TECHNISCHE UNIVERSITÄT DRESDEN

FACULTY OF BUSINESS MANAGEMENT AND ECONOMICS
CHAIR OF WIRTSCHAFTSINFORMATIK,
ESP. SYSTEMS DEVELOPMENT

# Design and Evaluation of Domain-Specific Platforms and the Special Case of Digital Healthcare

by

Martin Benedict, M. Sc.
born August 19th, 1986

**DOCTORAL THESIS**

submitted to

The Faculty of Business Management and Economics
Technische Universität Dresden

in partial fulfillment of the requirements for the degree of

**Dr. rer. pol.**

Date of submission: November 4th, 2019
Date of defense: April 28th, 2020

supervised by:
Prof. Dr. Werner Esswein
Prof. Dr. Susanne Strahringer

# Vorwort

*Wissen ist wie ein Baum: Je größer und verzweigter er ist, umso ausgeprägter ist sein Kontakt mit dem Unbekannten.*

Blaise Pascal

Als ich begann, mich nach meiner Berufsausbildung intensiver mit Medizinischer Informatik und der Integration von Informationssystemen zu beschäftigen, erschien mir die Gestaltung interoperabler Softwarearchitekturen und die Entwicklung von Kommunikationsstandards als Schlüssel zur Lösung aller Probleme im Bereich digitaler Innovation im Gesundheitswesen. Im Zuge meiner weiteren Stationen, über Studium der Informatik, Tätigkeit in der freien Wirtschaft bis hin zu meiner jetzigen Tätigkeit als Wissenschaftler im Feld der Wirtschaftsinformatik lernte ich jedoch, dass Probleme in Innovationsprojekten nicht allein aus mangelnder technischer Reife hervorgehen, sondern von einer vielfältigen und bisweilen amorphen Menge sozialer, organisatorischer, legislativer und projektindividueller Einflussfaktoren getrieben sind.

Nicht nur einmal stellte ich mir die Frage, ob Innovation in unserem deutschen Gesundheitswesen überhaupt realisierbar ist. Die Implementierung von Standards ist auch heute noch unzureichend, die deutschlandweite Patientenakte lässt nach wie vor auf sich warten und moderne Softwarearchitekturen werden durch große Unternehmen nur zögerlich umgesetzt. Der Wille zur Gestaltung offener Systeme, wie auch die Akzeptanz von Standards, entwickelt sich nur zögerlich.

Diese Problemlage, die Beschäftigung mit der Plattformökonomie sowie bestehende Forschungsprojekte am Lehrstuhl weckten in mir den Forschungsanreiz, dass es möglich sein müsste, diesem Spannungsfeld mit der Implementierung von Plattformen zu begegnen. Plattformen können zu neuen Anreizssystemen für Innovationen führen. Beispiele im Konsumentenmarkt haben dies eindrucksvoll gezeigt. Gleichsam bestehen im Gesundheitswesen aber auch spezifische Herausforderungen, die mit dem konventionellen Endkundenmarkt wenig Gemeinsamkeiten aufweisen. Echte plattformökonomische Ansätze haben sich daher bislang nur in geringem Maße etabliert. In den letzen sechs Jahren habe ich mich daher mit der Frage auseinandergesetzt, welche Eigenschaften Plattformen im Gesundheitswesen aufweisen sollen und wie diese entwickelt werden können. Dies führte zu mehreren Forschungsbeiträgen,

welche in der vorliegenden Dissertation reflektiert werden. Ich freue mich, diese Station meines Lebens und meiner akademischen Laufbahn abschließen zu können und möchte mit diesen Zeilen allen meinen großen Dank ausdrücken, die mich dabei motiviert und unterstützt haben.

Allen voran danke ich meinem Doktorvater Professor Dr. Werner Esswein für alle profunden Hinweise und kritischen Diskussionen sowie für die Möglichkeit, neben meiner Dissertation auch meine akademischen Fähigkeiten in der Forschung und Lehre ausbauen zu können. Ich danke ihm für die Freiheiten und Möglichkeiten, die er mir durch die Mitarbeiterschaft an seinem Lehrstuhl eröffnet hat. Frau Professor Dr. Susanne Strahringer danke ich ebenso für die sehr gute Zweitbetreuung und die umfassenden Diskussionen, die auch außerhalb offizieller Termine möglich waren.

Meinem hochgeschätzten Kollegen Dr. Hannes Schlieter danke ich besonders für die langjährige Begleitung und die Unterstützung auch in schwierigen Phasen meiner Doktorandenzeit. Ich danke ihm für alle intensiven Diskussionen, Denkanstöße und aufgezeigten Perspektivwechsel. Er wurde mir zu einem wichtigen akademischen Mentor und vor allem zu einem guten Freund.

Weiterhin danke ich allen meinen jetzigen und ehemaligen Kollegen am Lehrstuhl. Insbesondere möchte ich dabei Dr. Martin Burwitz, Dr. Richard Braun, Peggy Richter, Marcel Susky, Tim Scheplitz und Stefanie Kaczmarek für allen wissenschaftlichen Diskurs und die gemeinsame Entwicklung von Forschungs- und Entwicklungsideen danken, die auch die vorliegende Dissertation maßgeblich beeinflusst haben. Unserer Lehrstuhl-Sekretärin Frau Gerstenberger danke ich, dass sie jederzeit ein offenes Ohr für alle kleinen und großen Probleme in Forschung und Lehre hat. Die Überwindung formaler und administrativer Hürden im Zuge dieser Dissertation gelang auch durch ihre Unterstützung.

Ich widme diese Dissertation meiner Frau Christina sowie meinen drei Söhnen Friedrich, Eduard und Theodor. Ihnen gilt mein inniglichster Dank. Sie haben alle meinen beruflichen Vorhaben und die vielen Stunden, die ich mental als auch physisch mit meiner Doktorarbeit verbracht habe, ertragen und bedingungslos unterstützt.

Martin Benedict
Sehmatal-Cranzahl, den 12. September 2019
S. D. G.

# Contents

# List of Figures

# List of Tables

# List of Abbreviations

**ADR** Action Design Research

**CDA** Clinical Document Architecture

**DREEM** Dresden Ecosystem Management Method

**DSR** Design Science Research

**HL7** Health Level Seven

**HL7v2** Health Level Seven Version 2

**HL7v3** Health Level Seven Version 3

**FHIR** Fast Healthcare Interoperability Resource

**FuR** functional requirement

**FeR** feature-based requirement

**ICT** information and communication technology

**IHE** Integrating the Healthcare Enterprises

**IOIS** interorganisational information system

**IS** information system

**ISR** information systems research

**ISDT** Information System Design Theory

**MMEI** Maturity Model for Enterprise Interoperability

**MPI** master patient index

**IT** information technology

**NFR** non-functional requirement

**RO** research outcome

**SME** small and medium enterprise

**SDO** standards developing organisation

**TR** theory-based requirement

# A. Synopsis of the Doctoral Thesis

## Contents



This synopsis corresponds to ”gesonderte Abhandlung” in §10(3) PromO 2018.

# 1. Introduction

## 1.1. Background

The digital transformation permeates all sectors of the economy (Baller et al., 2016, p. xii). Also, the healthcare industry is faced with a strong demand for digitisation (Thun, 2015; Thiel et al., 2018). Digitisation in this sector has reached political decision-making and has lead to governmental directives that explicate this demand. In Germany, for example, the Federal Ministry of Health has initiated an eHealth law (Bundesministerium für Gesundheit, 2019). This law was created with the aim of accelerating digitisation in the healthcare industry. Following the World Health Organisation (2019), eHealth is the ”use of information and communication technology (ICT) for health”. The delivery of digital healthcare promises positive effects like cost-efficiency, optimised treatment outcome, the delivery of high-quality care in the rural areas and stronger interdisciplinary care delivery (Lux et al., 2017; Schweitzer and Synowiec, 2012; Elmer, 2016). Digital innovations in the healthcare industry and care innovation through digitised care models are manifestations of the digitisation in the healthcare sector (Hwang and Christensen, 2008; Wessel and Gersch, 2015). While digital innovations represent the product and process innovation, digitised care models represent organisational innovations which are supported by ICT (Omachonu and Einspruch, 2010, p. 5).

However, over the last years, many innovation projects could not reach a sufficient level of maturity to be transferred into widespread adoption (Andreassen et al., 2015; Gersch and Rüsike, 2011, pp 10 f.). eHealth projects are often delayed, completed at higher costs than planned or failing to achieve the intended treatment outcome (Murray et al., 2011; Ekeland et al., 2010). The implementation of interorganisational information systems (IOIS) often does not reach the necessary level of digitised integration. Different authors identified a broad range of challenges and barriers which negatively affect the successful implementation of eHealth. Important barriers and effects are named in figure A.1 and are further explained and verified in appendix a.

In order to overcome these barriers, a lot of efforts are necessary which can hardly be fulfilled by small and medium enterprises (SMEs) as well as self-employed innovators. These efforts can be reduced by providing eHealth platforms. There is a consensus that they can drive the success of eHealth innovations and support their scaling-up (Lauterbach and Hörner, 2019; Accenture, 2016; Fürstenau and Auschra, 2016; Labrique et al., 2018; Alstyne et al., 2016). Platforms create a modularised foundation which innovators can use to create own innovations and provide them to demanders of digital solutions (Yoo et al., 2010;

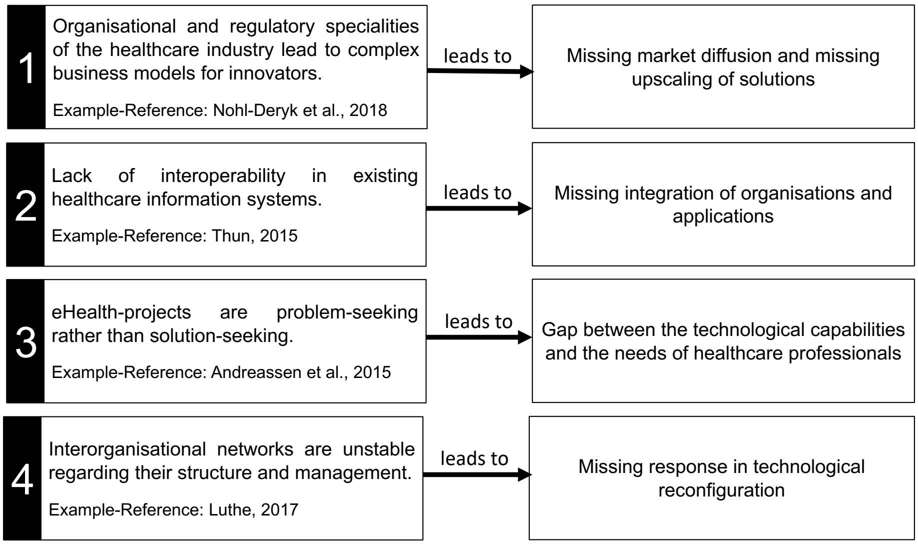


Figure A.1.: Barriers for implementation of eHealth, explanation in appendix a

Eisenmann et al., 2008). In the last years, many public and commercial projects have been initiated to implement regional eHealth platforms. Also, national initiatives have created nationwide eHealth platforms (Benedict et al., 2018) and eHealth infrastructures (Aanestad et al., 2017, p. 14).

## 1.2. Subject and Motivation

EHealth-platforms are digital platforms in the healthcare sector. Digital platforms are a specific type of platforms that support the creation of information systems. They are established on an existing digital infrastructure (e. g. the internet or parts of it) and comprise digital services (Blaschke et al., 2019; Hanseth and Lyytinen, 2010; Henfridsson and Bygstad, 2013). Platforms with pre-existing consumable and configurable generic services create a basis for an efficient IOIS-design and foster digital innovation by providing reusable components (Fedorowicz et al., 2004; Cusumano, 2010; Zimmermann et al., 2015)[1].

Platform thinking enhances product thinking by defining the ability of products to be complemented with new services and technologies by third parties (complementors) (Cusumano, 2010; Iansiti and Levien, 2004). This enables functional gaps of a product to be closed by the complementors[2]. The system of interrelated innovations which emerges around the platforms is called an *ecosystem* (Iansiti and Levien, 2004). It is the environment around the plat-

[1] In the following, the term ”platform” always means digital platform.

