013) see this tension related to their model as a tension between resourcing and securing.

Infrastructure research has focused on a broader range of tensions involved. Examples include the stability brought by the installed base to enrol new actors and services versus the flexibility to leverage unbounded growth of actors and services (Hanseth et al. 1996; Tilson et al. 2010). Another example is the top-down demands for integration versus the persistent, bottom-up reliance on the installed base of systems and practices (Hepsø et al. 2009). A third example is 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). At a high level all these tensions are between stability and change in the evolution of large structures.

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.

2.3 Architecture-Governance Configurations

Research on how to deal with the tensions mentioned above has focused on the role of 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). 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 is also controlled in a distributed fashion, i.e. independently by the individual app developers. Tiwana et al. (2010) and Tiwana (2014), however, go 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.

Information infrastructures are not based on an 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.

This literature review reveals that platform ecosystems and infrastructures have a lot in common. It also reveals that, as stated in the introduction, in spite of the fact that many ICT solutions in use in organizational contexts are talked about as platforms, there is virtually no research on platform ecosystems within organizations. Further, it demonstrates that platform configurations represent a specific and widely successful way of managing the tensions between stability (and integration, centralized control, and standardization and universality) on the one hand and change (and modularization, autonomy and variety and adaptation to local needs) on the other. From this we conclude that research on how platform based architecture-governance configurations can help manage the evolution of corporate infrastructures is much in demand. To develop our argument we build on the concepts of platformization and platform oriented infrastructure.

3. Platform-oriented Information Infrastructure

We will here present our concepts of platformization and platform oriented (information) infrastructure. These concepts are primarily abstracted from our case. But our concepts also draw extensively upon Ghazawneh and Henfridsson's (2013) boundary resource model of platforms as illustrated in figure 1.

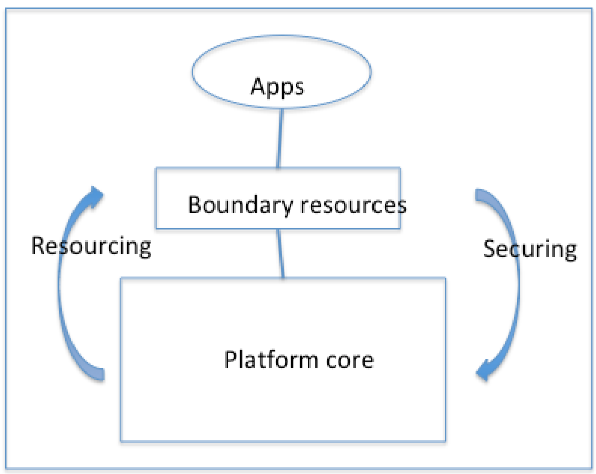

Figure 1: The Ghazawneh/Henfridsson platform concept

The health care sector, as most other sectors, is populated with a huge number of applications. Most applications are exchanging information with others in various ways. Applications can, then, be seen as composed of a database (and a set of basic operations upon this), which we can look at as a platform core, and a set of functions available to users that are implemented as one or more user clients. In addition applications provide a set of resources through which other application can exchange information with them, which we can see as boundary resources. This implies, then, that applications can be seen as platform ecosystems conforming to the boundary resources model. This model of applications is illustrated in figure 2. (Applications will be different from platform ecosystems in the sense that the user clients (or apps) may access the platform core without using the boundary resources available to other apps and that all components are controlled by the application vendor.)

A key feature of platform-oriented infrastructures is the fact that they are composed of a multiplicity of traditional applications sharing information. Many applications exchange information with a large number of other applications.

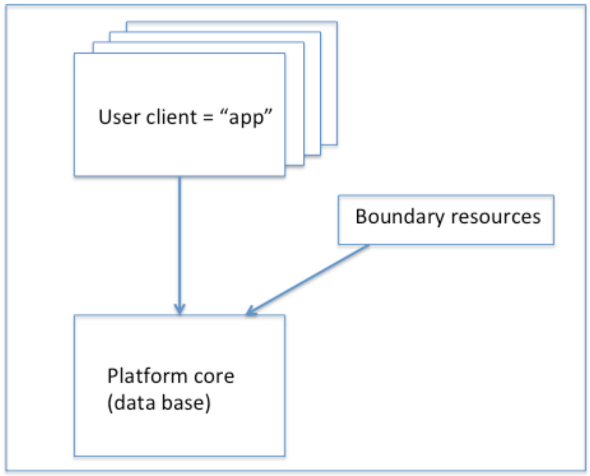

Figure 2: ***Applications (silos) seen as platforms***

Or in the language of the boundary resource model: user clients of many applications will access the platform core module of many other applications through these applications' boundary resources. This may be facilitated in a structured manner by the establishment of a separate layer, a separate boundary resource, on top of the individual applications' boundary resources. This layer may provide, then, a coherent interface for all user clients towards the totality of platforms of an organization. We call this 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.

Both resourcing and securing are critical aspects of the organizational boundary resources. Resourcing enable the provision of a coherent set of resources to user clients across all vendor platforms. Securing gives the organizations control over which resources each user client get access to and under which conditions, i.e. securing the totality of vendor platforms. This model is illustrated in figure 3.

The combination of vendor platforms and an organizational boundary resource on top of these we call an *organizational platform*.

The user clients of an application 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. This situation is illustrated in figure 4 using an Electronic Patient Record and a lab system as examples. 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 multimedia data in the organization while the Imatis solution (see section 5.3.5) is an example of the former.

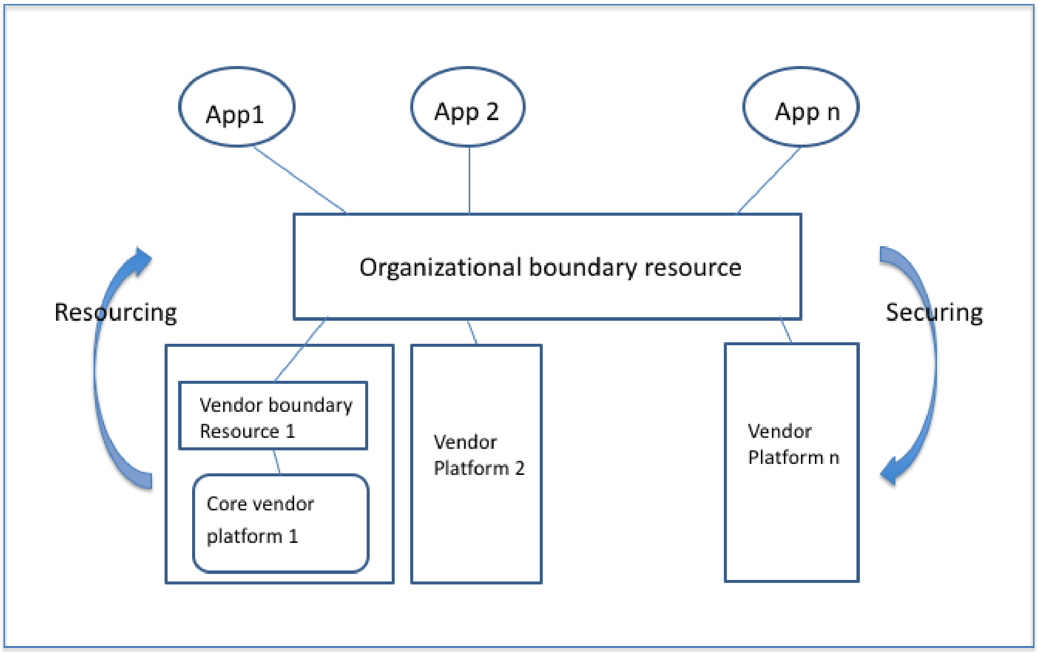

Figure 3: *The role of organizational boundary resources in multi-platform infrastructures*

Larger organizations usually have a hierarchical structure – sometimes based on functional domains, sometimes geographical areas. In our case there are three important levels in the hierarchical structure: hospital, regional health trust, and national level. On each level there may be organizational platforms, i.e. hospital, regional, and national platforms. The organizational boundary resources on one level may be connected to the organizational boundary resource on higher levels, i.e. a hospital boundary resource may access regional and national boundary resources while a regional boundary resource may access a national one. Individual user clients may in this way access platforms on all levels. This is illustrated in figure 5.

