Towards an IoT Implementation Framework - About a New Building Project of a Hospital in a European Microstate

Manuel Weber[1][0000-0001-8361-4988], Gregor Kipping[1][0000-0001-6156-1416], Jan vom Brocke[1][0000-0002-0071-3719]

[1] University of Liechtenstein, Institute of Information Systems
{manuel.weber,gregor.kipping,jan.vom.brocke}@uni.li

Abstract. Implementing the Internet of Things (IoT) is associated with several multi-layered challenges and questions for practitioners and scholars alike. However, little knowledge is available to guide practitioners in the successful implementation of this emerging technology at the organizational level. In this research-in-progress paper, we report on a project from a state-funded hospital located in one of Europe's microstates. The hospital is currently planning a new building and sees this as an opportunity to reflect on the adoption of IoT to prepare the organization for future trends and challenges. We apply a Design Science Research (DSR) approach and base our findings on a workshop with project managers and department heads from the hospital. Motivated by practice and grounded in the socio-technical and adaptive structuration theory, we develop an IoT implementation framework that serves as guidance and navigation for such an implementation endeavor. We discuss this framework and present the next steps for future research.

Keywords: IoT, Healthcare Organization, Implementation Framework.

1 Introduction

Due to the developments and advances in the society and competitive environment of organizations, firms are even more challenged to successfully adopt new technologies such as the Internet of Things (IoT). The benefits are often uncertain, and the investments from a resource and monetary perspective are high. This requires a careful assessment of IoT-enabled services, products, or business models [9]. Besides, we observe limited attention in the scholarly debate about the implementation [e.g., 14] of IoT technology and supporting the practitioners in such a complex and multi-layered endeavor. In this research-in-progress paper, we report on an ongoing construction project from a hospital located in one of Europe's microstates. The old building no longer satisfies all stakeholders' needs in terms of performance and expectations. As part of the current pre-project phase, the hospital seizes and scopes the potentials associated with IoT for various use cases such as advanced process analytics or asset tracking of medical devices. Against this background, the project managers lack knowledge and

guidance about its successful implementation considering the future organizational structures and processes. This paper aims to develop an IoT implementation framework that guides the project leaders in the successful navigation through different challenges and dynamics during their endeavor. This leads to the following research question: How can we guide organizations in successfully implementing the IoT technology paradigm?

2 Related Work and Research Background

IoT can be understood as a new technology paradigm of interconnected, integrated, interacting devices, machines, and other technologies [1]. From a technical point of view, IoT makes use of sensors based on radio frequency identification (RFID), wireless sensors networks (WSN), middleware, cloud computing, and the IoT application itself, which serves as a user interface [9].
The existing body of knowledge has addressed the IoT in the healthcare and hospitals domain using different perspectives: Feibert and Jacobsen [4] take a business process management perspective on the refinement of the technology adoption theory for a hospital. They identify factors that managers can use to adopt technologies in logistic processes in the context of healthcare. Jha et al. [7] also take a process perspective and discuss dominant issues at the intersection of IoT and business processes. Kodali et al. [8] address the advanced possibilities in data collection and analysis and discuss IoT systems used for enhanced healthcare services for patients in hospitals. They also refer to technical aspects and different applications of interconnected devices for monitoring patients and their health status. Others, such as Mahajan and Gupta [10] focus on the development and architecture of IoT-based applications to measure and monitor the heart rate of patients, for example. In this regard, they also present technologies for medical sensors and observe several data-related issues such as real-time monitoring.

Scholars also addressed technology adoption in the context of healthcare organizations [e.g., 4]. The (adaptive) structuration theory extends the technological aspects by social processes – as major elements of information systems. This theory suggests that the adoption of new technology in organizations is not deterministic but influenced and manipulated by its users within their social context and the relationships they maintain with each other [3, 11]. Because IT alone does not add value to organizations or business processes, scholars also consider the human and social components. According to the socio-technical theory, information systems can be seen as two independent but inter-connected sub-systems. This perspective is one of the fundamental concepts in information systems research to account for both the technical artifacts but also for the people (individuals or groups) within their social context and structure [2, 15].

3 Research Context and Design

3.1 Case Description

The case company is a hospital, which we refer to hereafter as “House of Health (HoH)” or just “hospital”. It is a state-funded hospital in a European microstate. The main tasks

of HoH are to provide primary and emergency care to the local population and those living in nearby foreign countries. HoH decided to build a new hospital at a new location. From a technology and infrastructure perspective, the old building has reached its capacity limits and is also no longer state of the art. The new HoH building will approximately cost between 60 and 70 million Euros and hence has already received a high level of political and social interest. HoH sees this as a chance to incorporate new digitalization trends and technologies to prepare the organization for future challenges in cross-border cooperation, patient services, and safety, for example.

