ARCHITECTURE WORK: MODES OF ARCHITECTING IN LARGE-SCALE INFRASTRUCTURES

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ARCHITECTURE WORK: MODES OF ARCHITECTING IN LARGE-SCALE INFRASTRUCTURES

Research Paper

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Abstract

IT architecture forms the digital core of contemporary organisations: thus, architecture work directly concerns the transformation of these organisations. The literature on architecture work and architecting has identified the principles, styles and characteristics that define the policy ideals of architecture work and has demonstrated how these drivers play out in real-world projects. With an in-depth case study, we add to this literature by investigating the multilevel challenges that architects address in transforming large-scale infrastructures and how major challenges come to the surface during the architecting process. Our empirical evidence comes from our longitudinal investigation in a large health region in Norway. We offer two contributions. First, identification and a rich description of three modes of architecting framed as functional, spatial and temporal dualities. Second, we integrate the empirical data into a process model and theorise how contextual and professional drivers are transformed through the architecting modes and form the actual results.

Keywords: Digital infrastructures, Architecture work, Architecting process, Hospital sector.

1 Introduction

Information technology (IT) architecture is crucial in organisational activities concerning planning, designing, implementing and maintaining IT systems (Venkatesh et al., 2007, Bradley et al., 2012). This means that IT architects including enterprise architects are central actors in realising digitalisation. IT architecture and architecture work are often embedded in strategies with defined goals. By using new technology, IT strategies are expected to lead to cost savings, better digital interaction and increased ability to change. A significant body of literature has identified and formulated many professional principles that architects draw on in their work to achieve these goals and has addressed these issues as best practices, including formal structures, architecture principles, challenges and lessons learned (Ross, 2006, Haki et al., 2012, Ajer and Olsen, 2020). Furthermore, the roles of enterprise architects are described extensively (Strano and Rehmani, 2007, Doucet et al., 2011a, Ullrich et al., 2021). Nevertheless, these professional best practices do not address all aspects of the architecting process, e.g., how to deal with short-term needs versus long-term visions and how to present the architecture to different stakeholders.

The healthcare sector is an example of large-scale infrastructure (Aanestad et al., 2017). Large complex organisations, such as healthcare, have a plethora of applications, ranging from large organisational information systems to smaller specialised apps for certain units. The complexity in the healthcare sector comes from the interdependencies among medical specialisations with their own processes and data requirements, a complex decision structure with different levels and autonomous units, continual digitalisation and changes in regulations (Romanow et al., 2012, Aanestad et al., 2017).

In professional organisations such as hospitals, the IT systems are specialist systems in which a lot of financial and human resources has been invested. Multiple specialist systems operating partly in isolation create fragmentation and introduce the need for integration. The specialist systems are often
proprietary legacy systems. This makes integration more demanding, and the integration among the systems adds new complexity. Unsurprisingly, radical changes in architectural strategies can encounter resistance in such complex organisations (Bui, 2015), and tensions among actors in the hospital sector, stemming from architectural strategies, are reported (Bygstad and Hanseth, 2016, Ajer et al., 2019).

Overall, there are numerous challenges in architecture work (Brée and Karger, 2022), but we argue that architecting in large-scale infrastructures has additional challenges. Therefore, we are concerned about the pragmatic trade-offs in this heterogeneous landscape where major challenges are addressed. The pragmatic trade-offs are often the results of negotiations and compromises regarding a range of issues, including short-term needs and long-term goals, local needs and national goals, and functional requirements from different actors. Rolland et al. (2015) suggest that a process perspective can be fruitful for addressing challenges in large-scale infrastructures. Thus, we perceive architecture work in large-scale infrastructures as a process. In this process, architects take advantage of the knowledge gained from their education, practice and professional community (Scott, 2014, Boonstra et al., 2018).

This study investigates the activities among architects in a multi-level organisation when a regional unit is making important architectural decisions with future implications. The organisation is in the middle of a transition process from a silo-oriented architecture that was developed using waterfall methodology to an innovative architecture that includes platform orientation, process automation and agile methodology. Beese et al. (2022) calls for research addressing how new disruptive technologies and the utilisation of new development practices influence architecture complexity and enterprise architecture management (EAM). In this matter, it is important to understand the architecting processes as part of EAM, which is a way to keep the technological complexity under control while the organisational complexity grows (Beese et al., 2022). Moreover, enterprise architecture (EA) research lacks empirical studies, and architectural design and problems with the EA approach remain areas to explore (Kotusev, 2017). Responding to these calls, our research question is: How can we conceptualise major challenges in architecture work, and what are the roles of the architecting process in addressing these challenges? We propose three architecting modes which cover specific challenges in the architecting process in large-scale infrastructures. Modes are ways to explain why challenges in the architecting process occur and how they can be perceived. In practice, these insights can prepare both architects and managers to understand the importance of sufficient dialogue among stakeholders in order to understand another’s goals, as well as prepare for paradigm shifts in their organisations when moving from silos to adaptive systems (Lapalme, 2012).

In the following, we first position our research within the literature on architecture work. Next, our method and the three modes of architectural work are described in detail, followed by a discussion of these modes as part of a dynamic architecting process before concluding the paper.