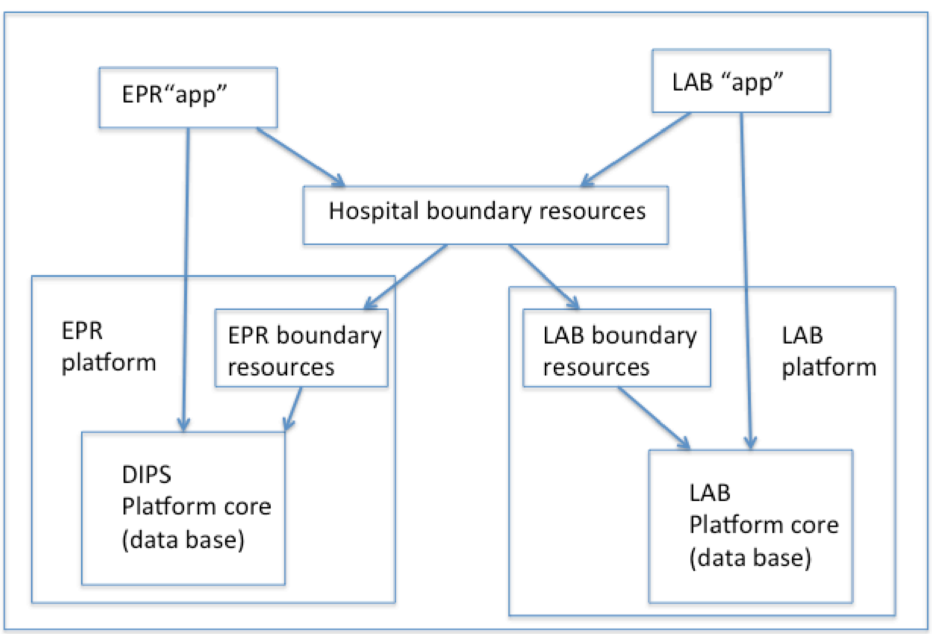

Figure 4: *Interactions between applications (silos) in a platform perspective*

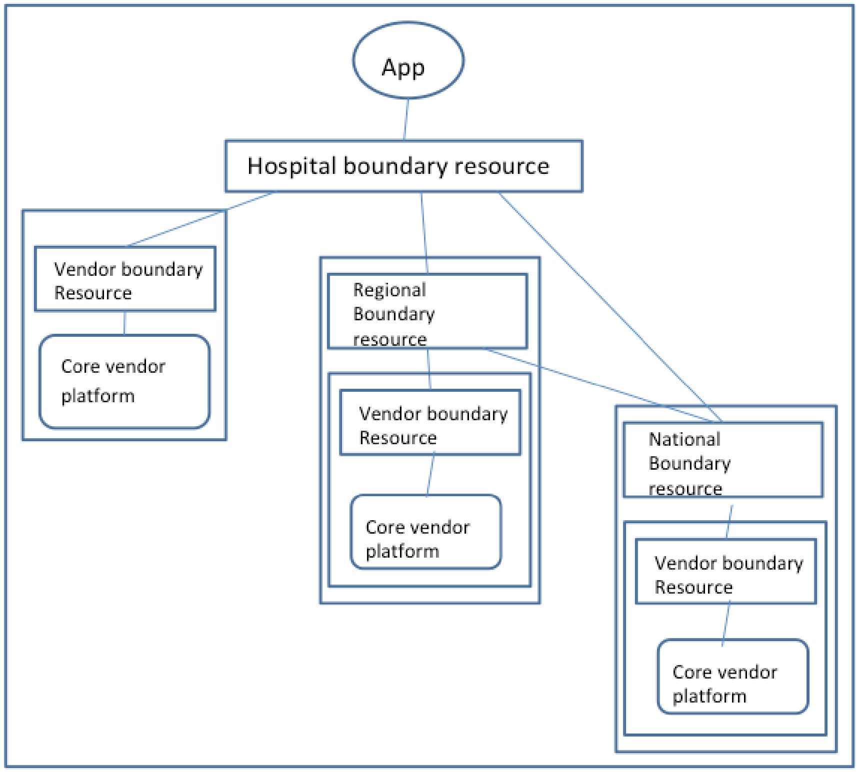

Figure 5: *Multi-level platform-oriented infrastructure*

4. Method

We develop our framework in the context of a particular class of corporate infrastructures: large scale e-health infrastructures. The reason for choosing this is that e-health infrastructures are extremely complex, both in terms of the clinical processes they support, and 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.

We chose a multilevel case study (George and Bennett, 2005) approach in order to investigate the evolution and transformation of a very complex application portfolio. We studied the governance and development of a national e-health infrastructure in Norway over a period of eight years (2009-2018), at three levels:

- *The national level:* we interviewed top executives and IT managers at the Ministry of Health and Directorate of Health, analysed plans and initiatives, and we followed the governance and development of the first national e-health service, the ePrescription solution in 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 medication and chart projects, and a separate initiative at Østfold Hospital.

Our starting point was the national policies for e-health, which was a salient public debate issue during these years and also presented some high-level IT governance and architecture issues. From there we selected the largest health region to investigate how policies were translated into IT strategies and governance structures, in the form of the Digital Renewal programme. In order to investigate how these initiatives unfolded into concrete projects and solutions, we selected the implementation of the key clinical solutions in Digital Renewal.

4.1 Data Collection

In dealing with our research question we carefully combined two perspectives: First, we interviewed top health and IT managers and enterprise architects on their ambitions and conceptualisations. Second, we followed the implementation of these plans by interviewing selected project managers, software developers, clinicians and specialists.

We focused on relational information; the co-operation of sub-projects, the communication with vendors, the relationship to the overall Digital Renewal programme, and the social and technical dependencies between different units. Data was mainly from two sources. First, we collected data by interviewing 77 informants, some of them twice. 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. Second, the sector was extensively documented with policy documents, regional policies, and project plans (feasibility study, main project directive, sub-projects directives), and project status information, such as status reports and on-going risk assessment. It was also well documented in technical terms, with a wealth of requirements specifications and IT architecture descriptions. See Table 1 below.

Level	**Interviews**	**Documents**
National 2009-15	*Ministry of Health*: Senior managers and executives *Directorate of Health*: Senior managers, E-prescription project managers and architects Consultants	Ministry of Health: White paper: “One citizen, one journal” 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 2013-17	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 1: Data Sources

4.2 Data Analysis

In multilevel analysis a key aspect is to understand the interactions between levels; in our case the interplay of national, regional and project levels. Following Hitt et al. (2007) we investigated top-down (management) influences and bottom-up (emergent) influences. Data were analysed in three steps (Miles and Huberman, 1994). First, we used the information from each informant and written documents to construct a chronology and rich picture of the programs, projects and their surroundings, and to document a case description. Second, we conducted a comprehensive analysis of the tensions of the case. As our concepts of platformization and platform-oriented infrastructure crystalized we then zoomed in on the issues related to integration of and information exchange between applications. This included, for instance, a focus on the tensions between a long time perspective (holistic architecture) vs. short-time priorities, identified through interviews with architects and project managers, were mitigated by platformization elements. Finally, we assessed the results within each area, and the overall results of the various integration efforts. See Table 2.

Step	Task	Output
Identify events and issues	Identify key events and issues in the data material, focusing on IT architecture and governance.	Case description
Analyse tensions and platformization	Analyse the tensions of the case, and reposition the study as the emergence of a platformization process	Findings section
Propose solutions	Propose an architectural and governance configuration	Discussion section

Table 2 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.

5. The Case: Transforming a Regional e-Health Infrastructure

We will here present our case – the transformation of the application portfolio, which we call an information infrastructure, of a health region in Norway. We will first present relevant national strategies and projects that the region has to follow and integrate with. Then we will describe the region's IT strategy and activities since about 2012 including some historical background information we find relevant. Finally we will describe the region's main IT projects since 2012.

5.1 National Level

Norway is a Scandinavian country with 5,2 million inhabitants who enjoy a high standard of living and public health services. The sector is governed by the Ministry of Health and Care, while the Directorate of Health is an implementing agency and health advisory. Primary care is supported by private GPs and municipal services. The hospitals are organised in 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.

Individual hospitals, first the larger ones, started experimenting with developing IT systems during the 70-ies. Until 2003, the hospitals were owned by the 19 different counties. As the number of applications started growing, some coordination across the hospitals within each county was taken care of by county administration. During the 1980-ies, the number of applications was reaching a significant level and with the emergence of communication technologies, a consensus about the importance of sharing information among applications within and between health care institutions was established. This triggered activities aiming at establishing standards for such information sharing – both at the national and the organizational levels.

In 2003 the government was taking over the ownership of the hospitals, organizing them into the four (initially five) Regional Health Authorities mentioned above in order to improve collaboration among hospital – also across county borders. All Health Authorities established central administrations, and local IT departments were merged into central IT organizations. All regions also reached the conclusion that the standardization strategy focusing on the information exchanged had not delivered. Fragmentation had increased rather then being reduced. So they all decided to standardize on applications: all hospitals within a region should implement the same EPR system, the same lab system, etc. Then sharing patient record information was assumed to be trivial. In addition to this, the Ministry of Health established a sort of committee, called National ICT, with representatives from the regions and the Ministry, for “strategic coordination” of ICT activities across the regions.