[2] An example of a digital platform is “salesforce” (`www.salesforce.com`). It enables the consumption of electronic services for distribution and sales. Furthermore, it allows third-party providers to complement it (`appexchange.salesforce.com`).

form where demand-side platform users (consumers of services), supply-side platform users (complementors) and platform providers interact (Eisenmann et al., 2008; Tiwana, 2015).

Different perspectives on platforms have evolved in various fields of research (see figure A.2). While the market-oriented perspective emphasises the relationship between the different user-groups of a platform, the engineering view analyses the role of platform architecture and governance for successful platform realisation (Gawer, 2014).

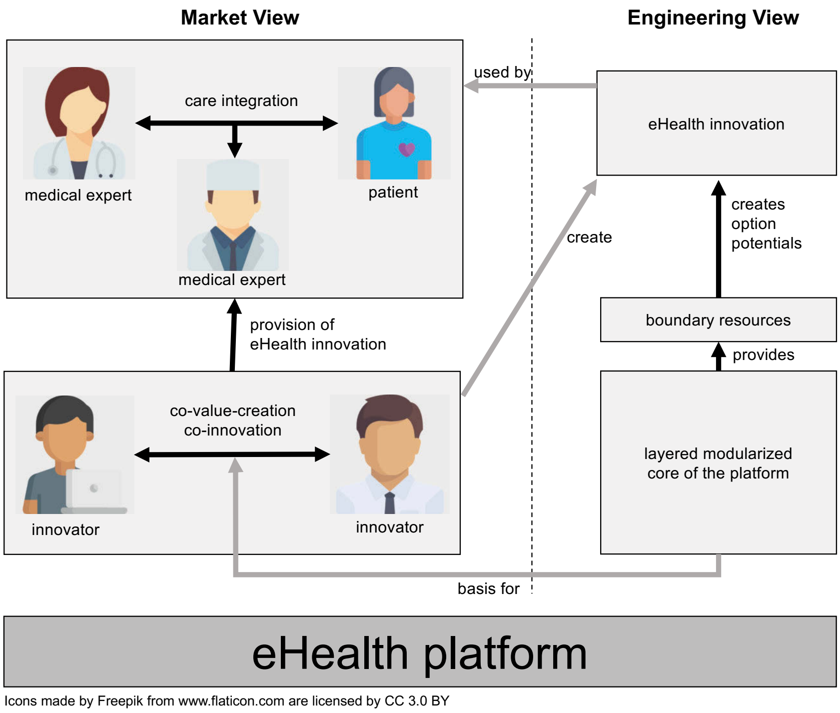


Figure A.2.: Market and engineering view to eHealth platforms following the perspectives of Gawer (2014)

From the market perspective, network effects (see section 2.1) are an important reason why platforms have been proposed in the field of eHealth (Vimarlund, 2016, p. 14). The healthcare sector is very disaggregated and consists of many independent stakeholders. Nevertheless, an aim is that these stakeholders work closely together in order to deliver comprehensive care to patients (Amelung et al., 2012).

EHealth-platforms facilitate the mutual integration of medical experts (direct network effects) and enable innovators to integrate their solution into existing healthcare networks (indirect network effect) (addressing barrier 1, see figure A.1). Furthermore, eHealth platforms aim to improve the integration of different health information technology products and lead to a reduction of integration and implementation efforts for application system interfaces (addressing barrier 2). This leads to easier cooperation between vendors (direct network effects). Last but not least, the group of patients is also increasingly important for the provision of digital health services. Consequently, they are a user group in digital health platforms, too. The more medical experts use platform services, the more patients are likely to adopt digital innovations of platforms (indirect network effect). (Ruotsalainen 2017, p. 74; Fürstenau and Auschra 2016; Gawer 2014)

Platforms allow the definition of regulated markets (Boudreau and Hagiu, 2008). Hence, they could be used as a catalyst for regulatory specialities of the healthcare sector and facilitate the set-up of business models for innovators and of eHealth-based care model adopters. Thus, platforms can contribute to a middle-out-innovation approach (Coiera, 2009) by implementing an innovation base, on which bottom-up innovators[3] can create new care models as well as digitised healthcare innovations (addressing barriers 1 and 3).

From the engineering perspective, platforms promise modular architectures which enable the flexible recombination of technological components (Baldwin and Woodard, 2008). They deliver a degree of autonomy to the complementors (see section 2.1). The versatility in eHealth innovation needs flexible environments, which are able to connect many different stakeholders and allow the implementation of solutions for different use cases (Iyawa et al., 2016). EHealth-platforms provide the "option potentials" (Baldwin and Woodard, 2008, p. 19) to develop both care innovations as well as technological eHealth innovations (addressing barrier 4). The access to the platform for different user groups is provided by boundary resources (Ghazawneh and Henfridsson, 2013). The design of boundary resources is essential for a successful ecosystem composition (Ghazawneh and Henfridsson, 2010). EHealth-platforms can provide such boundary resources by deploying standardised interfaces and reusable services. The specification of boundary resources and a corresponding platform architecture is accompanied by governance measures (Tiwana, 2014). For example, the Danish healthcare system provides technical facilities as well as organisational rules for the interconnection of different application systems (Kierkegaard, 2013). Another example are the Finish Kanta-services which provide an Health Level Seven (HL7) Fast Healthcare Interoperability Resource (FHIR)-based infrastructure for the integration of third-party applications (Cleary et al., 2017, pp. 38 ff.).

The implementation and provision of a digital platform is governed by the platform owner (Eisenmann et al., 2008). In the healthcare sector, different stakeholders occur as platform owners. National authorities, hospitals and other healthcare institutions as well as private institutions (e. g. software vendors) have implemented platforms (Benedict et al., 2018). Last but not least there are also platforms that were set up by consortia of companies and healthcare institutions. Depending on the role of a platform owner in the healthcare sec-

[3] Following Chowdhury (2012), bottom-up innovation in the field of healthcare means that innovation is driven by individual entrepreneurs and healthcare professionals (bottom-up innovators). Top-down innovation means innovation which is driven by governmental or corporate leadership. The latter often is implemented by large-scale projects.

tor, he or she may have different rationales to implement a platform. For platform owners, it is relevant how they should design their platform architecture, how well their platform performs and how they should establish their platform strategy to enable a successful and wide-ranging ecosystem with many supply-side-users and complementors (Saarikko, 2016). The strong interdependency between platform design and ecosystem dynamics is one constitutive characteristic of platforms (Tiwana et al., 2010). It is one of the central research objects in this doctoral thesis (see section 2.2).

Ecosystem dynamics may also appear as negative effects. Therefore, platforms can disappear or fail to be successful. For example, in the field of mobile platforms, Symbian initially had a growing user base, but suffered complex boundary resources. As a consequence a negative reception of supply-side users emerged. Meanwhile Apple facilitated the use of platform resources by strong governance and control and achieved a significant growth of supply-side users (Tilson et al., 2011). Consequently, the design of the platform boundary resources and the definition of governance-measures should be conducted in a systematic way when implementing platforms. They facilitate or hamper the growth of the platform. Additionally, a continuous monitoring of their surrounding ecosystems helps to identify adverse events (e. g. large-scale exodus of complementors). From a scientific perspective, digital platforms with their architecture are an output of a design process. The surrounding ecosystems are also objects of design, even if they cannot be designed directly but only by governance and architectural decisions regarding the platform (Jacobides et al., 2018; Ghazawneh and Henfridsson, 2011; Tiwana, 2014). Tiwana et al. (2010) term the plan of how an ecosystem develops as the "ecosystem blueprint". Different aspects of ecosystem design have already been questioned. For example, the alignment of platform strategy (Ghazawneh and Henfridsson, 2011), the design of boundary resources (Bianco et al., 2014) as well as central concepts of platform design (Schreieck et al., 2016) have been described in the literature. In several domains like in the healthcare sector (Christensen et al., 2014; Serbanati et al., 2011) or in the field of industrial applications (Petrik et al., 2018) the design of platforms and ecosystems has already been questioned. These research works focus on the outcome dimension and the impacts in the specific domains. *However, even if the concepts of platform and ecosystem design are well investigated, a comprehensive design methodology for domain-specific platforms has not been established yet*. Thus, there is a need for design guidance on how to create viable ecosystems and platforms that enable ecosystems in specific domains. *In particular, a systematic approach to develop eHealth platforms is missing.*

As a consequence of the view of platforms and ecosystems as objects of design, they are also objects of evaluation (evaluands) (Venable et al., 2012; Prat et al., 2015). Aspects of evaluation differ according to the design objectives (e.g. flexibility for innovations, openness for better adaptability, more dynamic markets, generativity). However, these objectives differ from traditional IS artefacts (reducing costs or time and foster utility) and may also differ between domains in which platforms are introduced. Established evaluation criteria (utility, feasibility, efficacy etc. in Prat et al. 2015) are not directly applicable to the evaluation of digital platforms. Existing evaluation approaches for platforms focus on openness of platforms (Anvaari and Jansen, 2010; Benlian et al., 2015), innovation capabilities (Riedl et al., 2009) or generativity (Elaluf-Calderwood et al., 2011). These works concentrate on solitary aspects of evaluation and are not integrated into a larger context covering different outcomes of platform utilization. From the evaluators' perspective, the existing evaluation frameworks may be appropriate to evaluate digital platforms and platform models (e.g. Cleven et al., 2009; Venable et al., 2012; Prat et al., 2015). Nevertheless, it has to be questioned what the different evaluation criteria (e.g. utility, efficacy) mean for platforms in the healthcare sector and which aspects need to be considered when evaluating these platforms. To gain a practically applicable set of evaluation criteria for eHealth platforms it is necessary to map effects of the ecosystem to the concrete systemic properties of the healthcare sector.

Existing evaluation frameworks do not define this nexus as they do not focus on specific kinds of platforms and specific domains in which ecosystems are created. Consequently, there is not much guidance to evaluate platforms in the healthcare domain. *Regarding the evaluability of platform projects in healthcare, there is a lack of comprehensive evaluation guidance that focuses on both organisational as well as technological aspects.* Such guidance would help to create comparable evaluation results between different studies, improve the rigour of design science studies that focus on eHealth platforms and support researchers as well as practitioners to set up a platform or platform model in the field of the healthcare sector.

The motivation of this doctoral thesis is to provide guidance for platform design and evaluation in the healthcare sector to improve the diffusion of innovations in digital healthcare through innovation-friendly platform-based ecosystems. It addresses the named gaps and contributes by introducing a set of methods for the development and evaluation of eHealth platforms. In order to achieve this goal, it presents ten papers that address design and evaluation issues of platforms. They describe how to specify platforms and their surrounding ecosystems in specific domains.

## 1.3. Research Design

According to Becker et al. (2003), the research objectives of a research project closely depend on the scientific position. They determine the methodical approach of the research work. In Wirtschaftsinformatik as well as in Information Systems Research the pluralism of methods leads to a high individualism of research plans. Therefore, the researcher has to explicate the scientific positions of his research (Becker et al., 2003, p. 3). He or she also has to disclose the methodical setting and the research objectives which determine the concrete instantiation of this methodical setting (Becker et al., 2003, p. 5). These three parts of the research design are introduced in the following subsections.

### 1.3.1. Philosophy of Science

When describing the scientific position, three positions should be explicated: the ontological position, the epistemological position and the linguistic position (Becker et al., 2003). When describing the concept of platforms and the surrounding ecosystems, it stays vague whether existing systems are structured and behave as the ecosystem metaphor (Moore, 1993) suggests. As a consequence, the author assumes an open ontological position (Becker et al., 2004). The existence of a subject-independent reality can neither be denied nor confirmed (Becker et al., 2003). The conceptualisation of ecosystems and platforms is always bound to the understanding of the researcher (Blaschke et al., 2019). Therefore, the epistemological position of this thesis follows moderate constructivism (Schütte, 1999; Becker et al., 2004).