2 Architecture Work

2.1 Architecture and architecting of large-scale systems

Architecture work in information systems has developed in conjunction with the increased technological progress and the intrusion of information and communication technology (ICT) in society in general. Especially, architecture concerning organisations and their need for collaboration across business units and sub-organisations have had impacts on architecture work. This indicates a movement from a more technical orientation to one that encompasses the organisation as a whole, including its stakeholders (Ross et al., 2006, Lapalme, 2012). Architecture can be defined as comprising ‘fundamental concepts or properties of a system in its environment embodied in its elements, relationships, and in the principles of its design and evolution’ (ISO/IEC/IEEE, 2011). In this study, we emphasise the importance of addressing the organisation as a whole.

The work related to forming the architecture of an organisation and its systems is architecting, which can be defined as the ‘process of conceiving, defining, expressing, documenting, communicating, certifying proper implementation of, maintaining and improving an architecture throughout a system’s
Architecture Work: Modes of Architecting

life cycle’ (ISO/IEC/IEEE, 2011). However, our context of large-scale systems implies the presence of numerous systems. Large-scale systems, ‘systems of systems’ or ‘collaborative systems’ denote a situation with integrated systems where each system has its purpose, and communication based on interface standards is a major architectural design principle (Maier, 1998). In practice, the architecting process transforms functional requirements into software solutions consisting of underlying modules, with subtle (yet well-designed) interfaces and infrastructure to be able to function properly in the ICT landscape. When an entire organisation is involved in architecture work, it adds complexity to the work. In sum, ‘architecting is a complex and multi-functional activity involving participants with differing levels of dependencies, goals and motivations’ (Espinosa et al., 2015, p. 4059).

Enterprise architecting can be regarded ‘as the scaling of system architecting to the enterprise – to a system of systems’ and as a means to implement an enterprise-wide coherent and consistent IT architecture’ (Kaisler et al., 2005, p. 1). The EA view represents a plan-driven, top-down approach, which can conflict with a bottom-up approach where requirements from clinicians are taken into account (Ajer et al., 2019). The stream of information infrastructure (II) addresses this latter view. II is a generic label for complex systems, recognised by their large number of components, great diversity and dynamic relationships. II addresses the insight that large-scale initiatives are difficult to specify upfront. Consequently, the design of the architecture should cultivate gradual growth through standards and stable interfaces (Hanseth and Lyytinen, 2010).

In their recent literature review, Brée and Karger (2022) show that prior studies have pointed to a diversity of challenges in the architecting process. Some of the challenges reported in architecture studies are described as dualities, dilemmas, frictions, tensions, and incongruence (Bygstad and Hanseth, 2016, Boonstra et al., 2017, Ajer et al., 2019, Ajer et al., 2021a). These latter studies revolve around persistent issues, including centralised versus decentralised control, standardisation versus customisation of the systems, long-term versus short-term prioritisation, and top-down versus bottom-up planning.

We are concerned about the architects’ activities when major architectural challenges in large-scale infrastructures are addressed. Large-scale infrastructures involve many actors and stretch within and across organisations. The actual outcome of the architecting process is often the result of pragmatic trade-offs between short-term needs and long-term goals, local needs and national goals, and functional issues. We refer to these pragmatic trade-offs as temporal, spatial and functional modes, and we suggest that the architecting process can be better understood by describing these modes.

2.2 Architects and architecting modes

Architects in general belong to the software engineering community. The community has upheld high ethical standards since 1966, where commitment to public health, safety and welfare is an overall umbrella (ACM_Ethics, 2018). The ethical principles guide software engineers in their architectural work, among others, taking care of the public interest and at the same time, the employer and the client, ensuring high professional standards and relying on their integrity (ACM_Ethics, 2018).

When it comes to professional standards, waterfall methodology is increasingly substituted with a more agile approach. The design of the overall architecture has generally shifted from the monolithic/silo design to service-oriented architecture (SOA), realised through microservices or web services. SOA highlights modularisation, and facilitates agility, innovation (also by third parties) and rapid change. SOA makes scalability, integration and interoperability easier. SOA is a foundation for a competitive firm (Tiwana, 2014, Bui, 2015, Ross et al., 2019).

Nevertheless, enterprise architects often play different roles during the architecting process, requiring multiple skills (Lapalme, 2012, Ullrich et al., 2021). Some of the main tasks of enterprise architects are aligning technology with business objectives, managing the complex set of interdependencies in organisations, and implementing the strategic direction of enterprises (Strano and Rehmani, 2007). More specifically, the EA team can be supportive in, for example, in relation to business units and projects, monitoring them for compliance with the architecture principles (Niemi, 2006).
Doucet et al. (2011b) describe how the roles of enterprise architects evolve as organisations matures, shifting from an IT-centric to an organisational-wide perspective. The authors split the evolution into three phases, which are conceptualised as EA modes of practice. First, the *foundation mode* is an IT-centric mode where the holistic view of an enterprise is the fundament for aligning IT and business. Second, in the *extended mode*, the EA methodology is used to improve the IT–business alignment, and the business managers’ scope of responsibility is expanded to redesign their business. Finally, in the *embedded mode*, the EA tools and methodology become part of everyday processes.