However, as the number of IT use areas increased and health care became more complex (due to more advanced medical services and increased specialization), more collaboration not only within but also across regions was required. This contributed to a growing consensus about the need to enhance data sharing at the national level. In 2012 the Ministry published a white paper “One citizen – one record” that called for a national solution where patient data should be available for clinicians regardless of geography or organizational level. In the same year the Directorate of Health established an IT division, growing rapidly to include in total several hundreds employees and consultants, with the responsibility for the national initiatives like the e-Prescription (implemented during 2012-16) and Summary Care Health Record (implemented 2014-17) solutions. Further, a large number of national registers were over the years established for monitoring and managing the health care sector on a national level. Examples include registers with information about all cancer patients, babies born, vaccines given, etc. In 2016 the Health Directorate’s IT division was turned into a new institution and the Directorate of e-Health was established to coordinate e-health initiatives at all levels. As a part of this the directorate also started to work on national policies and IT architectures.

5.2 Regional level: The South-Eastern Norway Health Region

The South-Eastern Norway Regional Health Authority (“Health South-East”) 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 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.

[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

We will here briefly describe the main elements in Health South-East's IT strategy and the evolution of its IT portfolio from its establishment until around 2012, then the situation as it was seen by the region's management at that time leading to a new strategy and an ambitious program called Digital Renewal. We will present this program and its status at the beginning of 2018. Finally we will describe the evolution of integration technologies and the organization of application integration activities.

5.1.1 2003-2012: Product standardization

Like the rest of the hospital sector, and as described above, the hospitals included into Health South-East had in the period before 2003 concentrated on the development and implementation of new applications supporting an increasing number of activities in the hospitals. It was assumed that the necessary information sharing among the applications would be taken care of by the vendors implementing defined and agreed upon standards. This long history of decentralized IT decisions had resulted in many individual well-working systems in each hospital, but also an extremely varied and fragmented portfolio of silo systems. So Health South-East concluded in 2003, like the other regions, that additional measures had to be taken to facilitate the required information sharing between departments and hospitals. The solution they decided to go for was to established a centralized IT governance structure and transfer all IT personnel into a new regional organization, Hospital Partner. Further, they concluded that standardizing the information to be exchanged was insufficient and that also applications should be standardized, i.e. all hospitals should implement the same like lab system, patient record system, patient administrative system, radiology system, etc.

During the period after 2003, in parallel with the effort aiming at standardizing applications, the implementation of new kinds of solutions (supporting activities not previously supported by IT) continued at a rapid pace, making integration and information sharing an increasingly more important as well as a more challenging issue. Around 2011 consensus was established 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. 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 high-level official 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 that 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*

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in 2003. After the merge, the IT personnel from the other regional organizations were transferred to Hospital Partner.

> *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 Health South-East 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. A new version of the strategy was approved by Health South-East's Board of Directors in December 2016.[7] This new version re-iterated the principles of the original one, the main difference being an even stronger focus on the main principles, centralization and consolidation of applications, and an extension of the time period for which the strategy should be valid for.

5.1.2 Centralization and consolidation: The digital renewal program

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, birth record system, and support for patient logistics.
- *Radiology:* Consolidating from several to one shared RIS/PACS8 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 solution with an enterprise system (SAP) and data warehouse.
- *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

[7] https://www.helse-sorost.no/Documents/Digital%20fornying/086-2015%20Vedlegg%201%20-%20IKT-strategi.pdf

[8] 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.

consultants regularly produced audits. The CEO of Oslo University Hospital, 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 program raised the level of ambitions regarding resolving the fragmentation problem. In the regional management jargon this was called tidying up the fruit salad (of systems). See Figure 6 below, showing the hospitals (vertical axis) and application types (horizontal axis), and different colours for different products.

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.

	PAS/EPJ	RIS/PASC	Medisinsk Biokjemi	Mikro-biologi	Patologi	Blodbank	Lønn/ Personal	Økonomi	Faktura-behand-ling	Innkjøp/ Logistikk	Kvalitets-håndbok	Avviks-hånd-tering
OUS	PasDoc DocuLive	Siemens Agfa / Sectra	Flexlab Swisslab Unilab	 Swisslab Unilab	DocuLive Patologi	Prosang	PAGA lønn Personal-portalen Web-cruter Lærings-portalen	Oracle Financials	Basware Visma E40	Clock-work Visma E40 Oracle Financials	Netpower	iKnow-base
AHUS	DIPS	Siemens	Analytix	Analytix	Doculive Patologi	Bloodcraft		Oracle Financials	Basware	Oracle Financials	EQS	EQS
VVHF	DIPS	Carestream Siemens	Flexlab Analytix	Miclis	Sympathy	Bloodcraft		Visma Enter-prise	Visma Enter-prise	Visma Enter-prise	Netpower	Synergi
SIHF	DIPS	Siemens	Analytix	Analytix	Sympathy	Prosang		Oracle Financials	Basware	Visma Enter-prise	EK	TQM
SØHF	DIPS	Sectra	Netlab	Miclis	Sympathy	Bloodcraft		Oracle Financials	Oracle Financials	IFS	EK	Synergi
SIV HF	DIPS	Sectra	Unilab	Miclis	Doculive Patologi	Prosang		Oracle Financials	Basware	Clock-work	TQM	TQM
STHF	IMX	Agfa	Flexlab		Sympathy	Prosang		Visma Enter-prise	Visma Enter-prise	Visma Enter-prise	EK	TQM
SSHF	DIPS	DIPS RIS / Sectra	Unilab	Miclis	Sympathy	Bloodcraft		Agresso	Agresso	Clock-work	EK	TQM
SunHF	DIPS		DIPS Lab			Prosang		Agresso	Agresso	Agresso	Netpower	TQM

Figure 6: *The "Fruit salad"*

After some time challenges emerged. First, 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. It included several new IT solutions, partly from the program portfolio, but also a large, solution for patient logistics, with touch-screens and mobile technologies. 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.

Further, while the various projects were organized in a classical way as independent projects, substantial interdependencies and coordination needs were confronted. For instance, due to the fact that there was no homogeneous infrastructure across the region, each project was responsible for establishing the infrastructure their solutions required. Many of the solutions would be used by overlapping user groups – accordingly they had to run on the same infrastructure. In addition, the various systems had to be integrated with each other. To address these challenges, the Regional Clinical Documentation, Lab, and Radiology projects were merged in 2015 and named the Regional Clinical Solution project. The projects were top-down controlled, but the coordination challenges also triggered a lot of mere ad-hoc lateral communication. For example, each sub program of Digital Renewal had an IT architect. After some time the architects agreed to meet every week to discuss current issues in the projects, but also more general topics. Informally, we also observed that employees from various sub-projects were engaged in discussions.

The Infrastructure project was, due to its importance and complexity, also taken out of the program and run independently by HospitalPartner. It was decided that the infrastructure should be outsourced and a contract was signed with DXC (formerly HP Enterprise). Early in the implementation phase, in May 2017, media reported that software developers in Bulgaria, in strong conflict with Norwegian privacy legislation, were giving access to patient data as part of their job of transferring existing applications to the new infrastructure. This triggered a major scandal leading to an immediate stop of the project as well as the firing of top IT managers of Health South-East, the program manager of Digital Renewal, and the managing director of Hospital Partner. Two new projects were established: one analysing how to proceed with the outsourcing project in a way that is in line with privacy regulations, and one analysing how to HospitalPartner could implement and operate a new infrastructure on their own. Both projects are still (May 2018) running. The outcomes are unpredictable.

This infrastructure scandal combined with the modest outcomes and rising costs of Digital Renewal, which will be described below, has brought more or less the whole Digital Renewal program to a halt and alternative strategies for its continuation are being discussed.

At the same time as the Infrastructure project and the Østfold Hospital activities were taken out of the Digital Renewal program, some new projects, like the procurement and implementation of a solution for chemotherapy, were included into the program. The growing interest in use of mobile technologies and Internet of Things in general triggered activities related to how to introduce and manage these technologies within the region's hospitals.

The most important Digital Renewal projects will be presented in section 5.3.

5.1.3 Integration strategies and technologies

Integration of information systems to facilitate information exchange and communication have been intended to be achieved through standardization since the late 80-ies. It was in the early days (implicitly) anticipated in the rationale behind the standardization efforts that when agreement about a standard was reached, the vendors would implement them according to their specifications, and then user organizations could install the applications and make them communicate through a simple "plug and play" process. Of course, it was not that simple. Over the years competing and overlapping standards have been developed – at national, European, global levels, etc. These standards turned out to be quite complex, so each vendor implement usually only a few of them, and also each standard is implemented only partially. Accordingly, lots of work has to be carried out the make two applications exchange the required information properly. And as the number of applications in use in hospitals was growing, the hospitals themselves had to take care of a growing part of the integration work.

Similar experiences made in all business sectors led to the development and implementation of various middleware products. Before the establishment of HospitalPartner, 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. The hospitals also hired architects to work on integration issues.

When Hospital Partner was established, they were taking over the responsibility for the operations of the middleware solutions as well as further integration work. An architecture section was established, counting about 20 people at the time Digital Renewal was launched. The architects have been involved in individual projects at the same time as they have tried to develop a coherent regional SOA based architecture. The latter activity has not materialized.