According to the subject-bound epistemological position, the linguistic position is also subject-bound (Becker et al., 2003). The terminology around platforms and ecosystems must be internalised by a researcher and integrated into the own subjective mind-set. Semantics are created by an individual researcher or via interpersonal verification by a community of discourse (Becker et al., 2003). Unambiguous meanings for language artefacts are not possible. Consequently, there cannot be a generalised intersubjective communication between researchers. However, a community of speakers is able to define interpersonally verified elementary language artefacts which can be used for the documentation of subjective mind-sets. These elementary language artefacts can be formed by consensus (Becker et al., 2003). Based on consensus and the internalisation of the language artefacts, this thesis follows the coherence theory of truth, which defines consensus as a specific criterion for coherence (Schütte, 1999, p. 231). Coherence is given if a specific statement is true in the context of other coherent statements (Schütte 1999, p. 230; Rescher 1996, pp. 58, 69 ff.). In this work, a consensual theoretical basis can be identified when understanding ecosystems as multilateral structures that are created around a focal product (the platform) in order to provide added value for the participants in the ecosystem (Adner, 2017; Jacobides et al., 2018; Eisenmann et al., 2008; Iansiti and Levien, 2004). Even if these systems cannot be objectively observed, existing research regarding ecosystems and platforms forms a set of consistent statements in the context of more abstract organisational theories (e.g. Peltoniemi and Vuori, 2004) and digital infrastructure theories (e.g. Tilson et al., 2010).

### 1.3.2. Research Objective

As introduced in section 1.2, there is a need for the guidance of design and evaluation of eHealth platforms. Guidance can be created by describing methods and models (Hevner et al., 2004), by describing Information System Design Theory (ISDT) (e.g. design principles) (Gregor and Jones, 2007; Walls et al., 1992) and by implementing instantiations of artefacts as a demonstration how a class of problems can be addressed by a specific artefact (Gregor and Hevner, 2013). Hence, this research work can be assigned to the stream of Design Science Research (DSR) (March and Smith, 1995; Hevner et al., 2004). Design-oriented contributions aim to explain how components in a system and their relationships should be organised (Walls et al., 1992, p. 42) and why a specific system composition is working (Kuechler and Vaishnavi, 2012). Systems in this understanding can be organisational, technological or socio-technical systems. Design-oriented research seeks to describe how systems can be transformed to new states (Becker et al., 2003, p. 12). Consequently, research objectives should focus on the measures for system design and the intended states and properties of a system to be designed (Österle et al., 2011, p. 8).

In particular, in Wirtschaftsinformatik, the construction of generic models and methods is a typical aim for design-oriented research work (Winter et al., 2009; Österle et al., 2011). Based on the strong dependency between the creation of models and the application of methods (Winter et al., 2009), two aspects for the design of eHealth platforms need to be addressed. First, the components of a platform, the elements of the ecosystem and their relationships need to be described structurally (platform and ecosystem model). Second, the methodical setting focusing on the actions to create the models (construction method for eHealth platforms) needs to be specified. These two aspects result in the following research objective, which justifies the further research questions and methods.

**Research Objective.** *The research objective is to create methodical and structural guidance for the design and evaluation of digital platforms and their surrounding ecosystem that considers the specialities of the domain in which the ecosystem is created. Thereby, the special focus is on the healthcare sector.*

The definition of the research objective follows the idea that specific classes of artefacts need specific design methods and prescriptive design knowledge (Winter, 2008; Kuechler and Vaishnavi, 2012). EHealth platforms can be considered as a special class of artefacts in a specific context. Platforms can be considered as a more generic class of artefacts but also have specific characteristics. This work addresses the "design objectives"-pillar in the framework for research objectives in Wirtschaftsinformatik of Becker et al. (2003) (cf. table A.1). By providing methodical guidance for platform design, evaluation and healthcare-

Table A.1.: Alignment of the research objective to the objectives and assignments of Wirtschaftsinformatik according to Becker et al. (2003)

| | **Cognition Objectives** | **Design Objectives** |
|---|---|---|
| **Methodical Assignment** | Understanding the methods and techniques of information system design | Development of methods and techniques for information system design: **Methodical guidance for digital platform design and evaluation** |
| **Content- and Functional-Driven Assignment** | Understanding enterprise information systems and their domains of use | Providing information systems reference models for specific sectors and enterprises **Methods for construction and evaluation of eHealth platforms** |

specific design knowledge, this work refers to the methodical assignment as well as the content- and functional-driven assignment of Wirtschaftsinformatik (Becker et al., 2003).

According to the DSR knowledge contribution framework of Gregor and Hevner (2013), this research work can be classified as an Improvement-DSR-work. Research on the relationship between platforms and ecosystems has reached a high maturity, but the solution maturity has not reached a sufficient level (see section 1.2). The research objectives and the research questions are formulated in order to contribute to the knowledge base with purposeful methodical artefacts as well as prescriptive design knowledge for eHealth platforms. The author aims to contribute to both camps of design science[4]. First, the framework is designed as a usable artefact. Second, this work aims to describe how digital platforms and ecosystems in the healthcare sector should be designed.

The main contribution of this work is the provision of a framework for platform and ecosystem design (in the following, referred to as Platform Design Framework). The framework should be domain-independent and should allow a domain-specific instantiation. This ensures a broader contribution to the design knowledge base and a broader range of usage in different domains. The following research question tackles domain-independent constructive aspects for digital platforms and ecosystems. This addresses the outcome dimension (Winter et al., 2009) of platform design.

[4]Gregor and Hevner (2013) state that two different camps of DSR have emerged. The pragmatic-design camp, mainly driven by contributions like the works of Hevner et al. (2004) or March and Smith (1995) and the design-theory camp, which were driven by Walls et al. (1992) or Gregor and Jones (2007), for example. The first camp focuses on the provision of artefacts. The latter focuses on providing design theory, that explains how artefacts should be built and why they work (Gregor and Hevner, 2013).

**RQ 1.** *Which design aspects are relevant for the construction of digital platforms and their ecosystems?*

The second research question treats the activities (Winter et al., 2009) that are needed to create platforms and surrounding ecosystems. It requests reproducible design activities for them. Hence, the following research question focuses on the dynamical aspect of platform and ecosystem creation.

**RQ 2.** *How can the construction of ecosystems and the corresponding digital platform be guided systematically?*

Accompanying the questions how platforms can be designed (RQ 1 and RQ 2), there is a need to describe domain-specific knowledge that can be applied in the Platform Design Framework. Hence, the following research question addresses the specialities of eHealth platforms. This research question relates to the barriers for eHealth implementation that were introduced in section 1.1.

**RQ 3.** *How should eHealth platforms be designed in order to foster the implementation of innovative eHealth solutions?*

While the Platform Design Framework aims to support the creation of a digital platform, there is a need to evaluate the outputs such a framework generates. An evaluation strategy for digital platforms needs to consider the goals and the socio-technical system (design context) in which the platform is designed (Venable et al., 2012, 430 f.). Therefore, the following research question regarding the evaluation of platform and ecosystems directly focuses on eHealth platforms.

**RQ 4.** *How can the ability of eHealth platforms to create innovation-friendly ecosystems be evaluated systematically?*

### 1.3.3. Research Process and Methods

Regarding the creation of design-oriented theories and artefacts, this thesis follows Gregor and Hevner (2013) who state that contribution to design theories could also be partial theories, incomplete theories or generalisations of new artefacts. Furthermore, the author follows the position that design-oriented research is an incremental process in which single research projects can create interim attempts to solve a class of problems in a larger research roadmap (Gregor and Hevner, 2013; Hevner et al., 2004; Iivari, 2007). Nevertheless, a research agenda for a single project needs to be rigorous. Iivari (2007) names two crucial options, to distinguish DSR from routine-design: the evaluation and a reasonable constructive method. While the first is more reactive focusing on the evaluation of existing artefacts, the latter is more proactive because it seeks to transparently justify the construction of artefacts by using the existing knowledge base. It seeks to innovate and improve information technology (IT) artefacts and not only tries to scientifically affirm the novelty of an artefact (Iivari, 2007; Hevner et al., 2019). This thesis emphasises the second option as a primary distinction for rigour without neglecting evaluation.

The methodical setting of this research is divided into two different parts: the *research process* and the *research methods* (Österle et al., 2011). The research process governs the overall design process while the research methods help to instantiate the process to specific systematic procedures. Research methods are techniques to gain knowledge or to create the artefact, while the research process describes a roadmap to compose different research methods. As examples for research methods, Österle et al. (2011) name expert interviews for exploration of the problem domain, reference modelling as a method for artefact construction and pilot applications as an evaluation approach.

In this doctoral thesis the research process of Peffers et al. (2007) is instantiated. This nominal process is used as an overarching research framework. Corresponding to step 1 in this process, the problem identification and the objective for this research have been introduced in sections 1.2 and 1.3.2. Based on these objectives, the demands in the problem space and the guiding requirements for the artefact construction are formulated in section 3. Peffers et al. (2007) name different entry points for design-oriented research. The entry point for this doctoral thesis was the aim to evaluate the openness of an existing eHealth platform. It is further explained in section 4.1.

The contribution of this doctoral thesis is composed of three different research outcomes (RO). The research outcomes are derived from the four research questions (see figure A.3). Research methods need to be tailored against the background of particular research projects (Frank, 2006, p. 31). The research outcomes help to build the context for the tailoring of the research methods and subordinated research processes. Section 4 describes the individual steps of the artefact construction and evaluation. The three research outcomes are the following:

**RO 1:** a framework for the design of domain-specific platforms as a central DSR artefact,

**RO 2:** prescriptive knowledge for platform construction in the healthcare domain, which supports the application of the design framework and justifies the evaluation of eHealth platforms,

**RO 3:** methodical guidance for the evaluation of existing eHealth platforms

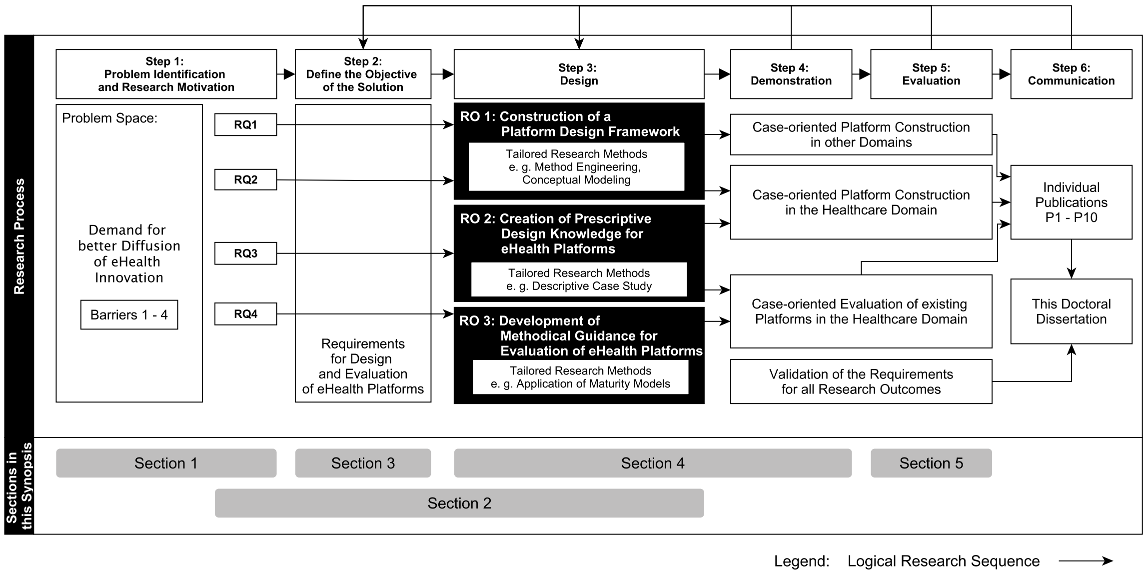


Figure A.3.: Guiding research process in this doctoral thesis, adapted from Peffers et al. (2007)

The design of the artefacts and the design knowledge are guided by individual subordinated research processes and instantiated research methods, which are explicated in the individual publications. The instantiation of more specialised research processes during the design step follows the idea of recursive problem solution in design processes (Zeng and Cheng, 1991). In this regard, the DSR-process of Peffers et al. (2007) and other research processes (e.g. Action Design Research, Sein et al., 2011) are applied as subordinated research processes in order to create the three research outcomes.