3.2 Design Science Research Methodology

To make the design and research process easy to follow, we refer to the Design Science Research Methodology (DSRM) developed by Peffers et al. [12]. Their methodology consists of six steps and follows a nominal process sequence. Figure 1 illustrates the research process. This paper presents the results until phase 3 ("design and development"). Towards the end of this paper, we discuss the future steps of our research.

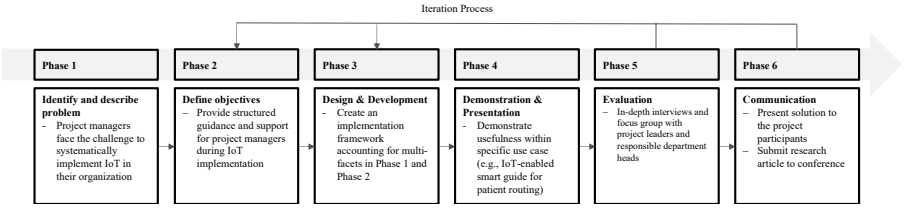

Fig. 1. Our research process adapted from Peffers et al. [12].

Identification of Problem and Definition of Objective (Phase 1 & 2). To understand the problem and scope of this research project, two authors engaged with the responsible experts of the new building project. First, we held a Zoom call to understand the bigger picture of this construction project and the general intention to implement IoT. Subsequently, the first author was then invited to a physical workshop addressing the future IT landscape, with a major focus on IoT. Besides the two project leaders and the first author, four additional department heads of the hospital were present and are part of the core project team. Two external IT specialists led the workshop and set the agenda for the day. They advise HoH in the dimensioning and procurement transactions for IT hardware (e.g., servers, fiber optic cables, etc.). The first author took the position of a silent observer and transcribed the conversations among the workshop participants. The handwritten notes were typed into MS Word on the same day for further processing, and the second author then reviewed the manuscript and checked the notes for consistency as well as validity. The main statements from the two project leaders are as follows: "*Our vision is to use IoT to track certain patients and medical devices for specific purposes; however, we are not aware of how to systematically use and adopt IoT – it's new for us (project leader 1)*" and "*We aim to implement IoT as a future technology for our new building. However, lack means what is important during this*

implementation and which factors are decisive – also, for which processes does IoT make sense (project leader 2).” Therefore, we hypothesize that an IoT implementation framework consisting of socio-technical elements and degree of intervention (in the organizational context) will positively support, guide, and direct the implementation process for the project leaders at HoH. This framework enables project leaders to identify essential IoT factors and elements as well as supports them in managing their development over the implementation period. Also, the framework aims to promote communication between the project stakeholders due to an increased awareness of the relevant IoT elements and factors (Figure 2).

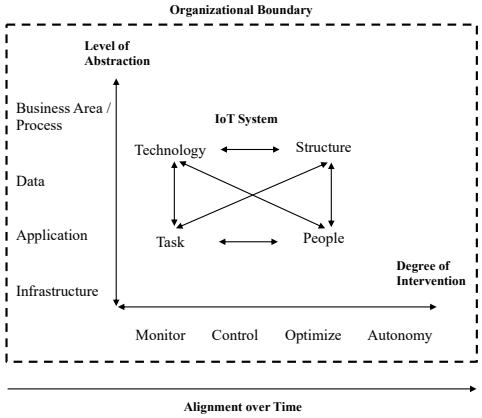

Fig. 2. IoT Implementation Framework [2, 6, 13].

Design and Development of the Artifact (Phase 3). The implementation framework is structured along two dimensions: the horizontal axis, which denotes the degree of the IoT roll-out, consists of the steps monitor, control, optimize, and autonomy, as developed by Porter and Heppelmann [13]. Simultaneously, they represent the degree of intervention between the physical objects (devices) and virtual elements. The vertical axis is represented by enterprise architecture layers [6] to account for the organizational context, including the functional areas and business processes. Here, we replaced “technology” with “infrastructure” to account for sensors, actuators, and other technical requirements. At the center of this implementation framework, we visualize the IoT system as a socio-technical system [16]. The dashed frame indicates the organizational boundary. The underlying rationale behind this framework is based on the adaptive structuration theory to account for the manipulation of this technology during its implementation. Second, the socio-technical theory considers the interaction between the social elements (people, structure) as well as technical elements (technology, task). Therefore, the successful implementation of IoT depends on the alignment and configurations of technological and human elements within their social structures over time. This IoT implementation framework intends to support and provide orientation to the project managers and support them in making informed decisions regarding the adoption of IoT at the organizational level. Moreover, this framework can be used as a communication tool among the responsible stakeholders to coordinate their activities and

use their resources efficiently. Finally, this framework aims to promote a shared understanding and knowledge among the project stakeholders.