Personnel working with integrations became organized into a unit called the Integration Factory.[9] Over the years the middleware solutions in use as well as the additional integration software has been growing. All this was named the region's Integration Platform. During 2010/11 the Integration Factory worked out a roadmap for the future evolution of the Integration Platform. In line with this, and combined with additional needs emerging in various projects, the Integration Platform has been 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 service middleware product). Recently they have emphasized implementing new APIs based as far as possible on the PHIR implementation of the HL-7 standard. Currently (January 2018), the Integration Platform is being extended with a so-called API Gateway that in particular will control access rights of different users and apps. The overall architecture of the Integration Platform is illustrated in figure 7.

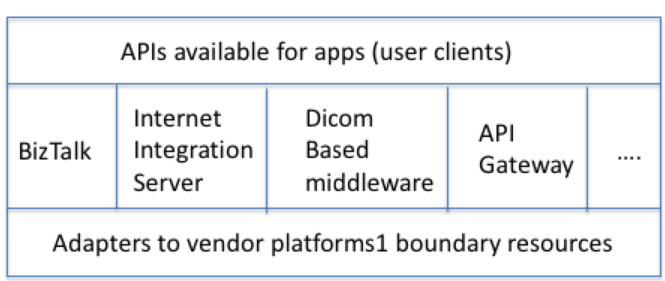

Figure 7: *The architecture of the integrated platform*

[9] The Integration Factory was renamed Integration Services during 2017.

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, bring the number of employees in the Integration Factory up to 40.

For both practical (or technical) as well as legal reasons the Integration Factory has developed one separate Integration Platform for 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, other regions, and primary care institutions (through Norwegian Health Network (NHN)) as illustrated in figure 8.

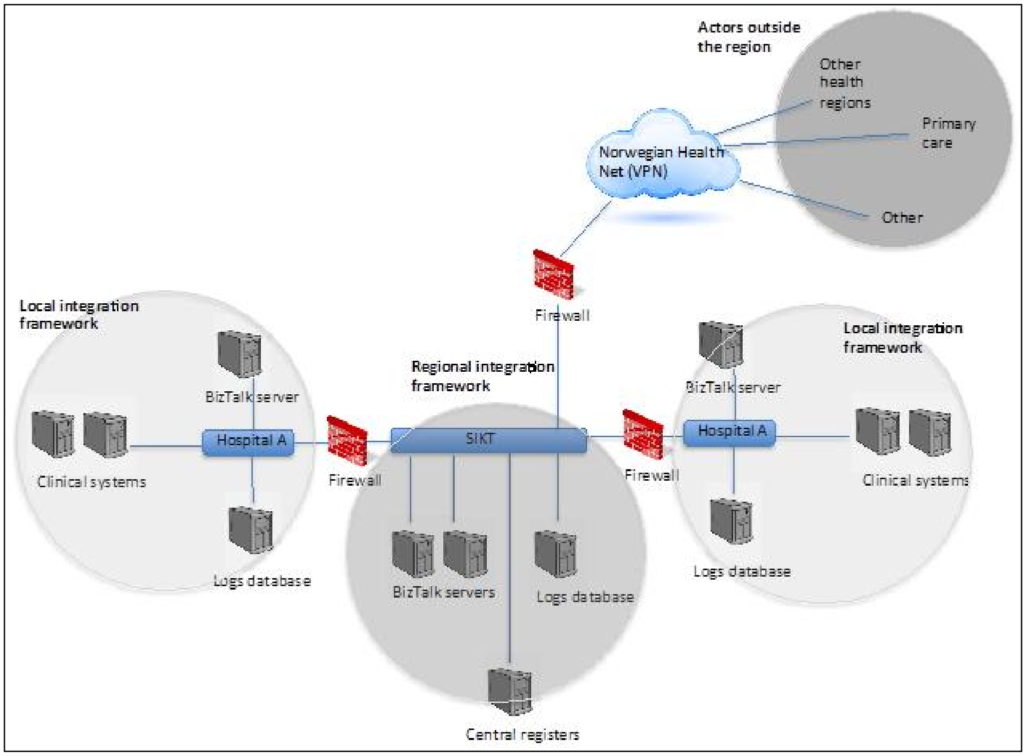

Figure 8: *Regional integration platform (source: Digital Renewal Programme*

The development of the Integration Platform has been, in our view, the key activity in the platformization of Health South-East's overall information infrastructure. The various components of the Integration Platform are playing the role of organizational boundary resources: 11 hospital boundary resources, one regional boundary resource, and one giving access to national platforms.

5.3 Project Level

We will now turn our attention towards the most important projects. For each we describe key aims, challenges met and responses to these, and outcomes (so far).

5.3.1 First project: Electronic patient record

All hospitals except Oslo University Hospital (OUH) were in 2012 using the DIPS EPR system (see "fruit salad," figure 6). A shared, consolidated, EPR solution was, then, planned as a two-step process: first implementing DIPS at OUH, then consolidate all DIPS installations into a regional one. Implementing DIPS at OUH was estimated to be the largest, and also the most important, project within the program, and accordingly the one given highest priority. OUH was the result of a merger of three hospitals in 2009.

The existing EPR systems had 12,000 users. The date for going live with DIPS was set to October 20th 2014. No additional functionality or adaptations were added, and only existing integrations between the existing patient record systems and others should be included in the project.

The budget was estimated to 685 MNOK (around 85 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, DIPS 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. The project delivered on both time and budget - on October 20th 2014 the new solution was successfully set into production.

The highest risks were assumed to be integration and data conversion. These were also the most resource demanding tasks. The integration risk was associated to technical complexity: 55 different systems should interact with the new EPR, through 345 interfaces. In order to mitigate the integration risks, the integration sub-project was in charge of all integration and worked closely with the Integration Factory who programmed the required technical modifications. Conversion included the technical conversion of large amounts of (about 2.5 M) patient records from the existing EPRs into the DISP data base and its structures.

The functionality of DIPS was not changed, but a number of services were improved through the Integration Platform: a major achievement was the successful implementation of one coherent interface, i.e. boundary resource, towards three different lab systems running in three different medical biomedicine labs. This made these systems look like a single platform seen from DIPS and the three physical labs appeared as one single integrated one as seen by the users. Clinical personnel could now order lab test from the DIPS user client and receive the results the same way. The same principle applied to radiology and a few other key services.

The general level of DIPS services, however, was perceived as relatively poor,[10] and some critics (both clinicians and managers) argued that large sums of money were spent on something that did not improve clinicians’ work.

In the following year (2015) the DIPS implementation was polished and some new integrations were established bringing the total number of integrated solutions up to 64 and the number of total physical integrations to about 350. At the same time, the effort to transform all the 11 different EPR systems into one consolidated installation started. Only the planning and estimation of the cost of this was quite challenging. By Summer 2017 the costs estimation work was completed: consolidation of all DIPS EPR installations into a single regional one was estimated to be in the area of 125 to 185 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

[10] A Gartner report in 2015 rated DIPS clearly below the American ”suite” systems, such as EPIC and Cerner.

benefits that would be achieved was proportional to the costs, and project participants started to discuss alternative strategies.