The demonstration of the resulting artefacts as well as the affirmation of design knowledge are done by case studies with real-world cases (Venable et al., 2012). Thereby, the research outcome *RO 2* can be interpreted as a healthcare-specific configuration which is applied to the two other research outcomes (*RO 1* and *RO 3*). The papers are organised by the three research outcomes (*RO 1* to *RO 3*).

Peffers et al. (2007) consider the cyclical nature of DSR by describing backtraces to the reconfiguration of the objectives or by directly redesigning the artefact[5]. In this thesis, this iterative approach is applied in order to refine both the Platform Design Framework as well as the evaluation guidance. The construction of the platform evaluation framework is iteratively applied to different domains. Besides the primary focused domain of eHealth, the Platform Design Framework is also applied to Industrial Symbiosis and Maintenance Analytics.

[5] As Venable et al. (2012) also interprets the demonstration step as a "lightweight evaluation", a return from "demonstration" is also integrated in figure A.3.

In the course of this doctoral thesis, prescriptive knowledge for eHealth platforms is created cumulatively in the different research contributions during the design cycles. According to Drechsler and Hevner (2018), the design framework for platforms as well as the evaluation guidance can be classified as solution design entities because they provide tangible methods and models for design. The research outcome *RO 2* can be understood as solution design knowledge (Drechsler and Hevner, 2018, p. 89) because it provides knowledge of how concrete artefacts (in case of this thesis: eHealth platforms) can be created.

# 2. Foundational Considerations

The design of platforms needs an understanding of what needs to be designed and into which components these complex system needs to be disaggregated. The first subsection (subsection 2.1) provides such understanding by explaining the different perspectives on platforms. The second subsection (subsection 2.2) defines the central concepts of ecosystems and platforms and explains the their relationships. Based on this framework, definitions for platforms and ecosystems and related concepts are given. The third subsection (subsection 2.3) describes a dynamical view of platform design by introducing a nominal platform design process.

## 2.1. Perspectives on Platforms

Based on the differentiation of Gawer (2014), two perspectives on platforms (see figure A.2) are explained in the following.

**By economists**, platforms are seen as multi-sided markets that involve at least two groups of platform users (Gawer, 2014; Rochet and Tirole, 2003). A differentiation between generic markets and ecosystems has been proposed by Jacobides et al. (2018). They distinguish between market-based value systems with generic complementary relationships and specialised markets, so-called ecosystem-based value systems with a focal product (the platform). In these ecosystem-based value systems, non-generic relationships between ecosystem participants occur. Those are different from generic relationships because they need a specific degree of coordination, which generic relationships in market-based value systems do not need[6] (Jacobides et al., 2018). In these ecosystems, the platform owner is understood as a coordinator of non-generic relationships and enables interactions between the different user groups (Eisenmann et al., 2008; Jacobides et al., 2018). The basic role model for platforms of Eisenmann et al. (2008) classifies two groups of users: demand-side users and supply-side users. One kind of the most important effects in these markets are network effects that occur between the different user groups (Evans, 2003; Gawer, 2014). For instance, a software platform provides more value to users if more and more developers provide software on this platform. This effect is called an indirect network effect (Evans, 2003). Direct network effects occur between members of of one group (Burkard et al., 2012). An example of direct network effects can be found in the context of chat applications. The more users are registered in a chat application the more value is generated for the single user because he can reach more of his social contacts using this app.

[6] An example for a generic relationship is the relationship between a pencil and a sketchbook, which need no further coordination to be used together.

**The engineering view** treats platforms as technological architectures (Gawer, 2014). In this regard, a platform is seen as a modularised architecture which consists of a stable *core* of components and components that may vary over time and domain. The latter are also called *complements*. The core and the complements are integrated by well-defined interfaces (Baldwin and Woodard, 2008). A vital characteristic is the modularity of the platform and its complements, which enables evolutionary development and allows decoupling of different platform participants (Tiwana, 2015). According to the General Systems Theory, modularity describes the degree to which the components of a system can be disaggregated and recombined and how they can be coupled (Schilling, 2000). It is the foundation for the autonomous development of complements and consequently for the ability of the platform to shape an ecosystem of independent innovators (Jacobides et al., 2018).

An important aspect besides the modularity is the degree of freedom and the design variability of the core. Baldwin and Woodard (2008) use the term ”option potential”, which means that the use of the core of the platform does not lead to a determined design of the complements and leaves autonomy to innovators in developing a complement. This option potential is the basis for the variability of complements and consequently for the degree of freedom of innovators.

## 2.2. Platforms, Ecosystems and their Relationship

The kernel theories which inform the construction of the research outcomes are the framework for platform evolution of Tiwana et al. (2010), the structuralist view of Adner (2017), the understanding of platform architecture according to Baldwin and Woodard (2008) and the role model for platforms of Eisenmann et al. (2008). The latter was already introduced in section 2.1.

The framework of Tiwana et al. (2010) states that the (evolutionary) dynamics of the ecosystem around a platform are influenced both by the platform design and the environmental dynamics (see figure A.4). The platform design consists of the architecture and the governance, which must mutually fit the environment. Additional to the evolutionary effects mentioned by Tiwana et al. (2010), in this work, the view is extended by other effects like value-cocreation (Adner, 2017), emergence (Woodard and Clemons, 2014) and diffusion of innovations (Chesbrough and Appleyard, 2007; Gawer, 2014). The framework is used to explicate the conceptual relationships between the platform, the ecosystem and the economic environment. It identifies the platform design as an important structure that influences the resulting ecosystem.

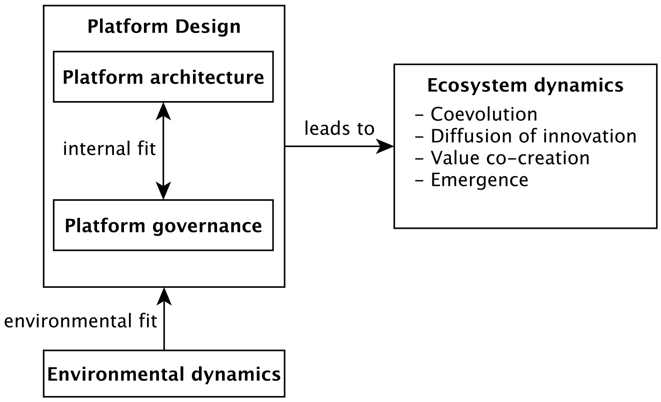


Figure A.4.: Framework for studying ecosystems adapted from Tiwana et al. (2010)

The design of the platform depends on the intended value proposition which motivates the ecosystem. Adner (2017) uses a structuralist approach and defines this dependence as follows:

> ”The *ecosystem* is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize.” (Adner, 2017, p. 42)

The alignment structure maps the different intentions of the actors in the ecosystem to the focal value proposition. This structure tries to address the individual goals of each partner in the ecosystem and mediates between conflicting goals. Platforms are an operationalisation of alignment structures.

*A digital platform* is ”a constant generification of IT-capabilities” (Hanseth and Lyytinen, 2010) that forms an extensible technological foundation (Tiwana et al., 2010). Baldwin and Woodard (2008) term platforms as a ”set of stable components that supports variety and evolvability in a system” (Baldwin and Woodard, 2008, p. 3). Such platforms are able to leverage innovation (Yoo et al., 2010). Compared to traditional software products, platforms are more generic. They aim to create a technological basis which supports variable usages that are not fully predictable.

Following the understanding of different artefact types (constructs, models, methods, instantiations) in DSR (Hevner et al., 2004), platforms can occur as models and as instances. Following Tiwana et al. (2010), the *platform model* is the ”conceptual blueprint” of a platform. The platform architecture is the first part of the platform model. The platform architecture describes the abstract design characteristics of a platform and organises the fundamental components. Platform models can also be designed for a specific business context, but be of a conceptual character. *Platform governance* comprises all decisions regarding the relationship between the platform owner and the actors in the ecosystem. The description of governance measures is the second part of platform models. This, for example, includes the definition of decision rights, the ownership of components and the degree of control the external actors get from the platform owner (Tiwana et al., 2010). All governance measures in a platform influence the behaviour of the actors.

*Platform instances* are implemented in a specific business context. Platform instances provide implemented technological components to individual market participants. They realise governance measures for individual platform participants. For example, a platform instance is the Finnish Kanta platform. It is situated in the Finnish healthcare systems and the platform participants (e.g. patients, medical professionals) can be individually identified (Cleary et al., 2017).

## 2.3. A Nominal Platform Design Process

As this work focuses on the design of platforms in specific domains, the author argues that platforms are a special class of design artefacts and consequently can be a result of the design process. Hence, the DSR process of Peffers et al. (2007) is used as a template for an abstract design process for platforms (see figure A.5). This platform design process supports the systematisation of the research contributions regarding their role in platform development.

The implementation of platforms starts with the intention to create a platform in order to address an existing problem in a business context (*step 1*). The reason to set up a platform business model may be various and depend on different domains. Consequently, the methodical support to develop a central platform vision and to identify the core value proposition of the platform is not part of this doctoral thesis. Nevertheless, the vision and rationale for eHealth platforms are articulated in the introduction (section 1.2) as well as in the research papers (sections 4.2.1, 4.4.1 and 4.4.2) that focus on providing prescriptive knowledge.

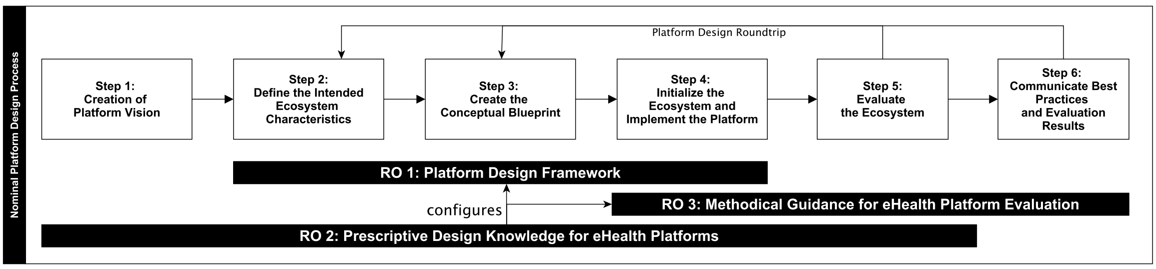


Figure A.5.: Nominal design process for the creation of platforms, adapted from the DSR-process of (Peffers et al., 2007)

Based on the platform vision, concrete characteristics for the platform need to be described (*step 2*). The creation of the platform model is part of *step 3*. These two steps are addressed by the intended Platform Design Framework (RO 1). In *step 4*, the instantiation of the platform models in specific business contexts is in focus. This may not necessarily be a real implementation but an investigation on how a platform model would behave in a specific context (in preparation of an artificial ex-ante evaluation) (Venable et al., 2012). *Step 5* comprises the evaluation of the instantiated platform model. The steps 4 and 5 are addressed by the methodical guidance for platform evaluation (RO 3). The descriptive knowledge for platforms in the healthcare domain (RO 2) creates domain context and thus addresses all steps. In *step 6* the results of platform design processes are communicated. This can be done by best practice patterns, by case descriptions or evaluation reports.

# 3. Requirements for Design Artefacts and Knowledge

The specification of requirements in DSR can improve the rigour of artefact creation by a detailing of research goals. Furthermore, they can help to evaluate whether a research goal was achieved (Braun et al., 2015). Maedche et al. (2019) provide a conceptual model for the description of requirements in DSR. Four concepts are central: *needs, goals, stakeholders* and *requirements*. In addition, Braun et al. (2015) differentiate between two types of requirements: problem-oriented and solution-oriented requirements. This enhances the framework of Maedche et al. (2019) by providing requirements in the solution space[7].

The needs and goals for this research have already been identified in the sections 1.2 and 1.3.2. Different stakeholders have different interests in outcomes of DSR (Maedche et al., 2019, p. 24 ff.). Consequently, these goals are refined by a stakeholder-specific view. In context of the three research outcomes, two classes of stakeholders are considered:

- **Platform owners:** These are organisations or persons who aim to develop platforms or to transform existing software products into platforms. Platform owners aim to achieve commercial advantages or other benefits (e. g. health authorities aim to improve patients care) by designing a platform (Rochet and Tirole, 2003, p. 993). Software providers which want to transform existing applications into platforms can also be treated as platform owners (Saarikko, 2016).