However, along with the accelerated speed of new technological possibilities and globalisation, organisations need to increase their capability for change. This need is formulated as the *enterprise ecological adaptation* school of thinking, where the architecture is designed to foster innovation through adaptive systems (Lapalme, 2012). In this school, the enterprise architects’ role, among others, is to nudge collaboration and organisational understanding towards paradigm shifts (Lapalme, 2012). Hence, this role of the enterprise architects changes adjacently to support innovation, being advisors to business managers in strategic work; thus, they have to have continuously focus on trends that can benefit the organisation (Ullrich et al., 2021). Moreover, the increased use of agile methodology at the expense of waterfall methodology will challenge the enterprise architects’ prevailing role as long-term planners (Ullrich et al., 2021). However, Doucet et al. (2011a), Lapalme (2012) and Ullrich et al. (2021) do not provide contextual descriptions of how the architects’ roles play out in the architecting process. EA has still a lack of empirical studies, and architectural design and problems with the EA approach are areas to explore (Kotusev, 2017). Addressing the research gaps pointed out in Sections 2.1 and 2.2, we conduct an empirical case study, building on the idea of modes from Doucet et al. (2011b).

## 3 Case and Method

To understand the architectural work in large and complex organisations, what their concerns and challenges are, our research is designed as an qualitative exploratory case study (Walsham, 1995).

### 3.1 Empirical setting

In Norway, hospitals are public and organised as health trusts (HTs). The HTs are allocated to four independent regional health authorities, which in turn are under the jurisdiction of the Ministry of Health and Care Services. We studied the largest region, the South Eastern Region Health Authority (SERHA). SERHA consists of 11 HTs (9 hospitals and 2 service units), with more than 81,000 employees and an annual turnover of 88.5 billion NOK in 2020. To illustrate the large-scale infrastructure, SERHA identified, in 2018, 2500 unique applications and 5700 instances of these, as well as 10,000 servers. In the wake of these findings, the SERHA board decided to reduce the number of applications by 50%.

SERHA has decided to implement a holistic ICT portfolio management. In this matter, ‘architecture management is an important contributor to ensuring that projects and programs deliver the right quality within the domain of architecture, but also to prioritise the most important projects’ (SERHA, 2020a, p. 4). Following this decision, a hierarchical decision structure appeared. First, a regional portfolio board was established. Second, a regional architecture council (RAC) was established to ensure holistic and coherent architecture management (SERHA, 2020b). Noteworthy, RAC only makes recommendations to the portfolio board when it comes to major decisions.

The region’s ICT operational service unit is the Hospital Partner (HP). The HP also provides resources for regional projects. All projects go through five phases: concept, planning, implementation, closing and realisation. The HP has a range of different architects, while SERHA’s technological department has a smaller core EA team, working on strategy and compliance issues, among others.

Our data are mainly obtained from four specific projects (see Table 1). The first, a *regional laboratory project*, started in 2013. The strategy has been to have one shared laboratory system to achieve interoperability and collaboration as means of making the correct diagnosis. The implementation of the system has been delayed for many years and has exceeded the budget. Additionally, it has received massive criticism from clinicians and has been debated in the press. Nevertheless, in recent years, one
HT has implemented the laboratory system in the areas of general chemistry, microbiology, and pathology, while five HTs have implemented the system for pathology.

The second, a regional *health logistic project* started in 2019. The project aims to improve the hospitals’ efficiency and effectiveness in logistics, among others to provide a better overview of inpatients and faster access to test results for clinicians. It will also support the preparation of patient rooms and order porters, and the use of mobile phones is part of the solution. For patients, the new service means that they can register themselves on arrival and pay digitally on departure, and get information about waiting times and delays. In spring of 2022, the project was in the implementation phase with four parallel pilots.

The third project started in the autumn of 2020 to investigate new ways of addressing the need for new services related to digital remote care, how to facilitate digitalisation of work processes and how to arrange new integration services. The investigation concluded with a recommendation to purchase an intelligent business process management system, internally described as the *process platform*. The investigation suggests that the process platform can improve the hospitals’ change capability and improve the coordination and automation of work processes that involve many ICT systems and departments. This will also improve the end-user experience.

The fourth, the *co-decision project*, is related to the acquisition of a digital clinical decision support system, a knowledge-based solution designed to support patients in participating in decisions related to treatment options. The project ran in 2021 but came in conflict with the architectural vision in the region (the process platform). Nonetheless, the project continued to the planning phase with the aim to purchase a silo system, but was terminated in the spring of 2022.

We found that all projects had issues related to architectural work, which challenged the architects’ mindset and steered the architectural mode with which each architect was occupied. These matters are elaborated in Sections 4.2–4.5.

<table>
<thead>
<tr>
<th>Project, year started – ended</th>
<th>Primary aim</th>
<th>Status, Phase</th>
<th>Main challenge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory for pathology 2013</td>
<td>Achieve interoperability for cooperation for improved diagnostics</td>
<td>In production by many health trusts Implementation</td>
<td>A high degree of specialisation and local standards</td>
</tr>
<tr>
<td>Health logistic 2019</td>
<td>Improve the hospitals’ efficiency and effectiveness related to patient flow</td>
<td>Piloting at four health trusts Implementation</td>
<td>The complexity and comprehensiveness. Affects many different parts of a hospital, both technically and functionally. Many actors and processes are involved.</td>
</tr>
<tr>
<td>Process platform 2020</td>
<td>Support automation and digitalisation of work processes to support a patient’s pathway and increase the hospitals’ change capability</td>
<td>Procurement Implementation</td>
<td>A new way of thinking, trust, knowledge, and experience</td>
</tr>
<tr>
<td>Co-decision 2021–2022</td>
<td>Establish collaboration between physician and patient regarding treatment</td>
<td>Terminated</td>
<td>Breaks with approved target image for the technical architecture</td>
</tr>
</tbody>
</table>

*Table 1. Overview of the projects in our study.*

### 3.2 Data collection and analysis

The data collection and analysis involved an iterative process (Miles et al., 2014). Our data comes from several sources. Many documents were available online, like government white papers, national and regional strategy reports, regional status reports, and articles from the press. Additionally, we gained
access to internal reports, like minutes from meetings, and information about the projects. In total, approximately 90 documents were collected for this study.

