TRANSFORMING DIGITAL INFRASTRUCTURES THROUGH PLATFORMIZATION

Research paper

Bendik Bygstad, Dept. of Informatics, University of Oslo, Norway, bendikby@ifi.uio.no
Ole Hanseth, Dept. of Informatics, University of Oslo, Norway, oleha@ifi.uio.no

Abstract

This paper explores and conceptualises a phenomenon called platformization. The background is that the growing complexity of IT solutions is in many organizations 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 we transform an IT silo structure into a platform oriented digital infrastructure?

The empirical evidence is a multilevel study of a large e-health initiative in Norway, where we analyse an emergent platformization process. We offer two contributions; first we give an outline of the key elements of a platformization strategy, second, we propose a new platform-oriented infrastructure configuration.

Keywords: Digital infrastructure, platformization, case study

1 Introduction

In this paper we explore and develop the concept of *platformization*. Currently, large organizations have typically hundreds, if not thousands, of application 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 variety of vendors, consultancies and internal IT units operating in a correspondingly complex mix of collaborative arrangements. It has been coined the IT silo problem (Bannister, 2008), but although the systems have gradually become more connected, other problems have surfaced. The overall complexity has grown, increasing costs, and making it difficult to adapt to changing organizational structures and user needs. To help organizations cope with this complexity, new frameworks such as SOA, Enterprise Architecture (EA) such as TOGAF, and IT Governance models, such as COBIT and ITIL, have been developed and adopted (Weill and Ross, 2004).

However, the results have often been disappointing, and some researchers have argued that radically new concepts and approaches are required (Sommerville, 2012). One stream of this research sees complex portfolios of connected IT solutions and the organizations developing and operating them as *digital infrastructures* (Hanseth and Lyytinen, 2010). 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 trajectories.

The *platform revolution* has redefined a key discourse of IT solutions; within economics the focus has moved from supporting the value chain in pipeline companies to platforms for n-sided markets, exploiting data abundance and network effects (Parker et al., 2016; De Reuver et al., 2017). In the IS field the basic architecture and governance mechanism of platform ecosystems has been well documented, with spectacular examples, such as Android and Apple, and other successful ecosystems (Tiwana, 2014.

What are the implications of the platform paradigm for all the organisations and companies that are basically pipeline organisations, with a large and complex digital infrastructure? Obviously, most companies cannot simply become platform ecosystems, and digitalisation of incumbent firms is in itself a quite challenging task (Svahn et al., 2017). However, there is no doubt that both the general discourse and the meteoric rise of platform companies will have a significant impact. In discussing the implications, we think two assumptions are central.

First, some of the principles and basic logic of platform ecosystems are useful in a more heterogeneous context of digital infrastructures. We take the most important of these to be the architectural principle of splitting the ecosystem into one stable core and a dynamic periphery of user services (Baldwin and Woodard, 2008), and the logic of network effects (Parker et al., 2016).

Second, while these principles are valid, they cannot address the key issues of more complex digital infrastructure evolution, which is characterised by tensions (Edwards, 2009); not smooth expansion. A "platform theory" of digital infrastructure must address these tensions. Most of the extant platform research builds on a uniform architecture/governance configuration, i.e. a central platform governed by a single corporate owner, as the centre of an app ecosystem in the periphery, while, particularly in the world of large organisations, platforms are less tidy, and often linked to many others. Moreover, while most platform research has focused on platforms providing services to individual consumers or citizens like Facebook, iPhone, Android and on-line shopping platforms, more complex digital infrastructures are prevalent in the business world, eGovernment and e-health. These infrastructures are characterised by a large number of systems from various vendors, usually IT silos designed for one specific purpose, and quite challenging to change. As expressed by an IT manager we interviewed:

> "Of course I am impressed by Google and Uber, but frankly, our business model does not even remotely resemble the one of Google, and our IT solutions are completely different. So when people ask, what can't we just transform into a platform company, I wonder if we are on the same planet".