- **Researchers:** These are organisations or persons who aim to understand platforms and to enrich the scientific knowledge base about platforms with descriptive (e.g. understanding why a platform is successful) or prescriptive knowledge (e.g. providing guidance for successful platform design) (Drechsler and Hevner, 2018).

In Table A.2, the leading problem-oriented requirements for the design framework (RO 1) and the evaluation guidance (RO 3) are described and assigned to the two groups of stakeholders. These requirements are represented as use cases for the individual research outcomes and stakeholders. They shape the problem space and provide a usage-oriented access to the requirements of stakeholders (Bittner and Spence, 2002, p. 3 ff.). For the eHealth platform design knowledge (RO 2), the problem-oriented requirements are summarised for each stakeholder as they enable the healthcare-specific use of the Platform Design Framework and the evaluation guidance. This, for example, addresses the need of stakeholders to understand the concepts of platform theory in the context of the healthcare sector.

According to the research outcomes, three different sets of solution space requirements can be derived from the problem-oriented requirements. These are described in the following

[7] This is similar to the distinction between business requirements and system requirements in the field of software engineering (Ullah and Lai, 2011). Business requirements represent the need of users. System requirements direct to the properties of a system to be developed.

Table A.2.: Use cases of the intended artefacts (problem-oriented requirements)

<table>
<tr><th></th><th>RO 1: Platform Design Framework</th><th>RO 3: Evaluation Guidance</th><th>RO 2: Prescriptive Design Knowledge</th></tr>
<tr><td>Researcher</td><td>• Investigate how platforms could be developed and applied in specific domains<br>• Develop design principles for platforms in specific domains<br>• Propose reusable platform designs and patterns for platforms</td><td>• Analyse which platform structures lead to specific ecosystem configurations<br>• Investigate the impact of platform design decisions on the ecosystem<br>• Analyse the effects of platform instances in specific domains<br>• Evaluate the utility and efficacy of existing platform approaches<br>• Compare different platform instances</td><td rowspan="2">Use eHealth-specific understanding of platforms and get support for the domain-specific configuration of platform design and evaluation:<br>• Transfer ecosystem concepts to healthcare sector<br>• Understand basic characteristics of digital healthcare ecosystems<br>• Understand existing eHealth platform approaches</td></tr>
<tr><td>Platform owner</td><td>• Create and implement new platforms and ecosystems<br>• Manage existing platforms and ecosystems<br>• Manage the transformation of existing products to a platform paradigm<br>• Definition and management of platform market strategy</td><td>• Analyse how well a platform architecture leads to business value<br>• Prognosis of platform success<br>• Identify weaknesses of own platform architectures<br>• Monitor the viability of the ecosystem around the own platform</td></tr>
</table>

subsections. The requirements in the solution space are differentiated into functional requirements (FuRs), feature-based requirements (FeRs) and theory-based requirements (TRs). In context of this work, functional requirements describe requirements according to the usage or function of the research outcome. For example, they describe how the Platform Design Framework can be used. Feature-based requirements describe conditions for the usage of the research outcome in the context of platforms and ecosystems. Theory-based requirements describe conditions that result from the field of design science, method engineering and design theories. While the two former types of requirements are informed by the problem-oriented requirements, the latter type is informed by theoretical constraints (Braun et al., 2015, p. 10 f.).

## 3.1. Requirements for the Platform Design Framework

The solution space requirements for the Platform Design Framework (RO 1) are defined in table A.3. They can be assigned to the solution space (Braun et al., 2015). These requirements are informed by the problem-oriented requirements from table A.2. Furthermore a rationale for each requirement is provided. Researchers in the field of design-oriented research may aim to describe how platforms should be developed. From the **researchers' perspective**, a framework for platform design can support the creation of purposeful artefacts in the sense of DSR. Considering the introduced nominal design process for platforms (see section 2.3), a platform design method should support the analysis of the environmental context (FuR 1). The platform design should be determined by the specialities of a specific environmental context. Context-specific objectives for ecosystems and platforms may be defined on different layers in order to address the belongings of the overall ecosystem as well as the belongings of the individuals within the ecosystem (Petrik et al., 2018). The method should support the definition of design objectives both for the platform owner as well as for the individual actors in the ecosystem (FuR 2). These objectives justify design decisions and can be used to derive criteria for platform performance measurement and evaluation.

Artefacts aim to address a class of problems and provide guidance for a class of problem instances (Frank, 2006, p. 34). Thereby, typical abstractions are conceptual models, architectures and patterns. The outcome of a framework for platform design consequently could be reusable conceptual models (FuR 3). As identified in the introduction, platform design may vary between different domains. Therefore, the framework should support the analysis and modelling of different domains (FeR 1). Specific domains may comprise specific types of elements, which cannot be represented by the existing conceptual models referenced in the framework. As a consequence, a Platform Design Framework may need situational adaptations (Brinkkemper, 1996, p. 277 f.). Therefore, the Platform Design Framework should provide the ability to be adapted to new ecosystem structures (FuR 8). Since researchers also want to describe parts of the ecosystem or the platforms, the framework should be able to create partial conceptual blueprints of platforms and ecosystems (TR 1). For example, researchers might want to describe role models for specific ecosystems or only governance measures for a specific case of platform usage.

**Platform owners** may aim to develop platform models based on their existing products in order to extend their range and to complement their own functionality by third parties (Gawer and Cusumano, 2014, p. 421). Also, the construction of new platforms based on a vision for value creation is a case which can be found in practice (e.g. Christensen et al., 2014). Consequently, they need to create comprehensive concepts for both, the technological and the organisational design of platforms (FuR 4). Since ecosystems are created in existing markets (Gawer and Cusumano, 2014, p. 420), platform owners need to analyse the existing market situation (FuR 5) and fit the platform architecture to their existing product landscape (FuR 6). Besides the initial creation of a platform, the management of the platform according to the effects occurring in the ecosystem is necessary. This comprises the adaption of existing platform strategies to changed situations in the ecosystem (Ghazawneh and Henfridsson, 2011). Furthermore, the adaption of technological facilities in the platform (Eaton et al., 2015) is necessary. Consequently, the framework also needs to deal with existing platform instances (FuR 7).

Table A.3.: Requirements for the Platform Design Framework (RO 1)

| **Req. ID** | **Requirement** | **Rationale** |
|---|---|---|
| Functional (FuR 1) | The Platform Design Framework should support the analysis of the environmental context of the platform | The environment of the platform determines how actors in the ecosystem behave and how the platform's access mechanisms are designed (Tiwana et al., 2010). |
| Functional (FuR 2) | The Platform Design Framework should allow the definition of objectives for the platform and the surrounding ecosystem. | Platforms are design artefacts created by platform owners. The reasons for creating a platform may vary between different platform owners (West, 2003; Adner, 2017) and may address different aspects (Petrik et al., 2018). Consequently, an analysis of guiding rationales for platform design should be possible. Platform providers should be able to systematise the ideas about how the ecosystem should emerge and behave (Riedl et al., 2009). |
| Functional (FuR 3) | The Platform Design Framework should be able to create formal or semi-formal descriptions (conceptual models) of digital platforms. | Systems (in particular information systems) can be analysed and represented by conceptual models (Wand and Weber, 2002). Conceptual models support the analysis and the construction by separating a complex system into different aspects. This also supports the creation of partial results. |
| Functional (FuR 4) | The Platform Design Framework should consider both organisational and technological aspects of platform design. | Platforms are socio-technical constructs and may provide a technological modular structure (Yoo et al., 2010). Platform and ecosystem blueprints also need to define how the interaction between participants should be regulated (Riedl et al., 2009). |
| Functional (FuR 5) | The Platform Design Framework should allow the analysis of market situations and possible value-creation logic. | Platforms are created in consideration of existing or prospective business partners (Saarikko, 2016). The method should support the analysis of their intentions and specialities. |
| Functional (FuR 6) | The Platform Design Framework should allow the transformation of existing products to platforms. | Platforms may also be created from existing intra-organisational product landscapes (Zhu and Furr, 2016). By opening them up a product owner becomes a platform owner. |
| Functional (FuR 7) | The Platform Design Framework should allow the management and reconstruction of existing platforms. | Products may be pre-existing without being developed with a clear explicated platform strategy (Zhu and Furr, 2016). |
| Functional (FuR 8) | The Platform Design Framework should be tailorable and extendible. | Specialities of specific domains (see FeR 1) may need special design activities (e.g. considering special roles of players in the healthcare domain). A situational adaptation of the Platform Design Framework may be necessary (Brinkkemper, 1996). |
| Feature-related (FeR 1) | The Platform Design Framework must be applicable in different domains (industries, sectors, economies). | Platforms may be created in different fields of the industry and economy. A universal platform approach consequently is not possible and multiple differently designed platforms can occur in various domains (e.g. Petrik et al., 2018). |
| Theory-based (TR 1) | The Platform Design Framework must be able to generate intermediary and partial results. | A researcher may also aim to describe interim artefacts (Gregor and Hevner, 2013). Partial models of platforms may be a result of a research process. |

## 3.2. Requirements for the Platform Evaluation Guidance

The requirements for evaluation guidance (RO 3) are defined in table A.4. From the **researchers' perspective**, evaluation is part of design processes. Rigour evaluation methods are also necessary in dedicated platform evaluation and comparison projects. Evaluation is a central part of design science research to prove utility, efficacy as well as quality (Hevner et al., 2004) and to create acceptance of the research results (Winter, 2008). Besides the three often-named criteria utility, efficacy and quality, other criteria like ethicality, ease of use, completeness, and simplicity are also present (Prat et al., 2015). As introduced in section 1.3.2, the application of these criteria to platforms is a research challenge. Guidance for the evaluation of platforms should support the operationalisation of these criteria for the particular evaluation in context (FuR 9). Furthermore, the evaluation should be applicable both to platform models and instances (FuR 10). This ensures that abstract conceptualisations of platforms, ideas on platform implementation as well as concrete platforms in practice can be evaluated. Therefore, the evaluation should also be applicable to perform a prognosis of the platform success (FeR 2). Evaluation results should be trackable and comparable in order to allow their communication to the scientific community (TR 2).

From the **platform owners' perspective**, the evaluation of platforms should help to improve the quality of platforms and to align them with the demands of the customers. Hence, the evaluation guidance should provide indicators that support the improvement of the platform. The results of the evaluation should lead to practically applicable statements, which could be used to define starting points for further measures of platform reengineering (FeR 2). The results of the evaluation methods should also allow a temporal tracking, because the platform owners may monitor their platform performance over time (TR 2). In order to achieve a practical utility, the evaluation guidance should be usable in an efficient way (TR 3). EHealth platforms can be implemented in very different technological settings (e.g. Christensen et al. 2014, Serbanati et al. 2011). Consequently, technological specialities of platforms should not impede the applicability and usability of evaluation measures (TR 4). The method should provide mechanisms to adapt to technological specialities.