These secondary data helped us understand the government’s goal and the preceding strategic choices that the region has developed, as well as comprehend the tactical architecture moves to support the strategy. Importantly, the documents also gave us a solid foundation to further discuss and prepare questions about architecture governance and architecture work with the informants. We used a purposeful sampling strategy to “identify people with great knowledge and/or influence (by reputation) who can shed light on the inquiry issues” (Patton, 2014, p. 268). The primary data were collected from November 2021 to June 2022.

Our primary data were obtained from semi-structured interviews, meetings and one workshop (the managers and special advisors mentioned below, had either a medical- or IT professional background and many of them had been involved in drafting the region’s technical enterprise architecture (SERHA, 2021, SERHA, 2022b):

- Related to the co-decision project and the process platform: a 2-hour meeting and 6 formal interviews, each for 1 hour (on Zoom). The informants were project members (1) and members of the steering committee (1), the RAC (3), and the regional portfolio board (1). They hold positions as clinician (1), special advisor (2) and manager (3).
- Related to the process platform and architecture governance: a 45-minute regional board meeting, where they decided to purchase the process platform, and a full-day workshop about digitalisation and regional architecture governance. 20 participants attended the workshop, whose positions were managers and special advisors.
- One of the researchers was stationed at the HP for three months and held one formal interview and many informal meetings. A total of approximately 5,000 words was noted from the conversations with 15 employees, mostly architects of various kinds (information, process, enterprise and special advisors). Several of these conversations were focused on the work related to the health logistics project and the laboratory project.

The themes in the interviews and meetings were about how specific projects had evolved, their challenges, and an elaboration of their arguments. Furthermore, we asked for an elaboration of the strategy and decision processes related to the regional architecture. In the informal meetings, the questions revolved around their current work, tools, challenges, how they solved them and why.

The formal interviews (except two) were recorded and transcribed verbatim (30,500 words). During the two interviews, that were not recorded, the formal meeting and the workshop, notes were taken and elaborated immediately after (2,300 words for the interviews, 2,900 for the meeting and 3,300 for the workshop). A summary of the informal meetings was written shortly afterwards. The summary had input from 16 persons and contained 3,900 words. In total, the primary data consisted of 43,900 words.

Our data analysis went through four steps. First, since our agenda is to understand the challenges in the architecting process in large-scale infrastructures from the architects’ perspective, we identified four cases that dealt with the problem. In this step, the secondary data were also analysed to reveal the drivers for changes in the hospital sector. Second, by coding the primary data (Miles et al., 2014), we identified important drivers derived from architects’ professional view and the main drivers in their professional work. Third, we analysed how these drivers were used as input to architecture work, and saw how the general drivers were transformed in practice. Further, the primary data was reviewed several times and by using the principle of first and secondary coding (Miles et al., 2014), different dualities that architects would need to deal with were identified. Analysis and theory development was an iterative process and proceed in parallel (Wynn Jr and Williams, 2012), thus, after repeatedly discussing and reflecting on the explanatory power related to the empirical evidence of each of them, four dualities stood out. These dualities are framed as modes since they concretise the pragmatic trade-offs between two ideal outcomes. Fourth, we described the architecture work and the architecting modes as involving a process that transforms input and the desired outcome into the actual outcome. The draft of the article was sent to the informants for approval of their quotations in context, and it led to clarifying discussions with some of the informants.
Findings: Modes of Architecting

In this section, the drivers for the new ICT strategy is presented, followed by a description of the four major dualities, giving three modes of architectural work. It is noteworthy that the appearance of one mode does not exclude the others.

Drivers of the regional architecture and architectural work

The main driver of the architecture and architectural work of the regional health authorities is the national hospital plan, whose digitalisation is guided by the vision of ‘One citizen – one journal’ (MHCS, 2012). The national hospital plan (MHCS, 2019) has digital technology as its central means to improve public health with connected and coordinated services for the patients’ care pathways, where the patients are active participators in their treatment. Furthermore, the hospital shall strive to offer healthcare at the patients’ homes. The drivers for change are the increasing elderly population, the citizens’ expected access to digital services and the expected scarcity of clinical personnel (SERHA, 2022a). To meet the national goals and utilise the rapid growth of new technology that provides new ways to treat diseases, the hospital sector needs to increase both its ability to change and the rate of change (MHCS, 2019). To be capable to meet the new demands, the basic architecture has to reflect those demands.

Based on the national and the regional strategies, a new technological EA was approved for the region in January 2021. The process platform project is a part of the new architecture (see Section 3.1). The project describes 17 major problems in the current situation. Examples include the following:

- Variations in clinical work processes lead to differences in the configuration of the ICT solutions and thus limitations for the central installation.
- The complexity in the integration landscape, with one vendor as the hub (among others), constrains the ability to execute rapid business development.
- Operational and management complexities are increasing because of a steady stream of new products that do not follow the regional standards.
- Other technical issues are security, competency, scalability, sustainability and limitation in the use of mobile applications through application program interfaces (APIs).
- For individual healthcare workers, fragmented systems imply a lot of wasted time by doing manual tasks, double registration and several log-in procedures during one day, as well as being subjected to long waiting times (years) before new technology or changes are available.
- The organisation as a whole suffers from the lack of support for automated distributions of work tasks to streamline resource consumption and for coordination and collaboration across the units.