The question, then, is how our understanding and management of large digital infrastructures can be improved by platform thinking, and how these insights can be complemented by extant infrastructure research. The result will not be a clean-cut platform architecture, but a more hybrid form; a platform oriented infrastructure. Our research question is*, how can we transform a traditional IT silo structure into a platform oriented digital infrastructure?*

We will address these research questions by developing a framework for *platformization. To* develop the framework, we build on extant research and a longitudinal case study in e-health. We chose e-health because it is a particularly challenging sector with regard to complexity (Christensen, 2009). The case deals with the evolution of the infrastructures within a regional hospital organization in Norway (involving about 4.000 applications used by about 80.000 users in 11 hospital trusts (including around 40 individual hospitals)) over a period of six years from (2012-2018). 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 theorise more complex structures than pure platform ecosystems. We also discuss the practical implications of our platformization theory.

2 IT Silos, Infrastructures and Platforms

IT silos are not wrong in themselves; they support the Weberian principle of division of labour with clear responsibilities. In e-health this led clinicians and vendors to design different systems for various diseases, and separate systems for labs, radiology and so on. However, the need to share knowledge across specialities to support patient oriented care made it clear that the silos had to be connected, both technically and socially. This effort has been a key activity for the e-health community the past decade (Aanestad et al. 2017).

The architectural results of this interconnection were relatively heterogeneous digital infrastructures, with many connected systems, often with middleware, such as enterprise service bus. A digital infrastructure is defined as a shared, open (and unbounded), heterogeneous and evolving socio-technical system (the installed base) consisting of a set of IT capabilities and their user, operations and design communities (Hanseth and Lyytinen, 2010). Infrastructures are complex socio-technical systems that are developed, operated and used by a large number of vendors and heterogeneous users groups, where neither the development activities, nor the use are controlled by one single actor.

The integration approach solved some important needs, but also introduced new challenges. First, integration generally increases the number of dependencies in a socio-technical system, resulting in more complexity (Bygstad and Hanseth, 2016), which in e-health has proven to be a major challenge. Second, large digital infrastructures have some inherent tensions. Edwards et al.'s (2007) identified three basic tensions in cyberinfrastructures; *time* (short-term decisions vs. the long-time growth), *scale*, (such as between global interoperability vs. local optimization) and *agency* (such as processes of planned vs. emergent change). These tensions have been challenging to deal with in the e-health field, and one promising approach has come from the platform literature.

Platform ecosystems have been analysed both from a technical (Tiwana, 2014) and an economics (Parker et al., 2016) perspective. In our e-health context of complex infrastructures, the platform concept offers a principle of order, i.e. the differentiation between the stable platform core and the more dynamic periphery of apps. In theory, platform configurations represent a specific 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. In addition, Ghazavneh and Henfridsson (2013) described a third structural element, the boundary resources, that connect the core and the apps. While not solving all the issues of the tensions of complex digital infrastructures, these elements constitute a possibility for *platformization.*

The concept has not been developed much so far. Helmond (2015) used the term to refer to the rise of the platform as the dominant infrastructural and economic model of the social web, while Islind et al. 2016) used the term more concretely to denote the socio-technical process of creating a platform. Our approach is broader, as a working definition we regard platformization as a process where IT silo solutions are gradually transformed to a platform-oriented digital infrastructure.

2.1 The Possibility of Platformization

The starting point for a possibility of platformization is the IT silo problem, which is characterized by many poorly integrated systems, with little flexibility for change, and slow innovation. For the users this often means that the services are poor, and new features requires a lengthy process at the vendor. The roots of these problems can be summarized in two points: The architectural problem is the tight integration between the three layers (GUIs, business logic and database), making integration costly and difficult, and limiting the development of new user services. The governance problem is that the evolution of the solution is solely the responsibility of the vendor, resulting in slow innovation (Bygstad and Hanseth, 2016).

Based on the insights from platform thinking we can envision a process of platformization, and a resulting architecture, which we call a platform-oriented architecture. The requirements for a platformization process are basically simple:

First, it is not enough to interconnect the silo systems; we need to break up the silo structure of the traditional three-layer systems, in order to establish a more flexible structure, where user services are more loosely coupled to the core. We also need to connect the core and the services with a mechanism that allows various user services to exchange data with the core (Ghazavneh and Henfridsson, 2013). They define *boundary resources* as tools and regulations that serve an interface between the IT silo systems and the user services. Boundary resources include two main processes; resourcing and securing. Resourcing denotes how the platform supports the ecosystem with the necessary technical and social resources, while securing denotes the degree of control executed by the platform owner. In line with Islind et al. (2017) we regard boundary resources as a socio-technical concept.

