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Expanding hospital infrastructures: boundary resources for peripheral actors

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Abstract. Fostering innovation while maintaining a traditional IT infrastructure is challenging. We have conducted a qualitative study in the health sector, following three ICT-related innovation initiatives in a hospital. The innovators sought to connect the new solutions with the complex hospital digital infrastructure but the governance regime was not conducive to experimental development. We describe the challenges of relating to the existing information infrastructure and thereby identify the requirements for innovative projects to be sustained. In our analysis we zoom-in on the problematic "meeting points" between the innovation initiatives and the pre-existing infrastructure, as these reveal which capabilities and resources are required for the existing infrastructure to accomodate novelty. Conceptually, we frame these as boundary resources. Our study contributes a concrete description of the resources that are required if large, entrenched infrastructures shall be able to harness innovation.

Introduction

Digital health infrastructures provide support to multiple different activities catering for a range of potential users and types of use currently and in the future (Pollock & Williams, 2010). Due to the inherent capabilities of new digital technologies (for instance, recombination and extensibility), digital infrastructures can be the basis for making healthcare smarter enabling the introduction of novel digital solutions to address problems and improve performance. Neverthless, even though innovations in medical devices and clinical procedures are revolutionising medical practice, everyday "information work" within hospitals is not

characterized by “smartness” as digital capabilities are not sufficiently exploited. Information work includes exchanging information and documenting information exchanges between healthcare practitioners within and across health organisations. It also includes the work entailed in exchanges between practitioners and patients related to the provision of care. Overall, hospital digital infrastrucures are slow in supporting novelty and are known to be lagging behind in terms of providing support for information exchanges (Afferni et al., 2018). This paper is researching the problem of extending hospital infrastructures to support information work by connecting novel peripheral solutions.

Our research is empirically grounded on the analysis of innovation initiatives within a Norwegian hospital that offers multidisciplinary rehabilitation to patients with complex functional impairment following illness or injury, and has a strong emphasis on research and innovation. We analysed three different initiatives to introduce new solutions related to information sharing. Following the trajectories of these initiatives, we traced challenges of relating to the existing digital infrastructure and identified the requirements for enabling innovative extensions of complex and heavily regulated hospital infrastructures. In our analysis we zoom in on the problematic “meeting points” between the innovation initiatives and the pre-existing infrastructure.

Theoretically, we leverage the concept of boundary resources which we draw from the research literature on platforms and ecosystems (Ghazawneh & Henfridsson, 2013). Platform architectures include a core and several peripheral modules (often developed by third parties) that interact through standardized interfaces. Boundary resources are the key means for exposing and extending the core and can be both technical and social in nature. For instance, application programming interfaces (APIs) are the most common type of technical boundary resources, while regulations, incentives and guidelines are examples of social boundary resources.

Our findings show the critical role of boundary resources for the introduction of novel digital services and their embedding to the pre-existing information infrastructure. Boundary resources serve as the interface between the core systems that are part of hospital infrastructures (e.g. Electronic Patient Record Systems) and new external applications that need to connect and build upon the capabilities of core systems. They are the key means for exposing the infrastructure core facilitating innovative development from the periphery.

Method

We performed a revelatory case study (Yin, 1994; Sarker et al., 2012) to reveal the needs and requirements for infrastructural embedding of novel digital capabilities. Thus, we selected initiatives where there was a challenging relation to the pre-existing information infrastructure. Data collection for this research

includes formal interviews with staff in the hospital's IT department, project managers, project participants, clinical staff (users) and less formal updates on project progress through conversations with project managers. Important data sources were the status reports, project documents and presentations that were reviewed for factual information. In summary, the research reported is based on data collected using a combination of fieldwork and documents' analysis.

The analysis of empirical material was performed from an infrastructure perspective informed by the concept of boundary resources (Ghazawneh & Henfridsson, 2013; Hanseth et al., 1996; Ribes & Finholt, 2009). Our concern has been to let empirical detail guide the development of insights. Thus, we followed closely the the trajectories of the initiatives studied. We analysed our material to understand how the initiatives met with the existing infrastructure and how they grappled with the related challenges.