4 Discussion, Next Steps, and Conclusion

In terms of the notions and dimensions used, the framework is kept rather generic, which allows to apply it in various use cases. However, each element and dimension can be further specified and characterized. For example, in terms of IoT infrastructure, more fine-granulated layers such as coding or network layer could be added [17]. However, for the moment, we retain a simplified layered structure. So far, we have only engaged with one case company (HoH). Therefore, we plan to extend the number of case companies from different branches facing similar implementation challenges to evaluate our artifact across several contexts. Next, we aim to demonstrate the usefulness of the artifact (phase 4) to solve at least two instances of the problem. This is in line with the intermediate feedback of one of the project leaders: "*Although the current version of this framework is rather abstract for our purposes, we need to check its usefulness in a concrete use case. However, we think it's helpful to grasp the interplay between these elements and better align the needs of the various employees associated with IoT (project leader 1).*" Therefore, as part of our future research, we aim to develop personas, identify use cases, and prioritize them together with the practitioners. Subsequently, we plan to evaluate the artifact according to Venable et al. [18]: our strategy is to conduct an ex-post and naturalistic evaluation of this process-oriented artifact in a real-life setting and use case (e.g., in-house patient routing). Next, we aim to conduct qualitative evaluation methods in the form of in-depth interviews, more specifically with the department heads, and conduct a focus group which is a suitable means for participatory and cooperative research studies between participants and researchers [5]. Our evaluation goal is an increased degree of awareness and coordination among the project leaders. Finally, we see evaluation constraints due to the time- and resource-intensive investments in IoT [18].

Motivated by the need to provide guidance and coordination among key stakeholders responsible for adopting IoT in the context of a state-funded healthcare organization, we developed an IoT implementation framework. Based on our workshop with experts from the hospital, we acquired first-hand insights about the challenges, goals, and motives for such an endeavor. We discussed this first draft and presented the next steps.

References

1. Atzori, L. et al.: The internet of things: A survey. Computer networks. 54, 15, 2787–2805 (2010).
2. Bostrom, R.P., Heinen, J.S.: MIS problems and failures: A socio-technical perspective. Part I: The causes. MISQ. 1, 3, 17–32 (1977).
3. DeSanctis, G., Poole, M.S.: Capturing the complexity in advanced technology use: Adaptive structuration theory. Organ. Sci. 5, 2, 121–147 (1994).

4. Feibert, D.C., Jacobsen, P.: Factors impacting technology adoption in hospital bed logistics. The International Journal of Logistics Management. (2018).
5. Filipowska, A. et al.: Procedure and guidelines for evaluation of BPM methodologies. Business Process Management Journal. (2009).
6. Hewlett, N.E., CEA, P.: The usda enterprise architecture program. PMP CEA, Enterprise Architecture Team, USDA-OCIO. (2006).
7. Jha, S.K. et al.: Implementation of IoT Frameworks in Business Process Automation. In: Proceedings of the 2nd International Conference on ICT for Digital, Smart, and Sustainable Development. , New Delhi, India (2021).
8. Kodali, R.K. et al.: An implementation of IoT for healthcare. In: IEEE Recent Advances in Intelligent Computational Systems (RAICS). (2015).
9. Lee, I., Lee, K.: The Internet of Things (IoT): Applications, investments, and challenges for enterprises. Bus. Horiz. 58, 4, 431–440 (2015).
10. Mahajan, R., Gupta, P.: Implementation of IoT in Healthcare. In: Handbook of Research on the Internet of Things Applications in Robotics and Automation. pp. 190–212 IGI Global (2020).
11. Majchrzak, A. et al.: Technology adaptation: The case of a computer-supported inter-organizational virtual team. MISQ. 569–600 (2000).
12. Peffers, K. et al.: A Design Science Research Methodology for Information Systems Research. JMIS. 24, 3, 45–77 (2007).
13. Porter, M.E., Heppelmann, J.E.: How smart, connected products are transforming companies. HBR. 93, 10, 96–114 (2015).
14. Riggins, F.J., Wamba, S.F.: Research directions on the adoption, usage, and impact of the internet of things through the use of big data analytics. Presented at the 48th Hawaii International Conference on System Sciences (2015).
15. Sarker, S. et al.: The sociotechnical axis of cohesion for the IS discipline: Its historical legacy and its continued relevance. MISQ. 43, 3, 695–720 (2019).
16. Schroeder, A. et al.: Digitally enabled advanced services: a socio-technical perspective on the role of the internet of things (IoT). Int. J. Oper. Prod. Manag. (2020).
17. Sethi, P., Sarangi, S.R.: Internet of things: architectures, protocols, and applications. Int. J. Electr. Comput. Eng. (2017).
18. Venable, J. et al.: A Comprehensive Framework for Evaluation in Design Science Research. In: Peffers, K. et al. (eds.) Design Science Research in Information Systems. Advances in Theory and Practice. pp. 423–438 Springer Berlin Heidelberg, Berlin, Heidelberg (2012).