Second, we need to deal with the tensions of stability and change (Edwards et al., 2009). This implies we should not disrupt the well-working parts of the installed base of systems and users, but rather stabilise the core elements of the systems (data and basic functionality), while redesigning the user services, in the periphery of the core. This will also require a new more decentralised governance regime.

Considering these two aspects, the result of the platformization process will not be a clean-cut platform ecosystem, since the interconnected silo systems will still be in operation. The result will rather be a platform-oriented digital infrastructure, which is a hybrid form, with elements from both platforms and infrastructure. In proposing our platformization approach we make the assumption that most of the current (silo) solutions – the installed base - are useful in their local contexts (Aanestad et al, 2017). Many years of hard work have resulted in many working socio-technical arrangements of systems, users, routines and vendors, solving the operational needs of clinicians and administration. Certainly, some solutions are poor, and some components should be replaced, but research has found no evidence for a silver bullet technology that can replace current silo solutions.

It is, however, an open question to which degree a platformization strategy is feasible in the context of large e-health infrastructures. In order to investigate it, we conducted a six-year case study in e-health in Norway.

3 Case and Method

We chose a longitudinal case study (George and Bennett, 2005) approach in order to investigate the platformization process. We studied development and the governance of a regional e-health infrastructure in Norway over a period of six years (20012-2018), following a mega-programme, "Digital Renewal".

The South-Eastern Norway Regional Health Authority ("Health South-East") may be regarded as a governmental "holding company" for 11 legal hospital organisations with around 40 different hospitals, including the largest, Oslo University Hospital (OUS). Health South-East serves a population of 2,8 mill, and had in 2017 80,000 employees. IT Services was centralized, run by the company HospitalPartner, which is wholly owned by Health South-East and has around 1.300 employees. The long history of decentralized IT decisions had resulted in many individual well-working systems in each hospital, but also a fragmented portfolio of silo systems. The number of IT systems and applications was reported to be around 4000; this situation was seen as a major hindrance for patient-oriented services and innovation, and was widely criticised by politicians and media.

As a response the Health South-East decided in 2012 to start an ambitious programme called Digital Renewal, in the period 2013-18 with a budget of 6 bn. NOK (around 500 mill Euro). The main aims were standardizing of work processes and technology, operationalized through 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/PACS solution in 2018
- *Medical labs:* Consolidating from several to one shared lab system within 2018 for the four most important kinds of lab (medical biochemistry, pathology, micro-biology and blood bank.
- *Digital co-operation*: Exchanging electronic messages on patient logistics between 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 central Programme Board, and a board for each sub-program. The many projects were run by professional project managers, with tight reporting and continuous risk management. External consultants regularly produced audits.

3.1 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 74 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.

3.2 Data Analysis

The platformization framework was developed in these steps, shown in Table 1. From the literature we identified three key elements in a platform-oriented infrastructure, i.e. data layer, boundary resources and user services. Then we analysed each case for the degree of platformization, i.e. the stabilisation of data, boundary resources and user services.

We also assessed the outcome of the whole Digital Renewal program. This enabled us to highlight the limitations of the top-down standardization approach, and to compare this to the platformization concept.

Step	Activity	Output
1	Identifying the key elements of a platform oriented infrastructure from extant research	Section 2.1
2	Analysing each case, to assess the degree of platformization: the stabilisation of data, boundary resources and user services	Section 4
3	Outlining the framework, and describing the three platformization steps	Figure 2 and section 5.1
4	Assessing the architecture - governance configuration	Section 5.2

Table 1. Data analysis

In step #3 we outlined the platformization framework. The cases had revealed the centrality of boundary resources (both the technical and the governance elements) in the process, and consequently we made it the key entity in the model, and also the first step in the framework (See Figure 2). Finally, we discussed the architecture - governance configuration of the platformization framework.