Overview of Empirical Cases and Key Findings

Three initiatives related to the introduction of new digital solutions for information sharing were analysed. An overview of the three iniatives is provided in Table I.

Table I. Overview of the three hospital initiatives studied

Initiative	Key aim	Brief trajectory
Scheduler	Information sharing for patient schedules for e.g. tests, physical exercise, or speech therapy. The schedules were earlier printed in multiple copies and distributed across the hospital. A digital version would be more easily updated and shared.	The vendor of a University Scheduling solution offered a test of the (web-based) solution. A pilot (without integration to EPR system) was successfully conducted and a scaling strategy planned. Gaining access to core infrastructure (for data exchange) proved challenging. The solution remained "stand alone".
Mobile Movement	Information transfer from patients to clinicians through a clinician devised solution for distributed harvesting of sensor data (for movement analysis). Enabling remote patient training and interaction with therapists.	The project successfully secured funding and a prototype for sensor data harvesting and analysis was developed. For the next step of testing there was a need for secure data storage and ideally integration with EPR to enter data. The project is on hold.
Bedside Data Harvester	Information registration by clinical personnel on a mobile tool for clinical documentation and communication. Enabling data entry on the move to improve work efficiency during documentation.	A prototype (based on extensive observations of clinical work) was tried out, first in a mockup version. Technical integration with the hospital infrastructure is pursued for pilot implementation (ongoing).

The trajectories of the three initiatives show that in the hospital under study it was possible to conceptualise and to develop proof of concept solutions for novel digital services. Nevertheless, taking a step further and making the new solutions an integral part of the existing infrastructure was very challenging. Specifically, it

was not possible to implement two-way communications and data exchanges with the core systems. Furthermore, it was not possible for the peripheral applications to use the secure storage facilities that serve the core systems of the hospital. Additionally, the further development and testing of the new peripheral applications was impeded as it was not possible to get access to realistic data or to test and experiment wiithin a comprehensive sandbox environment fully mirroring the production environment. In other words, it was not possible to use resources that would allow peripheral actors to gain *insight* into the infrastructural core through actual probing and experimentation. Furthermore, we found that the novel solutions could not benefit from the infrastructural dynamics because the peripheral actors were not *vested* with rights for leveraging existing infrastructural components or for deploying their solutions for other users within other hospitals currently sharing the same overall infrastructure.

Ghazawneh and Henfridsson, used the concept of boundary resources to theorise on the evolution of platforms and their ecosystems and found that the development of such resources was driven by: a) the aim of platform owners to secure control b) their aim for enhancing scope and diversity through third party resourcing (Ghazawneh & Henfridsson, 2013). For our research, we use this platform-related concept to look at infrastructural arrangements beyond platforms studying the interplay between the infrastructure core and new applications in the periphery. Ghazawneh and Henfridsson identified two types of boundary resources: securing resources (i.e. resources to increase control) and resourcing (i.e. resources to enhance scope and diversity). Drawing from our findings, we supplement the two types of resources identified by Ghazawneh and Henfridsson adding two more that relate to the needs of peripheral actors. Specifically, we named these additional types: discovery resources and vesting resources. Figure 1 provides an overview of the different types of boundary resources.