To address the abovementioned problems, SERHA has (among others) a process platform under procurement. The process platform shall exchange data with the core systems to support end-to-end processes. Additionally, the use of a ‘low-code’ approach enables health personnel to quickly enter data into an app, with support from ICT operations. The expected outcome is that ‘the rate of change in the health service will change significantly’ (SERHA, 2022a, p. 31). The procurement and implementation of shelfware will remain a strategy alongside the new strategy, as emphasised by the CEO of SERHA in its board meeting before the decision on the procurement, ‘The process platform shall serve two main purposes. First, ensure flow among different systems, the large core systems and apps, and healthcare workers and departments. Second, we will be able to develop several apps ourselves, but we will also buy apps, and they must enter this flow (Manager, Medical-1).

As illustrated, the architects work in not only a complex landscape with multiple organisational units and stakeholders but also a changing landscape with a range of new strategies.

Interoperability versus specialisation – functional mode

Interoperability versus specialisation concerns the pragmatic trade-offs related to functionality. The central governance’s strategy with shared systems can provide only sub-optimal systems compared to individual requirements for highly specialised systems customised to specific needs. Interoperability is
about the exchange and reuse of data, so the data follow the patients in their entire journey. SERHA’s main strategy to achieve interoperability has been executed by standardising both work processes and software systems and making the necessary integrations.

The co-decision project (see Section 3.1) illustrates how interoperability versus specialisation forms the functional mode. One of the enterprise architects at SERHA has explained how the recommended co-decision system, which is a silo solution, will collide with a solution built on the process platform, which has an end-to-end service perspective where co-decision should be an integrated part of the pathway. With a silo solution on one hand and a solution for the pathway on the other, the clinicians have to use two systems instead of one. Thus, ‘as information that the portfolio board could take into account in its assessment of how to proceed, we informed that there would be an overlap at the process level, at the information level and partly at the functionality level’ (Special Advisor, IT-1).

Another enterprise architect from the central architectural team reflects on the situation as related to a lack of holistic understanding. ‘During the planning phase, the project learned more, because they have had more dialogue with [...] those who work with the process platform, and they have had more dialogue with us, and they are beginning to see other possibilities. In addition, the professional community, [comprising] medical and health professions, understands that we are about to create several self-treatment plans next to each other with duplication of solutions, creating a complicated and inefficient situation. [...] It is a communication challenge for us to get professionals to understand and look outside the box of ordering professional systems that they traditionally do. [...] Perhaps we should have been more “active” in the concept phase’ (Special Advisor, IT-2).

The regional laboratory project (see Section 3.1) also illustrates the functional mode. The region wants a shared system to facilitate interoperability, but the strategy has encountered resistance. A special advisor explains, ‘The HT [that] I was engaged in had three lab systems, and they had spent a long time fine-tuning them. For the clinician, it is important to take into account the professional aspects and the way that one thinks in medicine. They have control over their processes that have developed over time, and [they] will, of course, not readily accept [the fact] that a technician comes and tells them how to [do their] work’ (Special Advisor, IT-4).

Finally, several architects have explained a problematic situation stemming from a prevalence of silo thinking at different levels (functionality, project and end-to-end process) with too little focus on how things fit together in a bigger picture.

This section discloses the challenging architecture work to align the central vision of interoperability to provide a coherent health service and at the same time fulfil the clinicians’ desire for systems that respond to their highly specialised needs. Based on our assessment, the new regional strategy has the potential to address this issue with a platform orientation and communication through a modern API.

4.3 Long-term versus short-term – temporal mode

In our context, long-term is connected to strategic planning of the ICT landscape, while short-term applies to plans and actions that circumvent the strategic goal in order to meet urgent needs. In Section 3.1, the current IT strategy is described. As shown, the long-term strategy involves a process platform and low coding, whose main purpose is to increase the change capability and support innovation. The new strategy is intended to support the short-term needs that keep appearing at the local hospitals because of new clinical knowledge and new technological possibilities.

While working with the new IT strategy, SERHA’s implementation of the strategy for shared core systems is still in progress. This has been a long process. It started in 2013, and the results are not as expected in terms of the use of resources and time or the achievement of the strategic goals. The historical backdrop means that many actors question whether the timetables related to the process platform are realistic. How do architects deal with this situation concerning long-lasting projects and impatient clinicians? In the next paragraph, the co-decision project illustrates the dilemmas faced by architects – how the long-term versus the short-term strategy forms the temporal mode.
After the initial investigation, the co-decision project team recommended purchasing a standalone solution, even if the project members knew that a process platform was approved as a central architectural component by the RAC. However, the process platform was not yet approved by the SERHA board and was thus perceived as a solution with great uncertainty. The recommendation was based on the assumption that this was the fastest way to attain the goal, as the comment from the project manager during the RAC meeting confirms, ‘we believe there is uncertainty related to when the process platform will be available […] therefore an independent solution is recommended. We believe that the time perspective must be given high weight’ (internal minutes).

Conversely, the RAC opposed this decision, arguing that there was no factual basis to claim that it was faster to purchase a standalone system; besides, it had several violations of the approved target architecture. The conclusion from RAC was, ‘[…] the proposed concept will thus not give the healthcare institutions the increased speed of change that good architectural choices should contribute to. The recommended concept is not in accordance with SERHA’s target for enterprise architecture and the strategic effects the portfolio board seeks’ (internal minutes). In contrast, the project group claimed that regarding compliance with the target image for the EA and the architectural principles, it was considered an absolute requirement in the concept analysis.