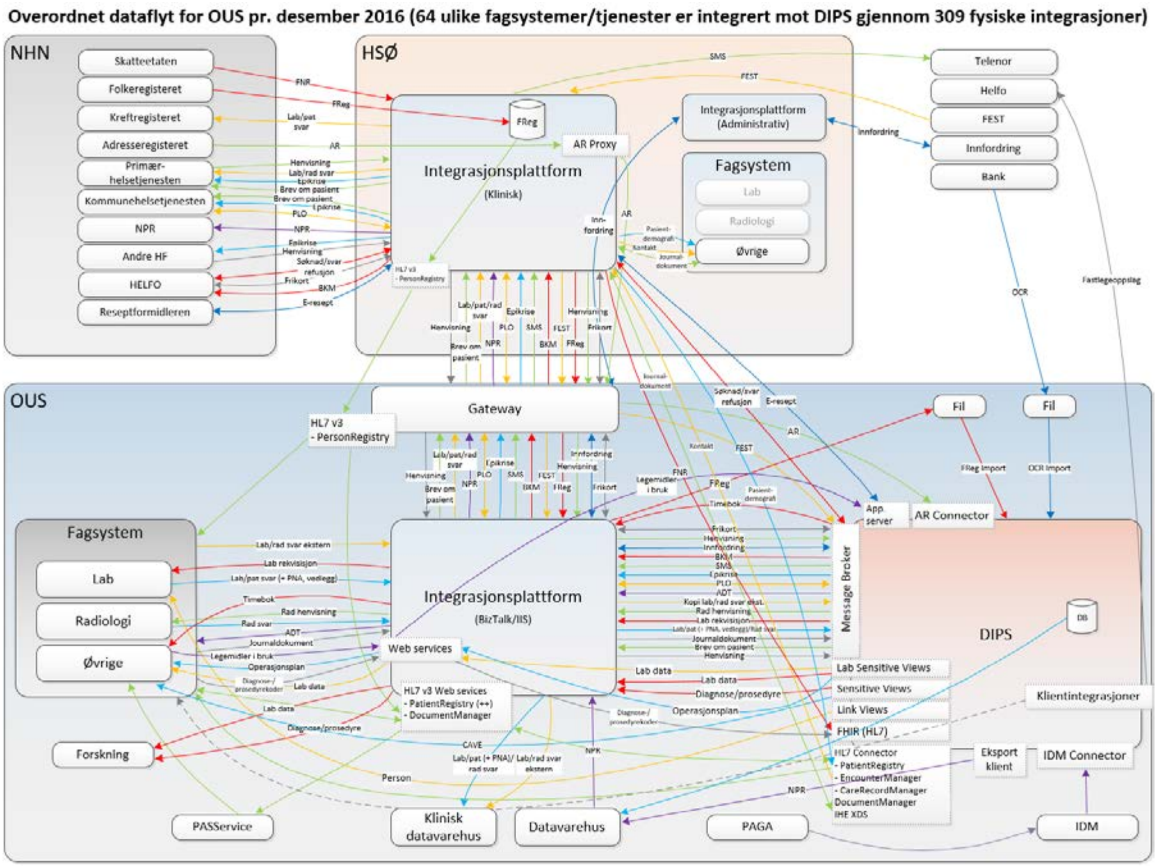

Figure 9: *The integration framework and physical integrations between the DIPS installation and OUH and other systems. The OUH box illustrates integration between DIPS and systems within OUH, the HSØ box with systems in other hospitals within the region, and the NHN box illustrates integration with systems outside the regions connected through the National Health Network.*

The main elements of the alternative strategy were to standardize the DIPS data bases, first of all the semantics of the data elements, and developing APIs providing functions for accessing all DIPS installations as if they were consolidated. Both elements of the strategy could, then, be implemented in a stepwise manner. By end of November 2017, 7 of the 11 hospitals enterprises have implemented the data base standard.[11] However, currently (January 2018), the Board of Directors of Health South-East has yet not made any decision about consolidation strategy after the estimates were presented. For this reason, all activities related to consolidation, except data base standardization, is pending. However, some activities related to developing new APIs are going on “under the radar.” This includes, for instance, one API initially developed for the MyJournal solution (Grisot et al 2014) providing patients access to (some of) their medical record data. This API provides access to all existing medical record documents (like lab reports and

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

admission and discharge letters) for one patient across all DIPS installations in the region. APIs for accessing DIPS is based on the IHE XDS standard.[12]

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The existing DIPS solution dates back to the early 90-ies, and most of its technology is, accordingly, out-dated. Recognizing this fact, DIPS started the development of a new and modernized product, called DIPS Arena,[15] some years ago. Health South-East has implemented two modules of this solution at two smaller units at OUH and has recently started planning the processes of replacing the existing DIPS installations with the new version throughout the region.[16] This has been estimated to cost about 85 M Euros.

To summarize: DIPS was implanted at OUH on time and budget – but the budget was very high, indeed. This implementation represented an improved and more well-structured hospital wide EPR as well as a platform-oriented hospital enterprise infrastructure that definitively facilitated more smooth collaboration between the different

[12] https://ehelse.no/standarder-kodeverk-og-referansekatalog/standarder-og-referansekatalog/ihe-xds-metadata-norsk-profil-av-ihe-xdsb-his-11692016
[13] http://hsorhf.prod.fpl.nhn.no/hso_nyheter_/Sider/Ahus-innførte-regional-journalstandard-som-det-7.-foretaket-i-.aspx
[14] https://ehelse.no/standarder-kodeverk-og-referansekatalog/standarder-og-referansekatalog/ihe-xds-metadata-norsk-profil-av-ihe-xdsb-his-11692016
[15] https://www.dips.com/no/dips-arena
[16] http://hsorhf.prod.fpl.nhn.no/hso_nyheter_/Sider/Utreder-modernisering-av-EPJ-løsningen.aspx

units merged into OUH in 2009. Important parts of, and steps towards the platform-oriented infrastructure were the development of the boundary resources turning three lab systems (local lab platforms) into a hospital wide (medical biochemistry) lab platform and the hospital boundary resource, represented by the hospital Integration Platform, integrating DIPS and the other solutions. On the other hand, the estimated costs of consolidating all DIPS installation into a regional one points to the fact that the consolidation strategy is problematic while a stepwise process towards a regional EPR platform through standardizing the databases and developing a regional boundary resource enabling access across the hospital EPR platforms seems more promising.

5.3.2 Second project: Medical labs

The medical lab portfolio was extremely fragmented (see the "fruit salad"), with different solutions for many hospitals for each of the four major lab types, i.e. medical biochemistry, pathology, microbiology, and blood bank.[17] The Lab program specified one solution covering all the four types of labs, and the tender process resulted in choosing the LVMS lab system. The contract 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. Accordingly, it could not be rolled out to the other hospitals.

When the solution was up in running at Østfold, 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 develop and implement standardized solutions for one kind of lab at the time, starting with pathology. 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).[18] The detailed specification of a regional pathology solution started in November 2017.[19]

The modest achievements and the high costs of this project again demonstrate the weaknesses of the official consolidation strategy.

5.3.3 Third project: Radiology

The radiology portfolio was, just like in the lab domain, quite fragmented, with products from five different vendors in use. After a tendering process, the solution offered by Carestream was chosen. The contract was signed during the spring 2013. This solution was planned to be implemented first as a pilot in the Innlandet Hospital. According to the plan the solution should be fully implemented and operational at Innlandet by February 2014, and then rolled out to the whole region by the end of 2016. The overall costs of the

[17] 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.

[18] https://www.helse-sorost.no/Documents/Styret/Styremøter/2017/20170427/042-2017%20Saksframlegg%20-%20Innføring%20av%20regionalt%20laboratoriedatasystem%20-%20status%20og%20videre%20planer.pdf

[19] http://hsorhf.prod.fpl.nhn.no/hso_nyheter_/Sider/Nå-starter-konfigurasjon-av-patologi-til-regional-standard.aspx

project was estimated to 478 MNOK, of these 183 would according to the contract be paid to Carestream.

The acceptance testing started at Innlandet Hospital in October 2014. The testing was quickly discontinued due to the huge number of errors discovered. Several new versions have been tested, but an acceptable solution has remained looking far away. Correcting the errors identified in September 2017 was estimated to take from 12 to 16 months.[20]
In parallel with the pilot testing at Innlandet gaps analyses have been on-going to specify in more detail the other hospitals' additional requirements to the pilot solution. This analysis revealed that there was huge variety regarding the work processes (to be supported by the RIS solution) of the various radiology departments. These issues were partly 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 OUS), 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 will necessarily be very complex.

Other activities were also taking place in parallel with the piloting at Innlandet. During the summer 2017 the Carestream PACS solution was implemented at the AHUS hospital enterprise and used in combination with their existing Siemens RIS product. The implementation was a rather smooth process and the PACS solution in itself worked well. However, it also made it clear that RIS and PACS solutions are usually tightly integrated and used in combination, accordingly using RIS and PACS solutions from different vendors is cumbersome.

Due to the slow progress of the development of the new radiology solution, many hospitals had to improve and upgrade their existing solutions in parallel. For instance, the four local hospitals being parts of the Vestre Viken hospital enterprise (Kongsberg, Drammen, Ringerike and Bærum) consolidated their local solutions into one platform shared by all four.[21] The Radium Hospital desperately needed a new radiology solution, and was in 2014 allowed to buy and implement a Sectra solution. Sectra was one of the vendors that lost to Carestream in the tendering process.

Due to the continuing struggles the development of the Carestream solution faced, during the winter 2017/18 alternative options were analysed. In April 2018 the board of Health South-East decided to cancel the Carestream contract. Further, they decided to concentrate on establishing shared radiology platforms at the hospital enterprise level in parallel with a stepwise development of a regional platform by developing APIs for accessing information across the hospital enterprise platforms similar to what they have started doing for the EPR.[22]

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[20] https://sykehuset-innlandet.no/seksjon/styret/Documents/065-2017%20Status%20radiologisystemet%20RIS-PACS.pdf
[21] http://hsorhf.prod.fpl.nhn.no/styredokumenter_/SHF/Andre%20orienteringer%20-%20Referat%20Fornyingsstyremøte%2021%20aug%202013.pdf
[22] https://www.helse-sorost.no/Documents/Styret/Styremøter/2018/201804/040-2018%20Saksframlegg%20-%20Radiologi-løsning%20for%20Helse%20Sør-Øst.pdf

The radiology project added evidence to that from the lab and EPR projects proving that the official consolidation strategy is highly problematic. But it also indicates that implementing a regional PACS platform is a doable task. The hard consolidation challenges are primarily related to the RIS solutions. From this we can conclude that what is needed is a flexible and dynamic consolidation strategy – a stepwise process towards a platform-oriented infrastructure in line with what has been decided.