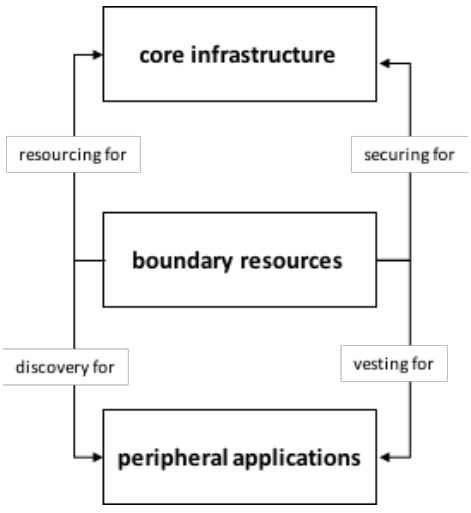

Figure 1. Overview of the four types of boundary resources

Discovery resources allow peripheral actors to gain insight into the infrastructural core through actual probing and experimentation. Periphery actors need to make sense of the possibilities and limitations of the core, ensuring some level of visibility into it. Vesting resources relate to arrangements for the appropriation of benefits, e.g. related to rights for exploiting the existing infrastructure or the new data streams. The two additional types of boundary resources reflect the needs of peripheral actors and complement the types of resources that reflect the concerns of those that control the core hospital infrastructure. In table II we provide examples of the concerns that relate to the four different types of resources.

Table II. Boundary Resources for the three initiatives

		Scheduler	**Mobile Movement**	**Bedside Data Harvester**
Perspective from the core	**Securing**	Need to protect sensitive data (in EPRs) from access by third-party cloud solution. Requiring the application to run within the secure environment. Limited resources offered relying on regulation.	Need for generic data storage facilities (not only for core systems' data). No such resources available (only development environment).	Need for adherence to IAM solution (Identity and Access Management) and MDM (Mobile Device Management).
	Resourcing	Limited interest to expand based on third parties. Lack of relevant resourcing boundary resources.	Boundary resource was planned but not provided (because regional resources prioritized core systems).	Available APIs for access to EPR data. APIs to feed data but not to receive.
Perspective from the periphery	**Discovery**	Need to use the EPR possibilities regarding demographic and logistics´ information. Not having access implied double work of manually copying information and also limited generativity of new types of functions.	Need to make sense of capabilities for secure storage of measurements now and in the near future. Also, visibility into analysis capabilities required for further development.	Need to be able to test/operate against the concrete production configuration (not a test instance). No test data available to third parties. Services for real life testing needed.
	Vesting	The vendor expands in healthcare but not clear if it would be possible to appropriate benefits beyond a single hospital to compensate for costs.	Potential data ownership and management issues. Requires related decisions.	Reuse data (based on employee consent) for analysis and learning. Decisions needed for data ownership and management.

Discussion

Focusing to the interface between the infrastructural core and the periphery, our study complements prior research which addresses mostly the concerns of keystone players (Dal Bianco et al., 2014; Eaton et al., 2015; Ghazawneh & Henfridsson, 2013). We add the perspective of actors that aim to link new peripheral components to an infrastructure core. Specifically, we extend the concept of boundary resources to include also types of resources relate to the needs of peripheral actors (discovery and vesting) going beyond the concerns for securing and resourcing.

As shown in the initiatives studied, novel services may emerge out of problem-solving activities in practice. This may also be facilitated by repurposing and transferring solutions and services used in other contexts and settings as in the case of the Scheduler (Garud et al, 2016). However, the introduction of novelty in everyday practice entails moving beyond successful solution demonstrations and ensuring that new technological solutions are not standalone objects, but elements in larger infrastructural arrangements (Hanseth and Lyytinen 2010). The inherent capabilities of new digital technologies make it possible to leverage existing arrangements for new services creating a wealth of possibilities for supporting healthcare operations and information exchange but this is far from straightforward. Healthcare organizations have now the opportunity to introduce novel technologies built around a core within an ecosystem of complementors (Cusumano, 2010; Tiwana et al., 2010). Nevertheless, the introduction of novelty is challenging, as it involves an immense number of localized and cross-cutting dependencies (Bygstad & Hanseth, 2016) in an environment where there are entrenched roles related to the management of the historically built infrastructural landscapes (Grisot & Vassilakopoulou, 2015). Analysing the interface between the infrastructural core and the periphery from both the keystone player´s perspective (governing the core) and the complementor´s perspective (aiming to link peripheral components) allows us to provide a unified foundation for addressing the challenges of introducing novelty within hospitals extending their infrastructures.

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