Table A.4.: Requirements for the Evaluation Guidance (RO 3)

| **Req. ID** | **Requirement** | **Rationale** |
|---|---|---|
| Functional (FuR 9) | The evaluation guidance must define criteria that are applicable to assess the achievement of design objectives. These must result from the context in which a platform is situated. | Design objectives are the main driver for the artefact construction. They are defined in a business context (Hevner et al., 2004). Hence, the evaluation criteria help to differentiate various degrees of target achievement. |
| Functional (FuR 10) | The evaluation guidance allows the evaluation of platform models as well as platform instances. | The evaluation of platforms can be done in different lifecycles and development phases. Therefore, ex-ante and ex-post evaluations should be possible (Venable et al., 2012). |
| Feature-Related (FeR 2) | The evaluation guidance should generate statements which support the further development of platforms | The usefulness of evaluation results determines the practical use of evaluation guidance (Moody, 2003). |
| Theory-based (TR 2) | Third parties should be able to review, compare and track evaluation results. The evaluation criteria must be accessible to third parties. | The transparency and verifiability are important quality characteristics to create evidence for the evaluated evaluation criteria (Prat et al., 2015). |
| Theory-based (TR 3) | The evaluation guidance must be usable in an efficient way. | According to Moody (2003), the efficiency of a method is important for its real utilisation. |
| Theory-based (TR 4) | The evaluation guidance must be independent regarding technical changes and technical specialities of the evaluands. | Technical changes and specialities should not prevent the use of the method. The guidance should be applicable to a class of artefacts (Drechsler and Hevner, 2018). |

## 3.3. Requirements for Platform Design Knowledge in the Healthcare Sector

Even if the provision of solution design knowledge (RO 2) does not lead to tangible artefacts, the articulation of requirements regarding the knowledge contribution to the scientific community can help to validate the research outcome, provide insight into the context of research results and aligns the research regarding the addressed class of problems (Drechsler and Hevner, 2018). The creation of prescriptive knowledge in the field of eHealth platforms can be integrated into a larger stream of research work that focuses on digital innovation in the healthcare sector (see section 1.1). Platforms leverage the provision of digital services in interorganisational care (Fürstenau and Auschra, 2016). Consequently, a central requirement is that the knowledge should address the innovation aspects of platforms in the field of interorganisational care (FeR 3). In order to fit to the Platform Design Framework, the knowledge should cover both technological and organisational aspects (FeR 4).

The knowledge which is created in the course of individual research contributions should be formulated with tangible representations like design principles, lessons learned, conceptual models and other structured knowledge representations (TR 5). These representations should also be applicable to partial classes of problems (Gregor and Jones, 2007) and may also address sub-components of platforms and ecosystem (TR 6). Design principles and other structured representations of design knowledge support efficient dissemination (Chandra et al., 2015). These representations are a form of solution design knowledge according to Drechsler and Hevner (2018).

Table A.5.: Requirements for the Design Knowledge (RO 2)

| Req. ID | Requirement | Rationale |
|---|---|---|
| Feature-related (FeR 3) | The knowledge created in this thesis should address platforms focusing on digital innovation in interorganisational care networks. | The delivery of care tends to more integrated interdisciplinary networks. Platforms are implemented in this context (Fürstenau and Auschra, 2016). |
| Feature-related (FeR 4) | The knowledge created in this thesis should address both technological as well as organisational levels of eHealth platforms. | Barriers result both from technological as well as organisational settings (see section 1.1). |
| Theory-based (TR 5) | The knowledge should be represented by adequately structured entities (design principles, lessons learned, conceptual models and technological rules support). | Beside the generation of knowledge, tangible and efficient communication is important for the reuse and distribution (Chandra et al., 2015). |
| Theory-based (TR 6) | The design knowledge should be applicable to sub-constructs of eHealth platforms and their corresponding ecosystems independently. | The creation of knowledge and its formalisation is purpose-oriented and indicative (Gregor and Jones, 2007). |

# 4. Structure of the Doctoral Thesis

In figure A.6, the dependencies of the research contributions and their development are shown. The figure also describes which research questions and which requirements from section 3 are addressed by the individual papers. In the subsequent sections, the genesis of the thesis is outlined. This comprises the description of preliminary research results (section 4.1). After introducing the initial research contributions (section 4.2), the papers are assigned to the three predefined research outcomes (sections 4.3 to 4.5).

## 4.1. Preliminary Research

According to the nominal platform design process given in section 2.3, the research objective in this doctoral thesis results from a practical setting where a telehealth platform was to be evaluated regarding its ability to be extended by third-party solutions (Benedict et al., 2015)[8]. This preliminary research work aimed to create a framework for the evaluation of interoperability and expandability of existing eHealth platforms. This framework was intended to gain statements about whether an efficient third-party extension of existing eHealth platforms is possible. It considers both technological and organisational aspects by adopting existing interoperability models (e.g. Coorevits et al., 2011).

However, the deduction of evaluation criteria for platform evaluation was difficult due to the the implicit knowledge about the organisational and innovation-oriented properties of eHealth platforms. The expectations regarding their abilities to support integrated care networks and to foster digital innovation in healthcare were not clearly identifiable. In particular, the existing interoperability frameworks do not sufficiently consider the perspective of emerging digital innovations (e.g. Yoo et al., 2010). It was under-researched how the design of eHealth platforms influences the ability to foster digital innovations in integrated care. From this problem setting, the leading research objective was derived (see section 1.2). Regarding the research process of this doctoral thesis, the work of Benedict et al. (2015) created a *context-initiated entry point* (Peffers et al., 2007).

## 4.2. Foundational Research Papers

### 4.2.1. P1: Governance Guidelines for Digital Health Ecosystems

Based on the findings in the preliminary research, an analysis in the context of an existing eHealth platform project was done in Paper 1. An Action Design Research (ADR) approach (Sein et al., 2011) was applied to derive governance guidelines for platform projects in the

[8] step 5 in the nominal platform design process: evaluate the ecosystem and platform

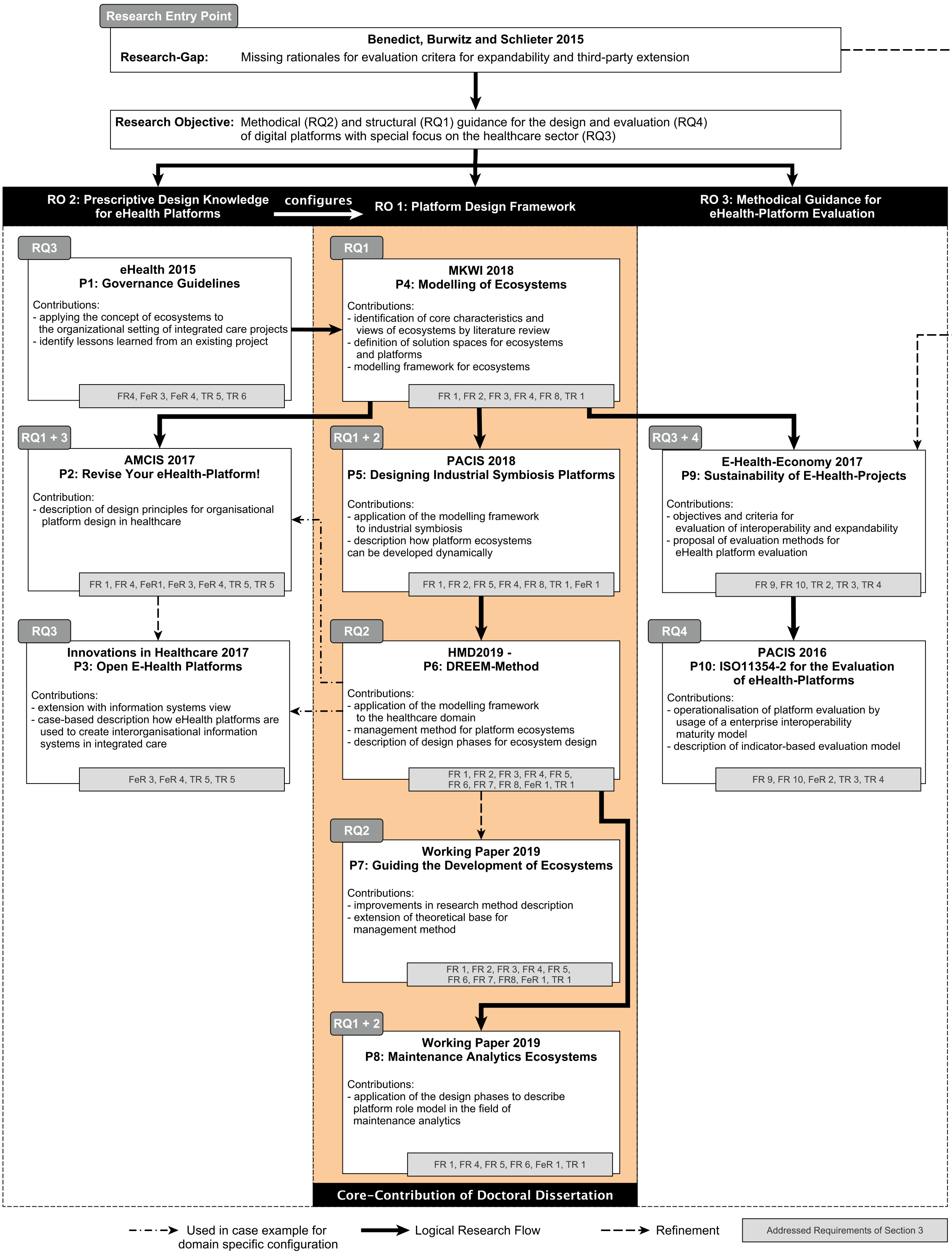


Figure A.6.: Dependencies and contributions of the research papers in this doctoral thesis field of digital health. The build-intervention-evaluation stage was instantiated through a four-phase platform design process (analysis, design, implementation and testing, utilisation). This process was derived from the practical project and defined a first dynamical description of platform design.

Using the existing digital ecosystem concept of Briscoe and Marinos (2009), the paper creates prescriptive knowledge regarding the implementation of projects which aim to develop an eHealth platform. It questions which measures lead to open platforms. The paper describes thirteen guidelines regarding the design of a digital health ecosystem. These guidelines instantiate the fourth stage (formalisation of learning) of ADR (Sein et al., 2011). The guidelines are assigned to the four phases of platform design. They address the creation of a solution-neutral environment and describe platform-specific measures during the elicitation of requirements, the platform specification, and the implementation of the platform. The paper is assigned to the second reseach outcome (RO 2) because it provides knowledge for eHealth platform design.

In the governance guidelines, the need for a stronger formalisation of ecosystem constructs and a more generic view to ecosystems is identified. They describe the need for a clear ecosystem strategy and a justification of the platform architecture. In particular, the authors found that design decisions depend on the intended ecosystem characteristics and that different understandings of ecosystems may lead to different design decisions. However, neither a design-oriented conceptual model nor a systematization of ecosystems and their characteristics could be found during the study in paper 1.

According to the nominal platform design process, the paper can be assigned to the platform development phases because it discusses four phases of the platform life cycle. It articulates a vision for eHealth platforms (step 1), defines objectives for digital ecosystems (step 2) and gives design guidance from analysis to utilisation (step 3).

### 4.2.2. P4: Modelling Ecosystems in Information Systems – A Typology Approach

In order to improve the understanding of the characteristics and views of ecosystems, a systematic literature review according to Webster and Watson (2002) and a qualitative full text analysis was conducted. A stronger formulation of characteristics helps to clearly identify design parameters of ecosystems and to justify design decisions in platform architectures. Furthermore, a tangible definition of ecosystem views helps to align an intended ecosystem design with existing phenotypes (e.g. business ecosystem, platform ecosystem) and supports the creation of conceptual ecosystem models. As a basic premise, it was assumed that these phenotypes and corresponding characteristics are articulated in the dominating information systems literature. The literature review is described in paper 4 which systematises the views of ecosystems and their characteristics. The paper questions how different understandings of ecosystems lead to different design guidances and asks which implications for the modelling of ecosystems result from these understandings. The modelling of ecosystems is the operationalisation of ecosystem design and follows the perception of conceptual modelling in information systems research (Wand and Weber, 2002). The result of such modelling (ecosystem model) can be used as the conceptual blueprint of an ecosystem.

As an essential result, the paper describes seven types of ecosystems with their characteristics and maps them to two dimensions: *System Types* and *Platform Focus*. This systematisation leads to the demand that ecosystems need to be modelled from a socio-technical view. Furthermore, it leads to the implication that platform modelling and ecosystem modelling should be separated. An important kernel theory driving this implication was the work of Tiwana et al. (2010) (see section 2.2).

Based on the systematisation of ecosystems and their characteristics, a dependency model with two different solution spaces (below: *Solution Space Model*) as well as an *Ecosystems Modelling Framework* with different modelling-views within these solution spaces are derived. The description of the views follows the metamodel for architectural description of ISO 42010 (International Standardization Organisation, 2011). The views are defined in correspondence to the identified layers of the system-type dimension. They are assigned to three modelling aspects, following the defined Solution Space Model:

- **Goal Modelling:** The aspect of goal modelling can be mapped to the definition of the core value proposition of the ecosystem (Adner, 2017). It also has to consider the restrictions resulting from the environmental context of the ecosystem.