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

4 Findings: Transforming a Regional e-Health Infrastructure

In our analysis we focus on four major projects in the Digital Renewal program, and one external, but closely related project, here called Lightweight IT. For each project we conduct an analysis of the three steps of platformization; establishing boundary resources, stabilising data layer, (re)designing user services - as described in our framework. We also discuss the results of the efforts, as illustrated in Table 2.

Project	Elements of platformization process	Outcome
1. Electronic Patient Record	Regional standardisation and the establishment of an integration framework (and integration factory)	Moderately successful
2. Medical labs and radiology	Product standardisation projects	Failures
4. Chart and medication	Pilot projects	Some progress
Lightweight IT (apps, touchscreens)	Lightweight layer on top of regional systems	Quite successful

Table 2. Cases

First project: Electronic Patient Record

The largest project within the program, and the one given highest priority, was the EPR implementation at Oslo University Hospital (OUS, the result of a merger of three hospital in 2009), with 12,000 users. The other hospitals in the region were already running DIPS. A shared medial record system for OUS was a requirement for making OUS work as one hospital. The main benefits were stated to be a shared EPR system for all users, and the standardization and restructuring of work processes.

The regional IT department *HospitalPartner* had since 2010 developed an environment with strong integration competence. This included a quite sophisticated integration platform and an organisational unit, called the Integration Factory. The regional platform (see Figure 1) was based on an enterprise service bus technology (ESB): Microsoft BizTalk middleware. The Integration Factory conducted all the programming on and format conversions on the platform. The enterprise bus solution offered a number of advantages for integrating a large number of systems. First, it served as a routing device; it supported the routing of messages and calls, so the addressing was not the responsibility of the applications. Second, it supported the transformation of formats. In the OUS implementation, it handled (for instance) the exchanges of HL7 messages from the EPR system, transforming them to the national KITH standard for the lab and radiology systems.

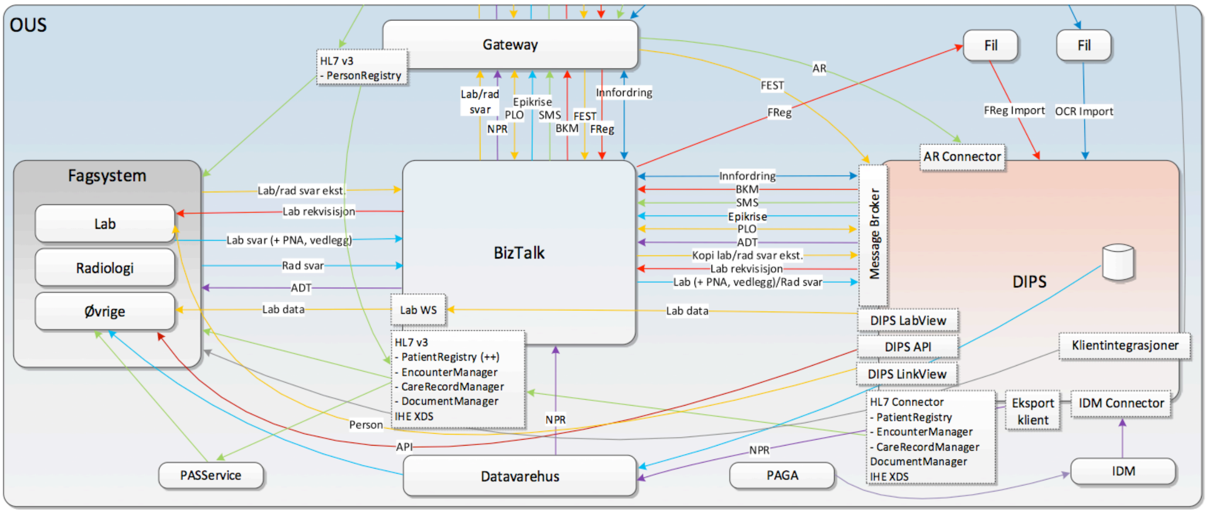

Figure 1. The integration framework, based on BizTalk ESB

The basic functionality of the ERP was not changed, but a number of services were improved through the integration framework: for instance the implementation of one coherent interface towards three different lab systems running in three different labs. The solution made these systems look like a single one seen from the users perspective. Clinical personnel could now order lab test from the DIPS GUIs and receive the results the same way. The same principle applied to radiology and a few other key services.