Notwithstanding the RAC’s recommendation to postpone the project and instead develop a solution on the process platform, the project’s steering committee decided to support the recommendation of the project team. From the minutes of the meeting, it appears that the clinicians urged the project team to continue quickly with their recommendation. Because of the dissent, the decision was made at a higher level. The portfolio board supported the project team’s recommendation, with the argument for faster delivery. Nevertheless, the SERHA management group put the project on hold after the planning phase because of many unforeseen expenses at SERHA and too few solutions available on the market. However, the architects are familiar with impatient clinicians: ‘The situation where clinicians do not have the time to wait is something we have experienced throughout the years’ (Special Advisor, IT-1).

The architects at the regional level work with long-term strategies, but processes are slow and lead to tensions among stakeholders. It took 11 months from the approval of the new technical EA until the SERHA board’s approval of the purchase of the process platform. Moreover, the public procurement rules imply that it can take at least a year before any development on the platform can be started. Meantime, the short-term needs have to be fulfilled, as in relation to the regional health logistic initiative which is still under development a CIO explained, ‘pending the [logistic] board that we had hoped to pilot in 2018 [because we should] move into a new hospital in 2021 […]. Thus, we developed our own solution.’

### 4.4 Distance versus proximity – spatial mode

Distance versus proximity denotes the spatial distance between the central governance authorities and the hospitals. In other words, it is about how close the architecture is to the hospitals’ practices and the user needs. Distance is conceptualised as the region’s goal of having shared systems for all hospitals to receive equal treatment across the nation. Proximity refers to the clinicians’ desire to continue with customised systems that meet their actual local needs stemming from local variations, such as the number of employees, the building structure and the degree of specialisation at the hospital. Balancing these potential contradictions is difficult, especially related to work processes and process thinking. In the next paragraphs, three stories illustrate the dilemmas faced by the architects in this spatial mode.

First, the region has worked towards a shared laboratory system for over a decade to achieve interoperability and collaboration as means to make correct diagnoses while reducing the number of laboratory systems in the region (see Section 3.1). A special advisor at the HP illustrates the dilemma in relation to the laboratory project: ‘Having exactly the same systems for everyone is difficult because there are different processes in the different hospitals, for example, size – the fact that in large hospitals, there are more employees with more specific tasks than in small ones. The building structure is also important for the processes’ (Special Advisor, IT-4). The special advisor also favours process ownership over system ownership: ‘There may be several systems within one process in the hospital. It should be
a clinician and not a technologist who is the process owner, but it is difficult to get a clinician to take ownership’ (Special Advisor, IT-4). The situation with physicians who do not want to take process responsibility – ‘the owner role’ – is a common issue in the architecture community at SERHA. Thus, the incongruence between central goals and local needs appears late in the architecting process, instead of having project deliberations to reach agreements at an earlier stage.

Second, the workshop on digitalisation and architecture governance clearly showed a challenge that the architects encountered, both at the HP and in the regional EA team, that is, explaining the intentions in terms of architecture due to the lack of descriptions of the clinical processes as forming an intermediate layer after the regional visions and goals. One of the special advisors put it this way: ‘It is important that the business management owns the process and not the activities. We must make digitalisation a management process. Teams must therefore be linked more closely to the strategy. When digitalising, it must be connected to work processes’ (Special Advisor, IT-3). During this discussion, the architects received some inexplicit leads from the medical and health representatives: ‘It is important that the business management owns the process and not the activities. We must make digitalisation a management process. Teams must therefore be linked more closely to the strategy. When digitalising, it must be connected to work processes’ (Special Advisor, IT-3). During this discussion, the architects received some inexplicit leads from the medical and health representatives: ‘It is important that the business management owns the process and not the activities. We must make digitalisation a management process. Teams must therefore be linked more closely to the strategy. When digitalising, it must be connected to work processes’ (Special Advisor, IT-3). During this discussion, the architects received some inexplicit leads from the medical and health representatives: ‘It is important that the business management owns the process and not the activities. We must make digitalisation a management process. Teams must therefore be linked more closely to the strategy. When digitalising, it must be connected to work processes’ (Special Advisor, IT-3).

The current situation gives the architects a hard time since the work processes can vary across the hospitals. However, in our third case, the health logistic project, the HTs have arrived at an agreement on the solution when it comes to functionality. Moreover, it will be possible to make local configurations, e.g. related to the digital whiteboard that gives an overview of the patient, as stated by one of the architects: ‘Concerning functionality, the HTs have agreed on a common way for setting up the solution. There have been large meetings with many clinicians where this was discussed and resolved. Further, it is actually possible in the long term to make local configurations to take account of different needs’ (Architect-1).

A common issue for all cases is related to process thinking, which we suggest is an important factor related to distance versus proximity problematics. One of the consequences of the lack of process thinking at a higher level is that the architects lack a coherent picture of the processes intended to support the digital infrastructure. This is in line with the conclusion from the workshop mentioned above; the weakness regarding the possibilities for digitalisation of SERHA lies in the lack of a target architecture for the clinical disciplines and in poor anchoring of the technical target architecture. Thus, two remedies will be to have a stronger focus on the business processes and to develop business cases.