- **Ecosystem Modelling:** The aspect of ecosystem modelling comprises the formalisation of the system that emerges around the platform. It comprises the socio-economical, the socio-technical as well as technological concepts that occur in ecosystems.

- **Platform Modelling:** The aspect of platform modelling comprises the formalisation of governance and architecture of the platform.

The Solution Space Model creates the foundation for the understanding of platform-based ecosystems and the identified characteristics are used as design criteria in further research. The Ecosystems Modelling Framework is the first part of the Platform Design Framework[9]. It contributes by providing a structural systematisation of ecosystems and platforms. The paper provides the foundation for all further research papers and consequently for all three research outcomes. The need for methodical modelling support and the need for evaluation of the Ecosystems Modelling Framework are articulated as research opportunities.

[9]This paper describes the first design iteration according to the DSR described in section 1.3.3. Consequently, it is part of the first research outcome (RO 1).

## 4.3. Research Outcome 1: Platform Design Framework

### 4.3.1. P5: Designing Industrial Symbiosis Platforms – from Platform Ecosystems to Industrial Ecosystems

Paper 5 applies the Ecosystems Modelling Framework developed in paper 4 to the domain of industrial symbiosis. In a case study, it describes how the framework can be used to develop an ecosystem and a corresponding platform architecture with a boundary resources model for platforms in eco-industrial parks.

Regarding this doctoral thesis, the paper contributes by an intermediate evaluation of the Ecosystems Modelling Framework. It evaluates the applicability of the Ecosystems Modelling Framework to a domain which is different from the healthcare sector. According to the healthcare domain, industrial symbiosis has quite different market mechanisms. The core value proposition is different as well as the resulting relationships and the revenue streams. The main aim of industrial symbiosis is to identify bilateral and multilateral resource streams that enable the reuse of material or energetic resources (Chertow, 2000). Commonalities with the healthcare sector are the diffusion problems with ICT solutions that support the implementation and management of the resource streams. The implementation of growing interorganisational information systems in industrial symbiosis does not measure up to the expectations (Grant et al., 2010).

A second contribution of the paper is an implicit methodical approach to develop ecosystems. From the methodical position, the paper demonstrates how a boundary resources model can be systematically built by an analysis of the goals and the roles in an ecosystem, a specification of the business models, and by the definition of a corresponding information system model. The paper shows an approach on how the roles of a specific domain can be mapped to different role models of the platform theory. Furthermore, it provides a simplified approach to formalise the business layer and the information systems layer of the ecosystem model. Moreover, the paper describes four classes of value creation streams that could be supported by a platform:

- **Business innovation:** A platform supports innovation of business models in the domain.
- **Business routine:** The management of existing business processes is supported by reusable platform services.
- **Service innovation:** New digital innovations are created on the platform that influences how business processes are conducted and enable the emergence of new business models.

- **Service routine:** The provision of established digital services to support the creation of information systems between the platform users.

These represent an operationalisation of the different views on ecosystems (business ecosystem, innovation ecosystem) (Jacobides et al., 2018). In further research they can guide the specification of how a platform supports the partners in an ecosystem.

### 4.3.2. P6: Management of Digital Ecosystems with the DREEM-Method – the Case of a Virtual Coaching Platform (German Original Title: Management Digitaler Ökosysteme mit der DREEM-Methode am Beispiel einer Virtual-Coaching-Plattform)

The case-oriented implicit methodical approach of paper 5 has been used in paper 6 to develop a process model for ecosystem and platform design and management, named Dresden Ecosystem Management Method (DREEM) (see figure A.7). It complements the structural ecosystem modelling framework with an explicit method description. This follows the convergence of method engineering and reference modeling (Winter et al., 2009). A methodical approach for ecosystem and platform design describes a systematic and logically ordered set of activities that help to achieve valid ecosystem and platform concepts (*activity view* according to Winter et al., 2009). The Ecosystems Modeling Framework (see section 4.2.2) focuses on the result and describes which concepts need to be defined (*result view* according to Winter et al., 2009).

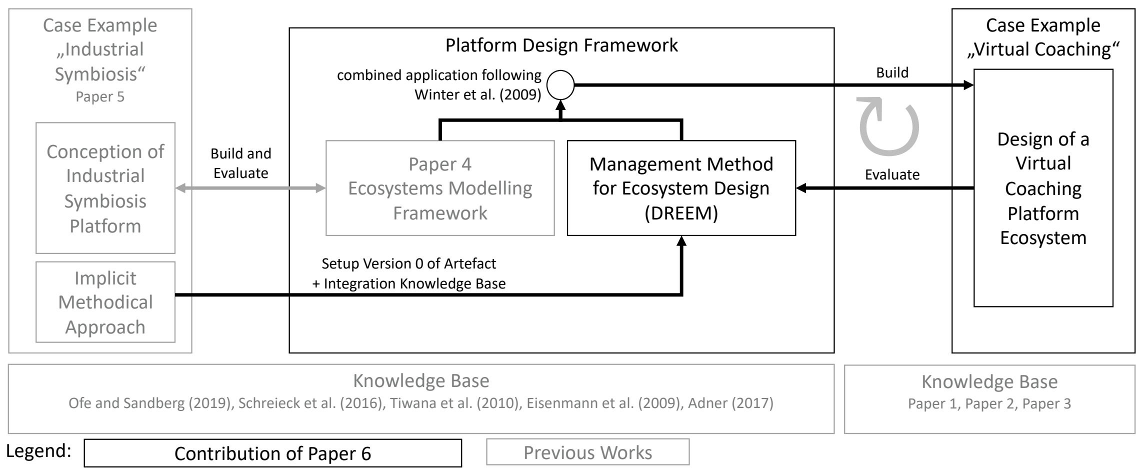


Figure A.7.: Cumulative construction of the Platform Design Framework

DREEM describes the steps for ecosystem construction in three phases: ecosystem design, platform design, and monitoring. The method is defined as a cyclic nominal process following Ofe and Sandberg (2019). The steps of the method integrate the modelling views defined in the Ecosystems Modelling Framework. The practical design concepts referenced in the individual steps of the method result from the work of Schreieck et al. (2016). The ”Dresden Ecosystem Management Method” (DREEM) defines reactive responses to effects that are identified in the ecosystem model as well as in the instantiation of the ecosystem. These responses are motivated by the ecosystem dilemma which is also explained in the paper. The development of boundary resources and platform strategies lead to potential development pathways in the ecosystem. If these development pathways leave the intended solution space, the platform owner has to reconfigure his or her platform strategy (Ofe and Sandberg, 2019; Ghazawneh and Henfridsson, 2011). The model-based approach of DREEM allows describing partial models that focus on such development pathways and provide the ability to iteratively develop new platform strategies and architectural decisions.

In order to provide a naturalistic evaluation setting, the method is applied to an eHealth platform for virtual coaching in the field of rehabilitation. In this case study, the governance guidelines of paper 1 and the design principles of paper 2 were considered.

### 4.3.3. P7: Guiding the Development of Digital Ecosystems

Paper 7 adds a stronger methodical and theoretical basis to the method definitions and justifies each step of the method by descriptive as well as prescriptive ecosystem theories. A guiding theory is assigned to each step of DREEM. The paper aligns the method construction and the case study to the design process of Peffers et al. (2007).

### 4.3.4. P8: Towards Maintenance Analytics Ecosystems: A Conceptual Role-Relationship Model

The steps of DREEM are defined from a generic position and need to be instantiated. The instantiation for a concrete platform depends on the domain in which the method is applied. Paper 8 outlines the usage of the design phases of DREEM and shows how a concrete step, the identification of roles in the ecosystem, can be done. The step is applied in the field of maintenance analytics platforms. Based on a multi-case analysis, a role-relationship model for maintenance analytics platforms is proposed.

The paper contributes by evaluating the applicability of DREEM in a domain different from the healthcare sector. In the course of the paper, the phases are applied in the methodical setting and integrated into the DSR process of Peffers et al. (2007). Thus, it also describes how the method can be used in the context of a platform design process. According to the nominal platform design process (see section 2.3), the paper demonstrates how objectives for ecosystems in specific domains can be defined and how platform design can be conducted.

## 4.4. Research Outcome 2: Prescriptive Knowledge for Platforms in Healthcare

### 4.4.1. P2: Revise your eHealth-Platform - Design Principles for a Descriptive Case Study

Paper 2 uses the Solution Space Model and the identified characteristics for ecosystems from paper 4 to describe seven design principles for platforms. The objective of the paper is to describe how open platforms for integrated care networks can be created. The paper takes an organisational perspective. Firstly, it questions how the organisational structures (management of healthcare networks, platform management) should be adjusted. Secondly, it reflects on how the business models of the platform should be designed in order to achieve ecosystem effects like emergence or coevolution. Hence, it extends the view of paper 1 by questioning how the utilisation and operation of the platform should be organised. Seven design principles are derived from the theory. These design principles question the importance of open business models, low entry barriers for ecosystem participants and the relationship of platform management and care management.

The paper applies the organisational design principles in a descriptive case study (Yin, 2003, p. 23) and investigates how these principles are realised in the case context. Since design principles represent prescriptive knowledge (Chandra et al., 2015), their application in a descriptive case study is an application of design theory, whereby the design principles represent the solution design knowledge (Drechsler and Hevner, 2018). The main contributions of the paper are

- the application of platform theory to eHealth platforms,
- practically oriented guidance for platform owners and
- the provision of a knowledge base for the evaluation of eHealth platforms.

The paper calls for the usage of the principles in evaluation studies on platforms. A study which uses the principles from the paper was conducted by Beštek and Eklund (2019), who instantiate the principles with concrete evaluation questions.

### 4.4.2. P3: Business Model Open E-Health-Platforms - Requirements and Potentials (German Original Title: Geschäftsmodell Offene "E-Health-Plattform" - Anforderungen und Potentiale)

Based on the design principles which mainly focus on the socio-economical context of an ecosystem, paper 3 extends paper 2 by introducing the socio-technical view by questioning how the platform and its services support the creation of interorganisational information systems in integrated care. The paper formulates a comprehensive view on the interplay of platform services, third-party solutions, the intraorganisational and interorganisational information systems, and the organisational design of integrated care networks.

The paper maps the understanding of interorganisational information systems to healthcare networks and explains how platforms help to create these systems. Based on the role model of Eisenmann et al. (2008), the stakeholders of the healthcare sector are mapped to the roles of platform ecosystems. Furthermore, potential platform owners in the healthcare sector are identified. The contribution of the paper is an understanding of how intra- and interorganisational information systems are related to platforms by adopting the interorganisational view of Fedorowicz et al. (2004). The mappings of roles are used to contribute with an adapted platform ecosystem model for the healthcare sector. This model is used to further explain design requirements for ecosystems. The applicability of the platform ecosystem model and the requirements are shown by two different case scenarios for an existing telehealth platform.

## 4.5. Research Outcome 3: Evaluation Guidance for eHealth platforms

### 4.5.1. P9: Sustainability of E-Health Projects (German Original Title: Nachhaltigkeit von E-Health-Projekten)

Paper 9 revises the evaluation approach from the given research entry point (Benedict et al., 2015) using the ecosystem characteristics described in paper 4. The paper motivates the evaluation by addressing the variability of eHealth sustainability (Fanta et al., 2015). It concludes that not only one dimension determines the sustainability of eHealth. Consequently, the evaluation of digital ecosystems in healthcare must consider this variety by addressing technological, social and economical aspects. The paper describes that ecosystems can support these aspects by creating a mutable environment in which interorganisational information systems between different stakeholders of the healthcare sector (see section 4.4.2) are adaptable (”living information systems:” Kanellis and Paul, 1997).

