Towards a X-as-a-Service Application in Industrial Laundry – A Case Study of Information Requirement Engineering in Emerging Data Ecosystems

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Abstract. In past years, Everything- or X-as-a-Service applications have left their mark on the consumer market, changing the landscape of on-demand delivery of goods and services. In recent years, these applications have also gained traction in an industrial context. However, companies are often unable to provide such a service on their own because they lack the necessary data or capabilities. To address this, companies are coming together to be part of larger Data Ecosystems. Based on a case study in industrial laundry, this paper explores the first steps towards a *Laundry-Finish-as-a-Service* application, focusing on the Information Requirement Concept. Based on Action Design Research as a guiding research process, three small to medium sized enterprises – a manufacturer of textile finishing machines, a manufacturer of gas burners as well as an industrial laundry – were scientifically accompanied over the course of eight months, with two workshops and several bilateral in-depth sessions. First results are presented and discussed in order to derive design principles for the Information Requirement Concept for a XaaS application in emerging data ecosystems.

Keywords: X-as-a-Service · Data Ecosystems · Information Requirement Concept

1 Introduction

As a result of the increasing penetration of internet technology in products and processes, a flexibilization of offerings and associated billing models – often under the label *Everything-as-a-Service* or *X-as-a-Service* (XaaS) – can be observed in recent years [1]. While the developments were initially applied in the consumer market in particular; for example, in the on-demand provision of films, music or other private consumer goods. XaaS applications are increasingly finding their way into an industrial context [2].

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The core of XaaS solutions is always the on-demand or usage-based provision of (digital) service [3] – for example, the on-demand provision of compressed air [4]. Due to the higher requirements and greater complexity compared with conventional business models, individual companies are often not able to implement XaaS applications on their own [5]. Instead, several organizations align their capabilities and resources around a collaborative value proposition (i.e., for XaaS, the on-demand provisioning and billing of (digital) service) and share their data in data ecosystems [6–9]. The cross-company availability and processing of data and information are a central challenge in the realization of XaaS applications [10]. In the scientific literature as well as in practice, it can be observed that companies already have difficulties in an early phase of data sharing, namely in the identification and description of the data and information required for the realization of the XaaS solution [11]. This paper therefore addresses the following research question (RQ):

RQ: *How can different actors gather the required data and information as a basis for a XaaS application in emerging Data Ecosystems?*

To address the RQ, relevant background concepts are introduced. Then, the methodological approach and the case study on which this paper is based are described. Finally, the results are presented and discussed.

2 Background

2.1 X-as-a-Service in Data Ecosystems

Recent years have seen a surge of discussion in the academic literature on the topic of Digital Business Ecosystems (DBE) [7, 12]. Underlying this is an understanding of Business Ecosystems in which different actors come together in both collaborative and competitive ways to jointly produce new products, value propositions – ultimately new innovation – through combinations of the actors' different capabilities [8]. Adner (2017) highlights the importance of the collaborative value proposition, seeing it as the central aspect in the ecosystem to which actors align their activities and capabilities to contribute to the collaborative value proposition [6].

Data Ecosystems are understood as a special form of DBE and focus on the exchange of data between the actors of the ecosystem [9]. The exchange of data helps the actors to gain a broader database and can be the basis for the realization of new value propositions. Data Ecosystems are therefore understood in this paper as follows: they refer to multiple economic actors that come together in a collaborative as well as competitive manner and share data with each other with the goal of realizing a common value proposition [6, 9]. Since the case study described below involves three companies, we will refer to the environment as an emerging data ecosystem.