Outcome: Degree of platformization

The regional EPR solution was as a significant step towards platform thinking, for two reasons. First, the integration platform and Integration Factory together constituted a powerful socio-technical boundary resource (Islind et al, 2015), which had proven efficient in a quite large project. Second, the data layer at the largest hospital had been successfully consolidated, and showed the way for further consolidation. The user services, however, were only marginally improved.

Second and third projects: Medical labs and Radiology

The medical lab portfolio was extremely fragmented in the region, with different solutions for many hospitals for each of the four lab types, i.e. medical biochemistry, pathology, microbiology, and blood bank. The same situation applied for radiology, with four different systems. The chosen solution was Carestream, which was new to all the large hospitals.

Both projects proved surprisingly challenging, leading to extended pilot projects with local resistance. While the technical challenges were mostly solved, the problem was that the various hospitals had spent several years (working with different vendors) to establish working configurations and routines, and the new solution required major changes in these respects. During 2018 the projects were more or less terminated as a regional effort.

Outcome: Degree of platformization

With the slow progress of regionalisation, stabilising the data layer was difficult. The boundary resources (the integration BizTalk solution described above) were working well, but local adaptations of the chosen regional system were difficult. The key problem was the user services, which were perceived to be poorer with the new system.

Fourth project: Medication and Chart system

This was considered a key system for the doctors, since the medication of patients and the surveillance of patient conditions (pulse, temperature etc.) were monitored in this solution. One of the aims was to support *closed medication loop*, i.e. ensure that all patient were receiving exactly the prescribed medicines. The MetaVision system was chosen in 2008, and piloted at Oslo University Hospital.

The first OUS Metavision solution was not integrated, but in 2015 the Østfold Hospital installation was fully integrated through the Integration Platform. The implementation required a careful interplay with the EPR, which was quite demanding, both technically and in terms of data quality. The MetaVision system offered a range of new user services, being rich in functionality and relatively flexible in configuration. It required however also a lot of training.

Outcome: Degree of platformization

In contrast to the lab and radiology projects, the clinicians appreciated the user services. Boundary resources (the Integration Platform) were established, but worked only partly successfully. After ten years of pilot implementations and various reports, progress was slow. In 2017 there was no movement towards a regional stabilisation of data, but the OUS was rolling out the system to all departments.

Fifth project: Lightweight IT

The Digital Renewal program was a typical heavyweight IT[1] project, focusing on large functional (silo) systems. The new Østfold hospital, initiated in 2015, built on the regional package, but also extended it with a layer of lightweight technologies (from the vendor Imatis), such as extensive use of touch-screens, tablets and mobile phones to support clinical logistics.

The Østfold solution established a new set of boundary resources, with a resource and control system, connecting the heavyweight and lightweight solutions. This was part of the Imatis solution, and was implemented by the lightweight team. However, the communication with the heavyweight clinical systems was implemented through the regional integration platform, as described above. Thus, in the Østfold solution the boundary resource was a two-layer structure. The lightweight part of the Østfold solution contained relatively little data, but operated on the data resources of the heavyweight clinical systems. The important aspect here is that the new lightweight layer did not disrupt the existing data layer.

A number of new services were made available through lightweight solutions, in particular in logistics. The touch-screens visualised and controlled patient flow through the whole hospital; receiving at the emergency department, allocating patients to wards, requiring lab and radiology services, and

[1] The distinction between heavyweight and lightweight IT was proposed in Bygstad (2017). Heavyweight IT was defined as a knowledge regime of traditional SW engineering, while lightweight IT was seen as an agile knowledge regime for digital innovation based on commercially available technology

supporting the discharge of patients. Mobile phones were used extensively to co-ordinate action between different units, and to inform patient families, usually via SMS.

Outcome: Degree of platformization

The Østfold solution offered some surprising novelties. In addition to the wealth of new services, it established a two-layer boundary resources (one regional and one local), with a corresponding governance regime. In sum, it offered a new perspective on platformization, since it illustrated that the heavyweight regional systems could serve as platforms to lightweight IT solutions.