This section discloses tensions between local specialised functionality and central goals for standardisation, with an implicit perspective of the high similarity among the hospitals. The stories show that distance versus proximity issues are closely related to interoperability versus specialisation. The architects thus have to address functionality and spatiality for the same matter. The new regional architectural strategy addresses this issue related to digital remote care. The plan is that the process platform and agile development can facilitate the accommodation of local variations to a greater extent, without challenging the whole centralised governance regime.

4.5 Visualisation versus realisation – functional mode

A recurring theme for the architects is communication with other stakeholders to enable collaboration. The architects’ task is to transform the organisational vision into a functional product. Communication and understanding are imperative when high-level business architecture, usually visualised as drawings of various kinds, is realised by being translated into actual applications. Thus, we conceptualise the translation process as part of the functional mode.

As stated in Section 4.4, there are a lack of descriptions of the clinical processes as forming an intermediate layer after the regional visions and goals, which we assert as a crucial deficiency that hinders architecting a coherent ICT landscape. In Section 4.2 as well, it is mentioned that the technical architectural goal is difficult to understand and that the core architects should work closely with the project teams that will realise this vision, since the architecture itself can be hard to communicate. An architect gives an example from a project where the discussion was about the new technical EA: ‘We
wanted more explanation about the boxes and how [they] all connected. This was not clearly stated in the document. However, the core enterprise architects did not provide [adequate] answers’ (Architect-2). The next paragraph show some of the architects’ tactics related to the communication challenge.

At HP, the architects have increased their attention to communication: ‘It is important that the enterprise architects simplify their drawings so that they can be used as a basis for discussion’ (Special Advisor, IT-4). To address this issue, storytelling is a new tactic employed: ‘The enterprise architecture team at the HP has lately had a great awareness of how to present the cases; before, it was very technical. We have emphasised the use of and have had training in storytelling’ (Enterprise Architect-1). A concrete example is cited by an architect who has worked with a new log-in procedure for the whole organisation. According to him, he uses a specialised tool for EA (ArchiMate) and a more general tool for technical drawings (MS Visio), but ‘when I present to managers, for example, top managers at the HP or manager groups at SERHA, it is important to sell the message in a more understandable format, so I mainly use PowerPoint slides’ (Architect-3).

To sum up, the visualisation versus realisation dilemma involves realising the organisations’ visions. To achieve this aim, the managers, the architects and other stakeholders must be able to communicate in a way that they can understand one another. During this dialogue, storytelling and the use of detaechologised drawings seem promising. Furthermore, an agile and iterative development process is a means to proceed in the right direction. The introduction of a process platform with local DevOps teams, where clinicians are heavily involved, is an attempt to facilitate the development of end-to-end pathways, which makes the journey from visualisation to realisation less challenging.

5 The architecting process in architecture work

New disruptive technologies and new development practices influence the architecture complexity and EAM (Beese et al., 2022), thus an understanding of the architecting process is important. Our analysis shows that during the architecting process the architects have to balance and align multiple non-consolidated requirements from a large number of different users, this challenging balancing is framed as architecting modes. Furthermore, our findings emphasise that architecting in large-scale infrastructures demands a holistic understanding of architecture work. Therefore, we have developed a model (Figure 1) that shows architecture work as a process, with the architecting modes integrated in the process. Thus, the outcome of the architecting process depends on how the modes are dealt with.

Figure 1. Model showing the modes of architecting as part of a dynamic architecting process
We define modes of architecting as functional, temporal and spatial dualities that occur to address architectural challenges in large-scale infrastructures. By framing the modes as dualities, the content of the mode (e.g., interoperability versus specialisation) can be balanced and perceived as interdependent issues, not as separate dichotomies (Farjoun, 2010). The background for the architecting modes is that they describe a situation of incongruence between the overall strategy for the ICT landscape and the stakeholders’ interests. It is well known that proposed organisational changes can encounter resistance in the sub-organisations (Oliver, 1991). The incongruences can be conceptualised as dualities, and the architects have to relate to the causes of the incongruence and balance the dualities in a deliberated way (Ajer et al., 2021a). Thus, the model (Figure 1) starts with the drivers for architectural work. This is followed by a situated context, where the architects experience difficulties in the architecting process (the modes). The modes can have dynamic interactions and the presence of one mode does not exclude others. Finally, the architectural work aims to produce outcomes aligned with the drivers (Pawson and Tilley, 1997). A detailed description of the model (Figure 1) follows:

**Drivers of architectural change** constitute a mechanism similar to that of institutional pressure, which drives organisational change, as argued by institutional theorists (DiMaggio and Powell, 1983, Scott, 2014). The most recent national plan for hospitals calls for action through ICT to improve the current situation (MHCS, 2019). The plan describes the socio-economic issues listed in Figure 1. Professional issues form part of what the architects bring into the architecting process. For example, the normative way of dealing with complexity in large-scale organisations is through platformisation and the use of a modern API, as this type of architecture reduces complexity by modularity, enables innovation and increases the change capability of the infrastructure (Tiwana, 2014). Furthermore, when times are uncertain, organisations tend to imitate other successful companies (DiMaggio and Powell, 1983). In our case, the process platform, to some extent, is proposed in relation to some successful stories, such as Heathrow Airport’s success with such a platform in the complex task of coordinating aircraft arrivals and departures. The drivers form the **input into the architecting process**.