The definition of XaaS has changed over time, as it has been closely tied to technological developments in software architecture and cloud computing for many years [1]. In recent literature, the term is increasingly appearing in discussions of data-driven business models in ecosystem scenarios [3]. XaaS is the on-demand delivery of IT-based services, such as production capacity, that can be used as the basis for new business

models. Building on the previous sections, this paper understands XaaS as a collaborative value proposition to deliver IT-enabled, on-demand services. This understanding is further applied to the concept of *Laundry-Finish-as-a-Service.*

2.2 Information Requirement Concepts

The transfer of data between various stakeholders within a data ecosystem is crucial for the implementation of innovative digital business models [11]. However, both practical experience and scientific literature reveal a number of concerns about data sharing [10]. One challenge is that players often find it difficult to formulate their data and information needs transparently. Other players in data ecosystems also struggle to align their data and information offerings with existing needs. To describe the exchange of data and information in data ecosystems [13], information requirement concepts can be utilized. Information requirement concepts provide tools and criteria to describe data and information for exchange. They form the foundation for effective communication between data users and providers [14].

3 Methodology

3.1 Action Design Research

To address the research question presented in this paper, we utilized Action Design Research (ADR) methodology [15]. This approach involves the scientific investigation of problems while simultaneously developing practical solutions. The researchers were not merely observers of the processes but were actively involved in developing solutions via an interactive approach. The research approach is well-suited for exploratory scenarios that necessitate close collaboration with actors from the field. ADR aims at iteratively developing a socio-technical "ensemble artifact" [15], which takes the form of an information requirement concept for an XaaS application in industrial laundry. The concept was developed in two workshops and several bilateral one-on-one meetings. The researchers prepared and moderated the workshops, and photo protocols were used to document them. Memory protocols were used to document the bilateral one-on-one meetings between the organizations. These protocols and documentation served as an empirical basis for a qualitative analysis according to Mayring [16]. Figure 1 summarizes the activities:

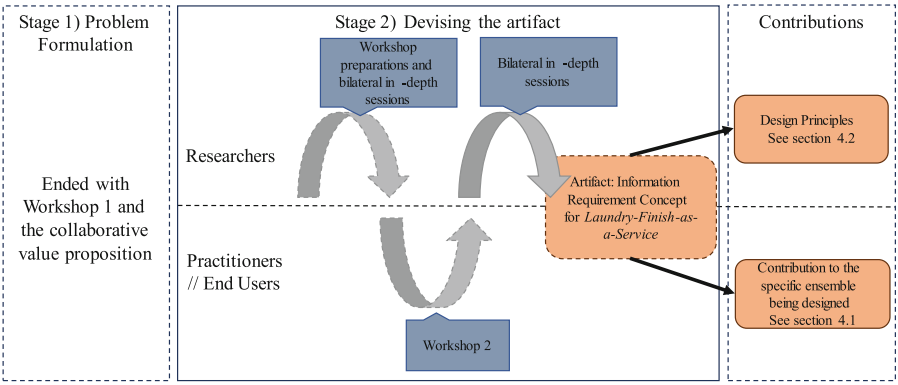

Fig. 1. Summary of the research process, based on Sein et al. [15]

3.2 Case Study in Industrial Laundry

The case study (CS) and collaboration with business partners (BP) began in January 2022 and lasted approximately 8 months until August 2022. The project involved three companies, 1) a textile finishing machine manufacturer, 2) an industrial laundry, and 3) a gas burner manufacturer, to jointly conceptualize the collaborative value proposition: to come together in an emerging data ecosystem that enables the participating partners to develop a *Laundry-Finish-as-a-Service* application. The application intends to furnish textile finishing machines with data and information to execute laundry drying and finishing on demand based on the type, quantity, and condition of laundry available, as well as the efficient utilization of downtime. Table 1 summarizes the CS:

Textile finishing machines use gas burners to heat air and dry laundry gently and quickly. Damp laundry is loaded onto the machine via transport systems, guided through a drying chamber, and transferred back to the transport system as dry laundry. The drying chambers can also be ventilated to adjust the temperature and airflow in the chamber. Modern textile finishing machines have various drying programs to effectively dry laundry items of different fabrics. The responsibility of selecting the appropriate drying program lies with the operator of the industrial laundry. Inaccurate selection results in repeated feeding of laundry to the textile finishing machine, leading to wastage of time and energy. If the machine does not receive any laundry for an extended period, gas burners in the drying chamber can be adjusted to save energy. The project aims to enable the textile finishing machine to autonomously choose the suitable drying program and to optimize downtime by collecting pertinent contextual data, laying the groundwork for a *Laundry-Finish-as-a-Service* application. Considering the project partners, these machines are utilized in industrial laundry and are manufactured by the same company that designs the transport system and textile finishing machines. The drying chamber includes a gas burner designed and configured by the manufacturer of gas burners. Figure 2 schematically visualizes the process and involved objects of laundry finishing:

Table 1. Overview of the CS

Emerging Data Ecosystem		
Business Partner (BP)	Number of Employees	Participating Persons
(BP1) Textile Finishing Machine Manufacturer	~ 50	Managing Director, Head of Construction, Expert for Machine Control System
(BP2) Gas Burner Manufacturer	~ 10	Managing Director
(BP3) Industrial Laundry	~ 100	Managing Director, Expert for Machine Control Systems
Activities overview		
Workshop Date	Workshop Duration	Focus of Discussion
18.04.2022	~ 3 h	Conception of the collaborative value proposition. Elaboration of the benefits of the business partners
14.06.2022	~ 3 h	Specification of the relevant data and required information
Accompanying bilateral one-on-one meetings between the business partners and the research team		

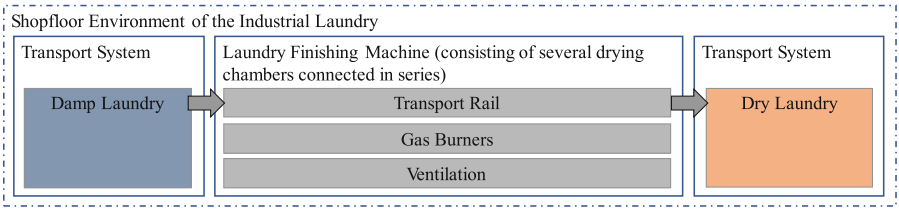

Fig. 2. Schematic of the laundry finish process and objects involved

4 Results

4.1 Information Requirement Concept for *Laundry-Finish-as-a-Service*

The objective of the second workshop was to collect information on the requirements for implementing the *Laundry-Finish-as-a-Service* application. Representatives from all the companies involved met for this purpose. As part of the workshop preparation, we identified the relevant objects needed to realize demand-driven laundry finishing: the transport systems before and after the textile finishing machine, the machine itself and relevant sub-systems, such as the transport rail on which the laundry is guided through the drying chamber, the gas burner, and the ventilation. We then discussed which data and information from these objects would be required to realize the textile finishing on demand. The company representatives were able to determine directly whether the objects in question

can provide corresponding data and whether additional sensor technology should be added. Figure 3 summarizes the concept:

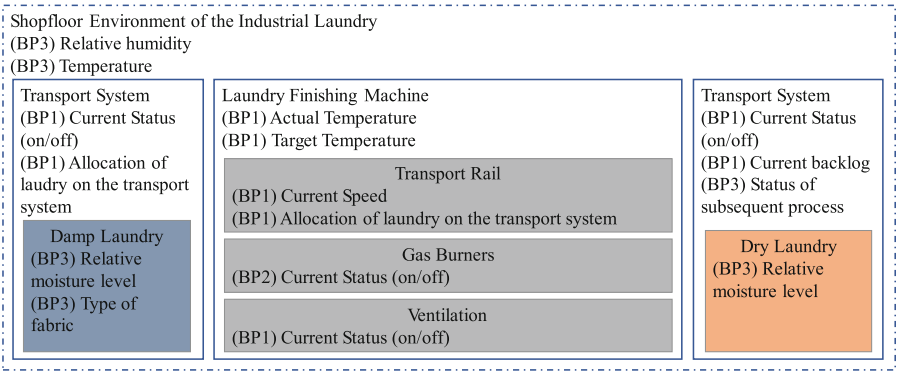

Fig. 3. Information Requirement Concept for a XaaS application Industrial Laundry

4.2 Emerging Design Principles

From the experiences of the activities of the CS, design principles (DP) can be extracted for the design of information requirement concepts in emerging data ecosystems:

Bringing together diverse stakeholders in companies was found to be effective. Although a comprehensive understanding of the finishing process was necessary, evaluations from domain experts on machine controls for various objects and machines quickly identified available or potentially obtainable data and information. While the managing directors contributed their domain-specific knowledge, such as the managing director of the industrial laundry outlining the specifics of drying different fabrics and the interplay between drying and surrounding processes, experts for design and machine controls from BP1 and BP3 also participated in the workshops.