Overall assessment

Building on the experiences from the successful EPR project at Oslo University Hospital, the program was reorganised in 2015, merging the EPR, lab and radiology programs (with a central IT architecture group), enabling a more holistic governance of the solutions. In 2018, however, the Digital Renewal program was in a challenging situation, because progress in the recent two years, particularly regarding the lab and radiology solutions, had been slow. The fragmentation and IT silo problem was unresolved, and a lot of money had been spent with moderate results. This raised doubts about the viability of the whole regional consolidation strategy; while there were several successful local implementations the regional solutions were contested. The Director of the Programme reflected on this:

> "In principle, everybody favours standardization, and have no problem in recognising that there are large benefits – economic, organisational, technical – in establishing shared and scaled solutions. However, nobody likes to be standardised. It is the others that should standardise."

From our *platformization* perspective the situation was somewhat brighter, for three reasons. First, the boundary resources, the integration platform and the Integration Factory, were successfully established and had been in stable production for a long time. It was well documented that they also were scalable, both technically and organisationally, and could serve as a foundation for the platformization. Second, the regional data layer was partly stabilised in the most important system, the EPR. Third, and most importantly, the quite successful Østfold solution showed that a layer of new services could be provided with lightweight IT, loosely coupled to the heavyweight systems. Together, these elements constitute a possible platformization process. We will discuss the implications of this in the next section.

5 Discussion

We return to our research question, how can we transform the IT silos in e-health through a platformization strategy? In answering it we will first discuss the transformational aspect of the platformization process, and present our framework (illustrated in Figure 2). Then, we define and discuss the result of the transformation process, i.e. the architecture-governance configuration of the platform-oriented infrastructure.

5.1 Platformization - a Transformation Process

The starting point of our research was the observed tensions of large digital infrastructures, such as e-health programmes, who have inherited the IT silo structures of the past. Our case shares the features of most infrastructures reported in the IS literature in terms of its socio-technical complexity and the variety of challenges it raises for those trying to control its evolution. It also that a platformization process can be emergent, i.e. it is process of experimentation and learning. While the Digital Renewal program was initiated as a top-down standardization effort, it gradually developed into a platformization process, as shown in the Østfold case.

Architectural change of established complex technological systems has proved to be hard (Svahn et al., 2017), particularly in e-health (Christensen, 2009). The transformation from the silo-oriented architecture towards a platform-oriented one has in the case reported her, however, been fairly smooth in the sense that the transformation has taken place in terms of a continuous process composed of a series of small steps. See Figure 2.