5.3.4 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 Core Journal 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 Core Journal solution give the same group access to the most critical and relevant information in urgency situations (primarily information about patients' allergies and active prescriptions). In addition the project has enabled the exchange of discharge letters from OUH to GPs in all municipalities in Norway. (OUH is a hospital providing a set of services as the only one in Norway like, for instance, organ transplants and complicated or advanced cancer treatments.) In addition, all Health South-East hospitals are accessing a huge number of national registers used for management, quality control and research. Examples include national cancer register with information about all cancer patients, and vaccination and birth registers. All interactions with these external solutions take place through the Integration Platform's (evolving) module for communication with actors outside the Health South-East, i.e. the boundary resource for accessing national platforms.

5.3.5 The Østfold Hospital and lightweight technologies

Although Health South-East's ambition was to run all ICT activities within the tightly controlled Digital Renewal program, a number of projects were running outside. Most important among these were the infrastructure project described above and the project responsible for developing the integrated solution that had to be in operation when the new Østfold hospital opened in 2015.

The package of integrated solutions developed and running when the new hospital opened is the most advanced hospital enterprise platform-oriented infrastructure within the region. It was built based on the Integration Platform. A number of new services were made available, in particular supporting patient logistics and coordination of patient related activities. These services were implemented based on technology from the Imatis company as a larger number of apps running in mobile phones, notepads or accessible through whiteboards touch-screens that visualised and controlled patient flow through the whole hospital as illustrated in figure 10. The services supported activities related to patients arriving at the at the emergency department, allocating patients to wards, ordering lab and radiology services, and supporting the discharge of patients. Also personnel preparing the meals for patients and cleaning patients' rooms made their services more efficient by getting access to information about patients' dietary requirements and when patients were discharged. Mobile phones were used extensively to co-ordinate actions between different units, and to inform patient families, usually via SMS. The services were implemented as simple apps accessing information in a number of applications (i.e. vendor platforms) including EPR, lab, radiology, chart and medication, and Patient Administrative systems.

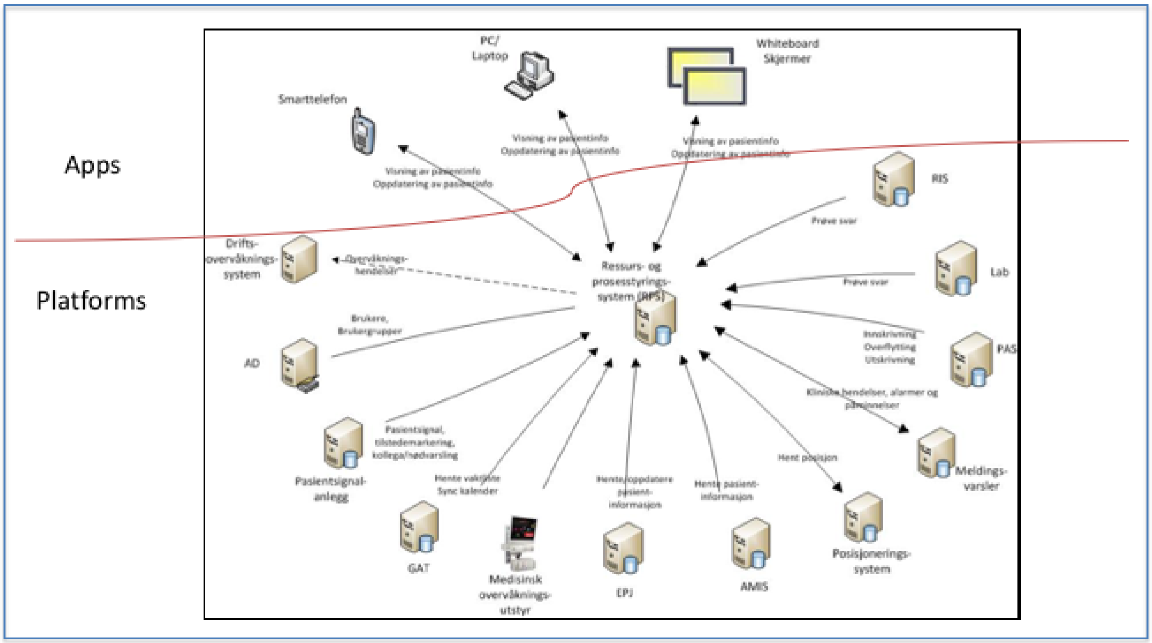

Figure 10: ***Solution at Østfold Hospital: Heavyweight systems and lightweight IT***

Based on the positive experience from Østfold 5 of the 11 Health South-East hospital enterprises decided to implement the Imatis solution where the costs will be covered by the hospitals' ordinary budget and not by Digital Renewal.

The development and use of the Imatis solutions stimulated and contributed to a rapidly growing interest in the development of solutions based on new mobile and Internet-of-Things technologies which most health as well as IT personnel believed enabled developing a broad range of new and improved new medical services. To address these issues a project called MediCloud was established. This project aimed at providing a cloud based platform where software companies could test their application that needed access to various software platforms, in particular the DIPS patient record system, but also lab, radiology, chart and medication solutions, etc. This includes the development of apps by small or star-up companies in collaboration with users, like for instance Diffia.[23] MediCloud also served as a communication channel between HospitalPartner and their Integration Services unit and software vendors related to the development of appropriate APIs for the vendors. This activity also 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 Health South-East's CEO request a report from the central ICT unit outlining a strategy for Health South-East related to "lightweight" technologies[24] like the Imatis solution. A proposed strategy was worked out during the spring 2017. But so far, to our knowledge, no strategy has yet been approved.

[23] http://www.diffia.no
[24] The distinction between heavyweight and lightweight IT is discussed in Bygstad (2016).

6. Analysis and Discussion

6.1 Overall assessment: Platformization, infrastructuring and the Status for the Digital Renewal Program in 2018

At the beginning of 2018 the Digital Renewal program is in a troubled situation. The consolidation projects of highest priority (EPR, lab and radiology) has failed and are more or less abandoned - the "fruit salad is still there" - and the grand consolidation strategy is about to suffer a silent death.

From our platformization perspective the situation looks brighter. Some significant practical achievements have been made. These achievements also represent important cases to learn from in terms of a platformization strategy for further evolution and improvement of the IT portfolio. Most important among these achievements are:

1. First of all the evolution of the multi-level boundary resources, the Integration Platform, and the Integration Factory.
2. The implementation of DIPS at OUH included the development of a rather sophisticated hospital enterprise boundary resource and platform oriented infrastructure where 64 systems interacted with DIPS. An important part of this was the boundary resource establishing a coherent lab platform based on the three different lab systems.
3. The standardization of the DIPS databases and the development of APIs for searching for documents across all local DIPS installations represent important steps towards a regional EPR platform.
4. The establishment of access (through the national boundary resource) to an extensive set of national platforms.
5. The overall hospital enterprise platform-oriented infrastructure established at Østfold Hospital.
6. The Imatis solutions in Østfold, consisting of a large number of apps running on top of the hospital boundary resource giving access to a number of vendor platforms.
7. The MediCloud initiative which, among other things, stimulated the focus on the development of APIs (boundary resources) enabling the development of supporting new and innovative services and work on a regional strategy for this. In that way it has contributed to a growing awareness of the "power" of platforms and platform ecosystems.
8. Together these examples also represent an incremental, evolutionary and need-driven strategy towards regional solutions (platforms) in contrast to the vision-driven waterfall like consolidation strategy of Digital Renewal.

These achievements represent a transformation of Health South-East's IT portfolio towards a multi-level platform-oriented infrastructure following the concepts presented in section 3. The platformization process and emerging platform-oriented infrastructure is not based on any deliberate strategy or specified model. It has emerged in a bottom-up manner through a series of small, incremental steps where IT architects and programmers working with integration issues have solved urgent issues and short-term problems as best they can. They have done so in parallel with continuous discussions among themselves about how the architecture of Health South-East application portfolio and the Integration Platform should evolve in the long run, and then solve the short-term issues in line with their ideas about the future of the Integration Platform.

More recently, however, the operational strategy of Digital Renewal has drifted towards the model we present here. Even though the existing Digital Renewal strategy is still the official one, the acting head of Technology and E-health in HSE has announced that the focus from now on will be one a stepwise development towards hospital enterprise and regional platforms in line with what is on-going regarding EPR and decided in the radiology domain on the one hand and capitalizing on the Østfold solution, in particular transferring the lightweight (app-based) Imatis solution, on the other.

While it seems clear that Digital Renewal program is about to collapse, no formal decision is made and no alternative strategy has to our knowledge been openly discussed.