**Modes of architecting.** The mode referred to as **functional** consists of two dualities, visualisation versus realisation and interoperability versus specialisation. By visualisation versus realisation, we aim to place at the forefront the difficult process of transforming the architecture from its organising vision into something real, as well as the communication with key stakeholders during this process (Dale and Scheepers, 2020). This process includes communicating with clinicians to help them participate in creating a system that has not yet materialised, which Sandkuhl et al. (2016) refer to as model processing. In our case, modelling points to the importance of using high-level sketches and storytelling to clarify the intentions of the system and enable fruitful communication, since technical architectural drawings are complicated and can make stakeholders lose interest in architects’ presentations and messages (Ajer et al., 2021b).

By interoperability versus specialisation, we seek to grasp the pragmatic trade-offs when balancing the region’s overall strategy (often created by the regional management) and the functional requirements derived from clinical work. Bygstad and Øvrelid (2020) demonstrate how architectural alignment mechanisms may contribute to facilitating interoperability without disturbing specialisation. In our case, the process platform is procured to facilitate interoperability through standards and open APIs, and the health logistic project introduces innovation thinking at the process level. Moreover, the regional laboratory project demonstrates the difficulties in creating interoperability through standardisation when local work practices are tightly coupled in IT systems. In the latter case, interoperability could have been achieved through standards, but this has proven to be difficult due to different interoperability standards for the same type of health information systems (Begoyan, 2007), additionally ‘medical professionals are confined to their specialisations, following clinical protocols to address specific clinical needs. They are not used to open-ended strategic efforts’ (Ajer et al., 2021a, p. 16).

The second mode is **temporal**, which aims to capture the challenges of balancing the long-term and the short-term requirements (Ullrich et al., 2021). The large-scale infrastructures’ tendency to be heterogeneous and often fragmented, specialised and only partly consolidated (Aanestad et al., 2017), makes innovation difficult (Nambisan et al., 2017, Bygstad and Øvrelid, 2020). Temporal also relates to balancing between the longitudinal work to prepare for the future and the frequency of daily tactical
demands (Espinosa et al., 2015). An example from our study is the cumbersome work involved in the co-decision project. The clinicians had quite high expectations, but the project finally crumbled. A solution to the difficulties of rapid innovation in large-scale infrastructures could be differentiating between lightweight and heavyweight IT (Bygstad, 2017, Bygstad and Øvreliid, 2020). In fact, the process platform is meant to facilitate innovation, while maintaining security and privacy. The health logistic project, using Bygstad (2017) principles, is also intended to facilitate the timely and precise update of important information, while still securing the consistency of the infrastructure.

The third mode is spatial, which focuses on the difficulties of keeping a close eye on the local requirements, while preparing for future requirements at the national (enterprise-wide) level (Haki et al., 2020). The architects thus struggle in balancing central and local needs. In large-scale infrastructures with multiple actors and agendas, the centralised management should ensure that local variations are monitored and addressed (Ross et al., 2019). The process platform allows local variations, while the health logistic project contributes to facilitating a contextual awareness of local needs (across the different hospitals), while still securing the infrastructure.

Actual outcomes of architecting are the products of the process. The intended outcomes have to be aligned with the drivers of architectural change (Pawson and Tilley, 1997), but it is not always the case (Ajer et al., 2021a, Beese et al., 2022). In the co-decision project, the architecture vision has become compromised, and it is difficult to put the regional laboratory project in place, but SERHA still argues for and works towards a shared system. The procurement of a process platform is an architectural choice to be able to resolve the socio-economic issues. We also argue that through the architecting process, situational awareness among the architects emerges, which can be conceptualised as modes. Ultimately, the outcome of the architecting process depends on how the modes are dealt with.

In sum, the modes address alignment challenges in large-scale infrastructures. Regarding the practical implications, since multiple challenges emerge during architecture work, this requires the architects to reduce their level of ambition and take a pragmatic stand, where trade-offs may occur. Although our study offers valuable insights into architectural work, it has several limitations. More interviews with architects in different positions can eventually disclose other modes. Another avenue for future research is to study how a process platform combined with low coding for decentralised innovation will affect the central control of the overall architecture in large-scale infrastructures.

6 Conclusion

This study investigates the architecture work in a large multi-level user organisation. The organisation has started a transition process from a silo-oriented architecture that was developed using waterfall methodology to an innovative architecture that includes platform orientation, process automation and agile methodology, – which represent a paradigm shift for the organisation. Addressing the call from (Beese et al., 2022) for research on how the new paradigm influences EAM, increase the amount of empirical research (Kotusev, 2017), and provide the missing contextual descriptions of the architect's role in the architectural process, our research question is: How can we conceptualise major challenges in architecture work, and what are the roles of the architecting process in addressing these challenges?

Our research gives two contributions, mostly targeted to the enterprise architect literature. Firstly, our description of architectural work gives a better understanding of the architectural process. Through the rich empirical data, we show that architectural work requires a holistic understanding of the entire process. The major issues the architects must deal with are functional, temporal and spatial dualities that emerge during the architecting process. Even if similar issues is reported in other studies, e.g., Bygstad and Hanseth (2016), Boonstra et al. (2017), Ajer et al. (2019), Ajer et al. (2021a), we add to the literature by conceptualised this dualities as modes that influence each other in a dynamic process. Secondly, we contribute with a model that portrays architectural work and how these modes help to transform input into output, as well as what this leads to. In this way, architecture work is shown as a complex practice in time and space, and demonstrates a trade-off between contextual realism and architectural idealism. Thus, the architecting process is a core activity in digital transformation.
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