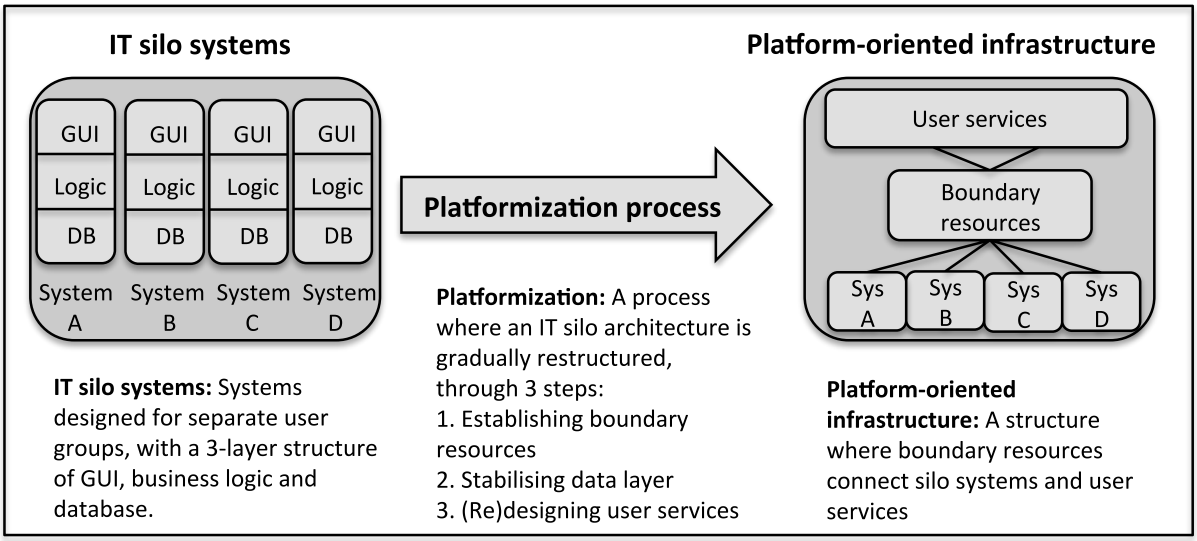

Figure 2: Framework

The platformization process is characterized as follows. *The first step is the establishment of boundary resources.* We build on the research of Ghazawneh and Henfridsson (2013), and define boundary resources as tools and regulations that serve an interface between the IT silo systems and the user services. Boundary resources include two main processes; resourcing and securing. Resourcing denotes how the platform supports the ecosystem with the necessary technical and social resources, while securing denotes the degree of control executed by the platform owner.

The introduction of the BizTalk ESB can be said to be the beginning of the development of the Integration Platform. After some time the idea emerged that an organizational unit should have the responsibility for all integration to ensure coherence and quality in the work done. Since then all new integration has application has been based on the Integration Platform and controlled by the Integration Factory while existing direct links between applications have been phased out resulting in an increasingly powerful integration platform. In the beginning focus was on hospital level and integrate applications around one ESB at each hospital. Gradually more focus and effort has been directed towards the regional and national levels. The Integration Platform has continuously evolved through connections to and integration with more vendor platforms and by extending the boundary resources available for applications with new functions at the same time as existing ones have been harmonized and made more generic (Pollock et al., 2007, Hanseth and Bygstad 2015).

The second step is the stabilisation of the data layer. Harmonizing boundary resources in the sense of establishing equal boundary resources towards different systems has also been an important issue because many systems store the same data, for instance basic patient information. One important illustration of this evolution is the boundary resources developed as a part of the DIPS implementation at OUS, which made three different lab systems look and act if it was one single system and the three labs using the different systems appeared as one single lab. Another example is the boundary resources developed at Østfold Hospital for the Imatis solution. These boundary researches were developed as a broad range of simple resources for lightweight technologies in general and access a series of vendor platforms where the EPR, chart and medication, lab and radiology systems were the most important ones. In parallel, the region started a slow process to consolidate the different databases. The evolving platformization of the infrastructure, then took place as the EPR data bases were standardized and a shared data base was built at the regional level at the same time as the local EPR "apps" were adapted to and connected to this. The key point is that the data layer *appears* consistent in the short term, and may slowly converge in the long term.

The third step is (re-)designing user services. The platformization process increases the quality of user services in several ways. In our case the regional boundary resources enabled sharing of patient information by giving apps in one hospital access to EPR information in other hospitals within the region. Through this process the regional EPR boundary resource gives the EPR "apps" access to a larger part of the EPR data produced at other hospitals at the same time as the regional boundary resource is streamlined. In the Østfold case, the second layer of boundary resources allows for 3rd party software and apps to support a range of logistics and communication needs.

5.2 A New Architecture-Governance Configuration: Platform-Oriented Infrastructure

The architecture - governance configuration of traditional IT silo systems is quite simple; the architecture is a three-layer structure, designed and maintained by a vendor, and governed by a system owner (Weill and Ross, 2004). The architecture - governance configuration of platform ecosystems are also, in its dominant design, relatively simple; the platform core and its boundary resources are owned and maintained by the platform owner, and the apps of the surrounded ecosystem are developed by 3rd party vendors, and utilised by various users (Tiwana, 2014). The platform-oriented infrastructure, being positioned somewhere in the middle, has a more complex structure.

The data layer consists of a number of vendor platforms, which are mostly developed, owned and controlled by vendors. Each of these individual platforms includes a platform core and a set of boundary resources. We call their boundary resources *vendor boundary resources*[2]. In addition, illustrated by the integration framework of the Health South-East case, a boundary resource is build on top of and across the vendor platforms' boundary resources. We call these them *institutional boundary resources*, which include both the enabling socio-technical resources (such as the Integration Factory) and the securing mechanisms, such as encryption and authorization. These boundary resources provide a coherent and consistent way in which the "apps" can access the various platforms, and they are controlled by organization (not the vendors). A crucial and distinctive feature is the two-level boundary resource structure. The institutional boundary resources are playing important roles related to the both two functions identified by Ghazawneh and Henfridsson (2013), i.e. resourcing and securing. Regarding resourcing, the institutional boundary resources are helpful in addressing two major challenges: enabling smooth interactions and integrations between solutions and structuring and 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 IT silos have been growing, so has also the need to integrate they more tightly.