6.2 Computing paradigms

We will now discuss our concept of platform-oriented infrastructure in relation to the dominant ways of thinking, or what we here call computing paradigms, in the Digital Renewal program and Health South-East more broadly. We will in particular compare and contrast Digital Renewal's concept of consolidation with our concept of platformization. Over the years a growing miss-match has emerged between the ways in which IT architects and developers in HospitalPartner on the one hand and users and high-level managers on the other see and understand the overall IT portfolio of Health South-East. The users' and high-level managers' perspectives and strategies are based on an application paradigm, while the IT architects and integrators developed models first in line with the SOA paradigm and later moving towards the platform-oriented infrastructure paradigm. This miss-match is still present.

6.2.1 The Enterprise Architecture and application paradigm

Overall, the Digital Renewal program is drawing upon the Enterprise Architecture framework (Weill and Ross 2004) and based on a perspective seeing Health South-East's portfolio of ICT solutions as a collection of applications. When the program started the portfolio was seen as complex and fragmented. This fact was leading to unnecessary high costs at the same time as it did not provide the required support to collaboration between organizational unites and medical personnel. Both problems were anticipated solved through the implementation of one single shared solution for the most important application categories. The Digital Renewal strategy is tightly connected to the silo phenomenon. It is based on a recognition of the silo problem and tries to solve it, not by means of an alternative model or paradigm – but by making the silos bigger and fewer.

The failure of the consolidation strategy is caused by the variety across hospitals regarding existing practices supported by IT solutions and, then, the necessary complexity of a shared solution providing the required functional support to all hospitals. But a just as important cause of the failure was the number and complexity of the integrations between the various solutions. The consolidation strategy was implicitly based on the assumption that the most important information flow was between applications of the same kind and between hospitals, i.e. between patient record systems in different hospitals, between lab systems in different hospitals, etc., and not between solutions of different kinds within or across organizational borders, for example between patient record systems and lab systems. Five years after the Digital Renewal program was launched, one must conclude that these assumptions did not hold. Strong evidence are, first, the implementation of DIPS at OUH, where the minimum number of solutions the DIPS had to be integrated with in the first phase was 55 (later 64); second, the estimated costs of harmonizing the integrations between the various DIPS installations and other applications within the region which amounted to 35-50 M Euros, if all 11 DIPS installations were to be consolidated.

These two examples also illustrate the importance and complexity as of the integrations between DIPS and other applications within Health South-East. The Digital Renewal strategy does not address this issue at all. The term “integration” is mentioned just a handful number of times. It is obviously taken for grated to be a mere trivial task.

6.2.2 The SOA paradigm

The silo problem is old, and IT personnel within Health South-East, in particular IT architects, have for a long time struggled with it and tried to fix it as best they could. The architects have over a long time worked on the design of SOA architectures (based on the TOGAF framework) – also within Digital Renewal. These efforts have, however, not contributed much to improving the messy structure of Health South-East’s IT portfolio - for several reasons. First of all, the SOA models become quickly unmanageable complex by themselves. Second, working out a SOA model at a sufficiently level of detail for an organization like Health South-East is a huge effort and takes a lot of time, accordingly it comes in conflict with deadlines and the urgencies of many projects. Further, SOA models are, when developed according to the TOGAF framework, rather idealistic. This fact makes how to transform the existing structure into a new SOA architecture a “new” challenge. This is so because the proposed SOA models are usually very different from those of the vendors’ products. I addition, Health South-East has proved to be unable to take the SOA models into account in the tendering processes. These tendering processes in themselves also become very complex, partly because of the way they regulated by the EU’s directive for public procurement, which brings lawyers into central positions, and the complexity of the user requirements when one aim at procuring solutions for all hospitals in the region. Finally, the SOA models are also different from how the top managers see the “world,” and because of the strategic importance and costs of IT, the important strategic IT decisions are made by top managers who see the IT “world” as populated by applications and applications (i.e. silos) are what they can make decisions about.

6.2.3 A third way: the platform-oriented infrastructure paradigm

The platformization process that we have seen unfolding, the transformation of the fragmented and chaotic application portfolio towards a more well-structured platform-oriented infrastructure, represents an alternative to both the application (Enterprise Architecture) and the SOA paradigms. Similar to the SOA paradigm, and opposite to the application paradigm, the focus is on integration of different systems and products. But unlike the SOA paradigm, the platform-oriented approach takes existing systems and products, i.e. the installed base, as its starting point. Further, while the SOA paradigm focus on technology only, the platform-oriented infrastructure paradigm is based on a socio-technical perspective also addressing the fact that different systems are developed and controlled by different vendors. We will elaborate more on these issues and the relations between the platform-oriented infrastructure paradigm and existing research on platforms and information infrastructures in the next section.

6.3 Platforms, Infrastructures and Platform-Oriented Infrastructure

Platform-oriented infrastructure share many features, quite naturally, with platforms, platform ecosystems, as well as infrastructures. Such infrastructures can be seen as consisting of a high number of connected and overlapping, i.e. infrastructure, platform ecosystems.

In the IS research literature concept of platform has primarily two meanings: an on-line market place (a two- or multi-sided market); or an architecture, combined with a governance structure, allowing a software system to be extended by third parties. In our case platformization is primarily a strategy (and architecture/governance configuration) for managing Health South-East's total ICT 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' IT units control 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.

Organizational boundary resources are helpful in coordinating the integration work different vendors have to carry out. Achieving this is a crucial issue because at the same time as the number and the size of silos have been growing, so has also the need to integrate they more tightly. Doing so has proved very difficult at the same time as their de facto degree of integration has made it very hard to change them in a consistent way as user needs have changed.

6.4 Platform Oriented Infrastructure and Tensions

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 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 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 more of a new version of the platform (as in the DIPS Arena case), 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. But also some user clients can be shared among all hospitals. The experience with implementing the PACS solution at AHUS (described in section 5.3.3) clearly indicates that a PACS user client is one example of such.

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, they 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.

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 users organizations together. So 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.

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 the case, however, we have seen that tensions are not stable, but changes over time. Accordingly, there is a need for an approach that also addresses stabilizing and destabilizing processes (Henning son and Hanseth 2012; Hanseth et al. 2018). The overall focus and aim of the Digital Renewal program is to replace different local systems with shared regional ones. When the program started, the hospitals had all 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 one the variety and total complexity of systems and processes involved. For instance, experience so far shows that the variety among PACS systems 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 while the variety among the overall work processes within the radiology domain as well as the solutions supporting these is much, much bigger. Accordingly, replacing all existing local RIS solutions with a regional 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.

7. Conclusion

The platform-oriented infrastructure model emerging at Health South-East has proved to be quite powerful in bringing the Digital Renewal programme on a more successful track. The model has emerged over long time as architects and programmers working with integration have struggled to make achieve short term goals in ways bringing them closer to their long-term visions. The formal plans and strategy documents is still written in a silo-oriented jargon, but the growing importance of the Integration Platform, and then naming of this as a platform, represents a change in language and conceptualization of the on-going activity and the way they see their IT portfolio. 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 (Bygstad and Pedersen 2012, Osei-Joehene and Ciborra 200), and the media sector (Saastad 2017, personal communication).

This concept of corporate platform-oriented infrastructures is our key contribution. The multiple layers of platforms incorporating a magnitude 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 is 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. This platform-oriented architecture-governance configuration is a powerful tool for managing the tensions involved in corporate infrastructures' evolution.

8. References

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

Aanestad, M., Grisot, M., Hanseth, O., Vassilakopoulou, P. (2017). Information Infrastructures and the Challenge of the Installed Base. Springer.

Arthur, W. B. "Competing Technologies, Increasing Returns, and Lock- in by Historical Events." Economic Journal, 99 (March 1989): 116-31.

Bygstad, B. (2016). "Generative innovation: a comparison of lightweight and heavyweight IT". Journal of Information Technology, 32(2), 180-193.

Bygstad, B. and Hanseth O. (2016). "Governing e-Health Infrastructures: Dealing with Tensions". Proceedings of the 37rd International Conference of Information Systems (ICIS), Dublin, Ireland.

Bygstad, Bendik & Pedersen, Nils (2012). Arkitektur handler om praktisk arbeid i organisasjonen, ikke en tegning". En forskningsagenda om IT-arkitekters utfordringer. NOKOBIT - Norsk konferanse for organisasjoners bruk av informasjonsteknologi. ISSN 1892-0748. s 1- 13

Constantinides, P. and Barrett, M. (2014) Information Infrastructure Development and Governance as Collective Action. Information Systems Research, 26(1):40-56.

Constantinides, P., Henfridsson, O., and Parker, G. P. Introduction—Platforms and Infrastructures in the Digital Age. Information Systems Research. Introduction to Special Issue on platforms and infrastructures. Published online in Articles in Advance 21 May 2018 . https://doi.org/10.1287/isre.2018.0794

De Reuver, M., Sørensen, C. & Basole, R.C. (2017). "The digital platform: a research agenda". Journal of Information Technology (2017). doi:10.1057/s41265-016-0033-3.