DP1: Assemble the stakeholders possessing both domain-specific and technical expertise to identify relevant data and information for the intended service and to consider technical feasibility.

The collaborative discussion in the workshops between stakeholders provided a secondary benefit. During the initial workshop, potential areas for optimization were identified, particularly through the discussions between the representatives of BP2 and BP3, who would otherwise not be in direct contact with each other. The comprehension of the interaction between individual objects and components during real-world use was a crucial requirement for conceiving the *Laundry-Finish-as-a-Service* application as it revealed a divergence between the intended and actual use of the laundry finishing machine. Achieving this level of transparency ensures that requirements are established based on real-life scenarios.

DP2: Bring together stakeholders responsible for relevant processes helps to establish transparency regarding the use and interdependence of relevant objects. This also ensures that requirements are derived from real-life scenarios.

Particularly in an environment dominated by small and medium-sized enterprises (SMEs), where familiarity with digital service design may not be a prerequisite, focusing on objects proved effective in identifying information needs. The object-focused approach was intuitive for even those without IT-specific expertise, facilitating goal-oriented discussions. Building the discussion around objects, like the transportation system or the textile finishing machine and its components, that were familiar to all participants was found to be helpful, especially in the second workshop and in the more in-depth individual discussions.

DP3: Focus on objects to provide an intuitive method for participants with no or little prior experience in digital service creation for the assessment of the information requirements.

In-depth discussions with machine control experts revealed that much data and information exists solely within the control systems of respective objects. However, to implement the concept, data must be aggregated and analyzed across different objects and companies. Acquiring relevant data from machine control systems and providing adequate connectivity to bridge different systems, would require considerable effort, the experts said. Utilizing Internet-of-Things technology can achieve interoperability between object data [17].

DP4: To aid interoperability use Internet-of-Things technology where possible to interconnect different smart objects.

5 Conclusion and Limitations

This paper outlines a concept for object-focused information requirements engineering in emerging data ecosystems. The concept serves as the basis for implementing a *Laundry-Finish-as-a-Service* application. This application delivers dry laundry on-demand, based on the type, quantity, and condition of laundry in an industrial laundry context. To meet the information needs of various companies' objects, they are collaborating to share data in an emerging data ecosystem. This effort was the first foray into digital service creation for the participating companies, stemming from the textile finishing machine manufacturer's desire to innovate its service model. For practitioners, the paper provides insight into the first steps of the process of developing an XaaS application. DP based on the experiences of the described activates prescribe actions for conceptualizing information requirements within an emerging data ecosystem, specifically targeting SMEs [18]. From a scientific perspective the study adds to body of literature outlining activities in digital service innovation in the context of SMEs [5, 19].

Unfortunately, the cooperation and advancement of the *Laundry-Finish-as-a-Service* application was suspended in early September 2022 owing to the European energy crisis that arose at that time. With a focus on new challenges in the operational business, the business partners could no longer guarantee the necessary commitment to the further development of the XaaS application. Thus, the research team intends to continue the collaboration and specifically implement a prototype of the conceptualized application. The work leaves ample room for further development and research. From a scientific standpoint, numerous intriguing questions will emerge throughout the project's progression, such as the critical elements in crafting appropriate billing models or inquiries

concerning liability and warranties for XaaS applications. The authors aim to examine these matters in future research.

Finally, this study has limitations. The generalizability based on a single case study must be considered. The study presents the methodological approach and results of information requirement engineering in an emerging data ecosystem within the context of industrial laundry. It is essential to note that not all findings in this study can be applied to the development of XaaS applications in general. However, the authors argue that they have achieved an apt abstraction of the outcomes with the DP discussed, enabling their portability to diverse contexts [18].

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