On top of this structure the user service layer is a hybrid of vendor GUIs, interfaced developed by the organization, and 3rd party apps. Typically, as illustrated in the Østfold solution, the "core users" of vendor systems (such as lab personnel with lab systems) will use the vendor GUIs, while nurses and other personnel will use 3rd party apps for logistical and co-ordination purposes. The overall benefit of

---

[2] Some of the vendor platforms have very complex boundary resources. These boundary resources are complex because EPR systems (and others) contain and are exchanging a large amount of data with other systems. Such data exchange and communication between systems have over a long time been intended to be based on standards. It is implicitly anticipated in the rationale behind the standards that the vendors should 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. That is far from being the case. Over the years competing and overlapping standards have been developed – national, European, global, etc. These standards are 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.

this arrangement is that it leverages the strengths of vendor systems, in offering secure and sophisticated services built on standards; while at the same time enables the flexibility and innovation of 3rd part app development in a larger ecosystem.

The ownership of apps will be organised accordingly. The institution will maintain a general ownership of the whole infrastructure, but the configuration requires a polycentric approach to governance (Constantinides and Barrett, 2014).

6 Conclusion

It is a fact that most of the world's digital infrastructures looks much more like the Health South-East silo architecture than the clean-cut platforms of Apple or Airbnb. We therefore believe that the platform-oriented infrastructure concept portrayed here can successfully be seen as generally valid for large-scale distributed organisations at large. We believe our concept of platformization shows a way forward for organisations in similar situations, and that the emerging platform-oriented strategy appears to be powerful both in terms of enabling a more controlled future evolution of the infrastructure and a smooth path to the new architecture.

Summing up, we offer two contributions. First, we offer a rich *platformization* concept that deals with the IT silo structures of large digital infrastructures, and their inherent tensions. The platformization process is a stepwise transformation process, where the IT silo structure is transformed to a platform-oriented infrastructure. The process includes three key steps; establishing boundary resources, stabilising the data layer, and designing new user services, and is characterized by gradual change and collective learning. A platform-oriented architecture represents a quite powerful and flexible tool for managing the tensions between standardization on the one hand and local adaptation and innovation on the other. The process deals with tensions in a sophisticated way, through a polycentric governance regime. This is a rather different picture from the more static approach reported in the Enterprise Architecture literature (Weill and Ross, 2004). This applies both in the architectural thinking, where platformization contrasts with EA in being more evolutionary and less designed, and in the governance approach, where platformization is based on polycentric governance.

Second, we offer a new *architecture - governance configuration* for digital infrastructures, which is distinctly different than the traditional IT-silo configuration, and the standard platform models (Tiwana, 2014). The explicit conceptual separation between a platform's core and its boundary resources proposed by Ghazawneh and Henfridsson (2013), is important for our concept. By utilizing this model, and refining it by introducing the possibilities of two layers of boundary resources, we believe we have pointed out a powerful approach for managing digital infrastructures that satisfies large-scale organizations requirements both regarding infrastructure architecture and governance. Regarding governance and organizing, the institutional boundary resources play an absolutely crucial role in giving the user organizations control over their infrastructures.

From a more practical point of view platformization offers a strategy with potentially large economic benefits. Most companies and organisations have, similarly with our case organisation, a large number of poorly connected IT silo systems. For these organisations a platformization is an opportunity to transition into a platform-oriented infrastructure, without a costly and risky replacement of the system portfolio.

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.

Bannister, F. (2008). “Dismantling the silos: extracting new value from IT investments in public administration”. Information Systems Journal, 11(1):65-84.

Bygstad, B. (2017). “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.

Christensen, C.M. (2009). *The Innovator’s Prescription.* McGraw Hill.

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

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.

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

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

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.

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

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.

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.

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.

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)

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

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

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