Eaton, Benjamin David (2012) The dynamics of digital platform innovation: unfolding the paradox of control and generativity in Apple's iOS. PhD thesis, The London School of Economics and Political Science (LSE). http://etheses.lse.ac.uk/463/

Eaton, B., Elaluf-Calderwood, S., Sørensen, C., and Yoo, Y. 2015. "Distributed Tuning of Boundary Resources: The Case of Apple's iOS Service System," MIS Quarterly (39:1), pp. 217-243.

Edwards, P. N., Jackson, S. J., Bowker, G. and Knobel, C.P. (2007). Understanding Infrastructure: Dynamics ,Tensions , and Design. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/49353/UnderstandingInfrastructure2007.pdf?sequence=3&isAllowed=y

Evans, D.S., and Schmalensee, R. Matchmakers: The New Economics of Multisided Platforms. Harvard Business Review Press, 2016.

Farjoun, M. 2010. Beyond dualism: Stability and change as duality. Academy of Management Review, 35: 202–225.

Foerderer, J., Thomas Kude, Sebastian Walter Schuetz, A. Heinzl.. Control versus generativity: A complex adaptive systems perspective on service platforms. International Conference on Information Systems, 2014.

Ghazawneh, A., and Henfridsson, O. 2013. “Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model,” Information Systems Journal (23:2), pp. 173–192.

George, A. L., and Bennett, A. (2005). Case studies and Theory Development in the Social Sciences. MIT Press.

Hanseth, O. and Ciborra, C. (2007). Risk, Complexity and ICT, Edward Elgar Publishing.

Hanseth, O., Monteiro, E., and Hatling, M. (1996). Developing information infrastructure: The tension between standardization and flexibility. Science, Technology and Human Values, 21(4), 407-126.

Hanseth, O., Lyytinen, K., 2004. “Theorizing about the design of information infrastructures: design kernel theories and principles”. Sprouts: Working Papers on Information Environments, Systems and Organizations 4 (4), 207–241.

Hanseth, O., and Lyytinen, K. (2010). Design theory for dynamic complexity in information infrastructures: the case of building internet. Journal of Information Technology, 25(1), 1-19.

Hanseth, O. and Bygstad, B. (2015). Flexible Generification. ICT Standardization Strategies and Service Innovation in Health Care. European Journal of Information Systems, 24(6): 645–663.

Hanseth, O., Masovic, J., and Mørk, B.E. The dynamics of complex sociomaterial assemblages. The case of Transcatheter Aortic Valve Implantation. In: Organizing for the Digital World, Lecture Notes in Information Systems and Organisation Vol. 28 2018, Springer International Publishing AG ISBN 978-3-319-90502-0

Helmond, A. (2015) “The Platformization of the Web: Making Web Data Platform Ready,” Social Media + Society, 1(2), DOI: 10.1177/2056305115603080.

Henfridsson, O. and Bygstad, B. (2013). The Generative Mechanisms of Digital Infrastructure Evolution. MIS Quarterly, 37(3):907-931.

Henningsson, S., Hanseth, O.2011. The Essential Dynamics of Information Infrastructures. Paper 14, ICIS 2011 Proceedings. http://aisel.aisnet.org/icis2011/proceedings/projmanagement/14

Hepsø, V., Monteiro. E., and Rolland, K. (2009). “Ecologies of eInfrastructures”, Journal of the AIS, 10(5), 430-446.

Islind, A. S., Lindroth, T., Snis, U. L., & Sørensen, C. (2016). Co-creation and Fine-Tuning of Boundary Resources in Small-Scale Platformization. Nordic Contributions in IS Research: 7th Scandinavian Conference on Information Systems, SCIS 2016 and IFIP8.6 2016, Ljungskile, Sweden, August 7-10, 2016, Proceedings (pp. 149-162). Cham: Springer International Publishing.

Kvan, O.J. Veien videre for Helse Sør-Øst? Presentation at FIGI seminar on Local and Regional Innovation: Balancing lightweight and heavyweight IT. University of Oslo, May 4th, 2018.

Lee, C.P., and Schmidt, K. A Bridge too Far: Critical Remarks on the Concept of “Infrastructure” in CSCW and IS. In: Socio-informatics: A Practice-based Perspective on the Design and Use of IT Artifacts. ed. /Volker Wulf; Volkmar Pipek; David Randall; Markus Rohde; Kjeld Schmidt; Gunnar Stevens. Oxford : Oxford University Press 2018, p. 177-217

Lyytinen, K., C. Sørensen, & D. Tilson (2017): The Generativity of Digital Infrastructures: A Research Note. In Handbook on IS Companion Book, ed. R. D. Galliers and M.-K. Stein. Routledge.

Modol, J.R., and Chekanov, A. (2014) "Architectural Constraints on the Bootstrapping of a Personal Health Record," Scandinavian Journal of Information Systems: Vol. 26 : Iss. 2 , Article 4. Available at: http://aisel.aisnet.org/sjis/vol26/iss2/4

Modol, J.R. and Hanseth, O. (2015) Stabilization and Destabilization Processes at Work in Digital Infrastructures: The Co-Functioning of Architecture and Governance. (In review.)

Northrop, L., Feiler, P., Gabriel, R. P., Goodenough, J., Linger, R., Longstaff, T., ... & Wallnau, K. (2006). Ultra-large-scale systems: The software challenge of the future. Carnegie-mellon univ Pittsburgh pa software engineering inst.

Osei-Joehene, D., and Ciborra, C. The Duality of Risk and the Evolution of Danger in Global ICT Integration. In Hanseth, O., and Ciborra, C. Risk, Complexity and ICT. Edward Elgar Publishing, 2007.

Parker, Van Alstyne, Choudary (2016). Platform Revolution: How Networked Markets Are Transforming the Economy And How to Make Them Work for You. W. W. Norton & Company.

Pipek, V., and Wulf, V. (2009) "Infrastructuring: Toward an Integrated Perspective on the Design and Use of Information Technology," Journal of the Association for Information Systems: Vol. 10 : Iss. 5 , Article 1. Available at: http://aisel.aisnet.org/jais/vol10/iss5/1

Pollock, N., Williams, R., and D'Adderio, L. 2007. "Global Software and its Provenance: Generification Work in the Production of Organizational Software Packages," Social Studies of Science (37), pp. 254-280.

Reimers, K., Li, M., Xie, B., & Guo, X. (2014). “How do industry-wide information infrastructures emerge? A life cycle approach”. Information Systems Journal, 24, 375–424.

Rochet, J-C., and Tirol, J. Platform Competition in Two-Sided Markets. Journal of the European Economic Association, Volume 1, Issue 4, 1 June 2003, Pages 990–1029, https://doi.org/10.1162/154247603322493212

Rolland, K. and Monteiro, E. (2002) “Balancing the local and the global in infrastructural information systems”. Information Society 18(2), 87–100.

Rolland, K.H., Mathiassen, L., and Rai, A. Managing Digital Platforms in Organizations: The Interactions between Digital Options and Digital Dept. Information Systems Research 2018.

Schneberger, S. L., and McLean, E. R. (2003). The Complexity Cross: Implications for Practice, Communications of the ACM (46:9):216-225.

Svahn, F., Mathiassen, L., and Lindgren, R. 2017. “Embracing Digital Innovation in Incumbent Firms: How Volvo Cars Managed Competing Concerns,” MIS Quarterly (41:1), pp. 239-253.

Sommerville, I., Cliff, D., Calinescu, R., Keen, J., Kelly, T., Kwiatkowska, M., McDermid, J., Paige, R.: Large-scale complex IT systems. Communications of the ACM 55(7), 71–77 (2012)

Skorve, E: and Aanestad, M. Bootstrapping Revisited: Ope ning the Black Box of Organizational Implementation. Scandinavian Conference on Information Systems. SCIS 2010: Scandinavian Information Systems Research pp 111-126

Star, S.L., and Ruhleder, K. Steps Toward an Ecology of Infrastructure: Design and Access for Large Information Spaces. Information Systems Research (7:1) 1996, pp. 111-134.

Tilson D., Lyytinen K., Sørensen C. (2010) “Digital infrastructures: The missing IS research agenda”. Informatin Systems Research (21:4)748-759.

Tilson, David; Sorensen, Carsten; and Lyytinen, Kalle, "PLATFORM COMPLEXITY: LESSONS FROM MOBILE WIRELESS" (2012). 2012 International Conference on Mobile Business. 6. https://aisel.aisnet.org/icmb2012/6

Tirol, J. Economics for the Common Good. Priceton Univercity Press, 2017.

Tiwana, A. (2014). Platform Ecosystems. Aligning Architecture, Governance and Strategy. New York, Morgan Kaufmann.

Wareham, J., Fox, P. B. and Giner, J. L. C. (2014). Technology Ecosystem Governance. Organization Science, 25(4), pp. 1195-1215.

Weill, P. and Ross, J. W. (2004). IT Governance. Boston, Mass, Harvard Business School Press.