The paper contributes by justifying interoperability and expandability as central criteria for platform openness and aligns it with characteristics of ecosystems. These two characteristics have been selected due to their importance for the evolutionary dynamics in the platform (Tiwana, 2015). A framework systematises the evaluation of interoperability and expandability on different layers. This framework provides objectives, subordinated criteria and evaluation measures. For example, the Architecture Tradeoff Analysis Method (Kazman et al., 2000) can be applied for the evaluation of expandability. The maturity model for enterprise interoperability (Guédria et al., 2009) is suggested as an evaluation approach for interoperability. According to the nominal platform design process (section 2.3), the paper describes aspects of platform evaluation and proposes methods for the evaluation of platforms. Possible further evaluation criteria and following evaluation questions are provided in appendix c. The criteria are derived from the characteristics of ecosystems that result from paper 4.

### 4.5.2. P10: ISO 11354-2 for the Evaluation of eHealth Platforms

Paper 10 describes a concrete methodical approach to evaluate the interoperability potentials of an eHealth platform. Interoperability was selected because it is a foundational characteristic and a determining premise for expandability (Tiwana, 2015). Furthermore, interoperability is well conceptualised in the field of information systems (Vernadat, 2010). Based on the Maturity Model for Enterprise Interoperability (MMEI) (Guédria et al., 2009), the paper describes an indicator-based evaluation model for eHealth platforms and a corresponding methodical approach to comprehensively evaluate the specific design criterion *interoperability* of an eHealth platform. It instantiates the evaluation measures for the organisational layer, logical layer and technological layer as articulated in paper 9.

The paper also addresses how the definition of evaluation criteria and the inspection of a concrete platform can be disaggregated. It describes a structural model which extends the MMEI evaluation model. The extended model separates the definition of the indicators from the observations. Additionally, the paper describes three different strategies on how the indicators can be numerically aggregated. These strategies formalise the different understandings on how concrete measures in platforms may contribute to the interoperability of the platform.

The evaluation model was applied in a case study. Therefore, the paper demonstrates how a concrete characteristic of a platform can be evaluated. Regarding the nominal platform design process, it describes a methodical approach for recurring evaluation. The indicator-based model can be applied to other characteristics (see appendix c) by replacing the interoperability barriers and concerns with corresponding views on the specific criteria. For example, coevolution can be analysed by introducing different levels (individual to organisational in Breslin, 2016). These levels could be adapted by assigning them to the goals defined in the evaluation model.

# 5. Conclusion

## 5.1. Results and Contributions

The platform economy has gained momentum both in the practice of digital products as well as in Wirtschaftsinformatik and Information Systems Research. Platforms change how companies provide their products in two ways: products become platforms and products become parts of platforms (Alstyne et al., 2016). Creating platform products, however, stays a challenge for platform owners and product managers.

The leading objective of this doctoral thesis is to provide guidance for design and evaluation of platforms. This objective is achieved by providing a design-science-oriented holistic view on platforms and their ecosystems. The corresponding research questions have been answered as follows:

1. *Which design aspects are relevant to the construction of digital platforms and their ecosystems?*

   Based on existing platform theories, the Solution Space Model and the Ecosystems Modelling Framework (see section 4.2.2) introduce the design aspects of platform-based ecosystems and explain how these aspects are interrelated. It is shown how the aspects can be used to systematise the modelling of platform-based ecosystems in different domains.

2. *How can the construction of ecosystems and the corresponding digital platform systematically be guided?*

   The DREEM (see sections 4.3.2 and 4.3.3) provides a methodical framework for the systematic composition of the modelling views defined in the Ecosystems Modelling Framework. It provides a proposal for activities to create platform-based ecosystems. It is shown how this framework can be used to systematically develop ecosystems in different domains.

3. *How should eHealth platforms be designed in order to foster the implementation of innovative eHealth solutions?*

   The specified design principles (see section 4.4.1) describe the organisational aspects of ecosystem design. The governance guidelines (see section 4.2.1) describe which measures are necessary in different phases of platform projects to achieve a viable ecosystem in the healthcare sector. The healthcare specific adaptation of a platform ecosystem model (see section 4.4.2) describes the specialisation of generic ecosystem concepts in this field.

4. *How can the ability of eHealth platforms to create innovation-friendly ecosystems be evaluated systematically?*

   The evaluation framework (see section 4.5.1) supports the organisational, logical and technological evaluation of eHealth platforms. It describes individual criteria and measures for each evaluation aspect. The application of the MMEI (see section 4.5.2) describes how the evaluation of a specific criterion can be conducted. The provided evaluation approaches can be applied to platforms created with the Platform Design Framework.

This doctoral thesis contributes knowledge on how to design and evaluate platforms in specific domains. In order to explicate the contribution to the knowledge base of Wirtschaftsinformatik and Information Systems Research, the three research outcomes can be aligned to the framework of Gregor and Jones (2007). The eight components of the framework help to understand and communicate how the research outcomes can be used by other scholars and how they form theoretical contributions (Gregor and Jones, 2007). For example, they determine the scope of an artefact (component ”purpose and scope”) and how it can be modified (component ”artefact mutability”).

The core contribution of this work is the first research outcome (RO 1). It focuses on the design and formalisation of platform-based ecosystems and provides the description of the Platform Design Framework. The framework describes a conceptual approach that helps to understand, develop and manage the complexity of platforms and their surrounding ecosystems. RO 1 consists of three subordinated artefacts (DREEM, Ecosystems Modeling Framework, Solution Space Model) that create the Platform Design Framework. In figure A.8, the instantiation of the eight components of Gregor and Jones (2007) is outlined for these artefacts. The Platform Design Framework enhances the existing methodical knowledge base. The DREEM as the dynamical part of the Platform Design Framework provides a tangible framework which adopts the existing platform theories and represents them in a methodical order. This supports practicians as well as researchers to systematically apply platform theory to their platform projects. Product managers can use the Platform Design Framework as guidance for the development and reengineering of their platform models or to develop new platform business models.

Researchers can use the Platform Design Framework to conceptualise platform approaches for different sectors and to propose architectural patterns for platforms. The systematisation of types of ecosystems (see paper 4, section 4.2.2) and the Solution Space Model help to comprehend the role of ecosystems in design-oriented research and their relationship to platforms. The combination of the structural (Ecosystems Modelling Framework) and dynamical (DREEM) understanding can be used as a theoretical framework to systematise and formalise how platform-based ecosystems emerge. Furthermore, researchers can adopt the Ecosystems Modelling Framework as a structural guideline to organise the knowledge about platforms. They can utilise it to identify and elaborate new research questions for specific aspects of ecosystem and platform development. The DREEM can be used as a method template for research projects in the field of platform development.

| | RO 1: Platform Design Framework | | |
|---|---|---|---|
| **Design Artefact** | **Dresden Ecosystem Management Method** | **Ecosystems Modelling Framework** | **Solution-Space Model** |
| Purpose and scope | Create and manage platform and ecosystem models and instantiations | | Understand design dependencies for platforms |
| Constructs | Platform models, ecosystem models, ecosystem actors and their behavior, ecosystem effects, boundary resources, governance measures | | |
| Principle of form and function | Phase model for ecosystem creation with steps and relations | Modelling views and their relationships | Solutions-spaces and explanation of dependencies |
| Artefact mutability | Variable selection of modelling languages, tailoring of phases | Addition of new views, different modelling approaches | Integration of new platform properties and ecosystem models |
| Testable propositions | Provision of applicability statements based on the application in different domains | | |
| Justificatory knowledge | Application of existing platform theory gained from literature review in paper 4 | | |
| Principles of implementation | Possible modelling languages are proposed, steps in DREEM | Description of systematic development of models | Phases in DREEM |
| Expository instantiation | Exemplaric modelling of a virtual coaching platform, development of role model for maintenance analytics | Exemplaric modelling of a virtual coaching platform and industrial symbiosis platform | Implicit in the different case examples |

Figure A.8.: Contributions of research outcome 1 - building blocks of the Platform Design Framework, adapted from (Gregor and Jones, 2007)

The instantiation of the eight components of design theories for the second research outcome (RO 2) is given in appendix b in figure A.9. The design principles and guidelines support practicians in developing healthcare-oriented platform business models. They supports initiators of platforms, for example national authorities, by an instantiation of platform theories for the special case of the healthcare sector. RO 2 creates a foundation for the development of eHealth platforms using the Platform Design Framework. The platform ecosystem model for healthcare helps practicians as well as researchers to map the stakeholders of the healthcare sector to roles in platform-based ecosystems. The results of this research outcome contribute to the body of prescriptive knowledge and thus can be integrated into further design-oriented research projects in the field of the healthcare sector. In addition to the design-supporting aspect, researchers can adopt the healthcare specific design principles and guidelines as a foundation for the analysis of platforms (e.g. Beštek and Eklund, 2019). Furthermore, the results of the case studies conducted in RO 2 can be used as a template for similar research efforts. Consequently, the doctoral thesis also contributes by providing domain-specific implementation knowledge.

The third research outcome (RO 3) deals with the question of how statements about the quality of the platform models and instances can be obtained. The instantiation of the eight components of design theories is provided in appendix b in figure A.10. RO 3 enhances the knowledge base with methodical guidance for eHealth platform evaluation and can be used by platform providers to benchmark own platforms. It can be used to analyse platform models that were created by the Platform Design Framework. Researchers can adapt the methodical evaluation approaches for their own evaluations by implementing new quality objectives and evaluation criteria. Beside the eHealth-specific contribution, the thesis contributes by providing domain-specific knowledge in the domains Industrial Symbiosis and Maintenance Analytics.

To sum up, the combination of the three research outcomes establishes a comprehensive theoretical approach to the design and evaluation of platforms in the healthcare sector. It supports both researchers and professionals by implementing and analysing own platform strategies.

## 5.2. Validation and Evaluation

Besides the evaluation using case studies in the individual papers, an artificial evaluation (Venable et al., 2012) is conducted by validating the research outcomes against the requirements (see section 3). The tables A.9, A.10 and A.11 in the appendix provide results of the validation. The evaluation measures for the individual research contributions are summarised in table A.6. The classification follows Venable et al. (2012). An evaluation is classified as naturalistic if it is applied to existing platforms or platforms that are created in a real-world context (for example to the aforementioned Telehealth Platform for Eastern Saxony). An evaluation is classified as artificial if it is applied to a theoretically constructed platform which could appear as a real-world case, but is not existing yet (for example the aforementioned Industrial Symbiosis Platform). This interpretation follows Gregor and Jones (2007) who differentiate between material artefacts that are instances of the real world (e.g. software or hardware) and abstract artefacts which represent theories about artefacts.

Summarizing, the evaluations conducted in the individual research works have shown the applicability of the proposed contributions. It was shown that the Platform Design Framework (RO 1) supports the systematic creation of platform and ecosystem models. The framework has successfully supported the instantiation of the platform theory for concrete artefact construction and the creation of models for ecosystems in three different domains. For the prescriptive design knowledge (RO 2) it was shown that this knowledge is applicable to a real project. The design principles were also used in the named platform project for Eastern

[10] acc. to (Venable et al., 2012)

Table A.6.: Summary of the evaluations conducted in the individual research papers

| P.-ID | Evaluation | Evaluand | Evaluation Context | Classification[10] |
|---|---|---|---|---|
| P1 | Integrated build, intervention and evaluation cycles conforming to ADR | Governance Guidelines | Telehealth Platform for Eastern Saxony | Naturalistic |
| P2 | Descriptive case study | Design Principles, Solution Space Model | Telehealth Platform for Eastern Saxony | Naturalistic |
| P3 | Scenario-based evaluation, two scenarios | Platform ecosystem model for healthcare, and corresponding requirements | Fictional Healthcare Network | Artificial |
| P4 | - | - | - | - |
| P5 | Case-based Development of ecosystem and boundary resources model | Ecosystems Modelling Framework, Solution Space Model | Industrial Symbiosis Platform | Artificial |
| P6 | Case-based modelling of platform and ecosystem | DREEM and Ecosystems Modelling Framework | vCare Virtual Coaching Platform | Naturalistic |
| P7 | as in P6 | as in P6 | as in P6 | as in P6 |
| P8 | Multi-case-based development of role-model | DREEM and Ecosystems Modelling Framework | Maintenance Analytics Platforms | Naturalistic |
| P9 | Case-based application | Evaluation Framework for E-Health-Platforms | Telehealth Platform for Eastern Saxony | Naturalistic |
| P10 | Case-based application | Indicator-based Evaluation Model | Telehealth Platform for Eastern Saxony | Naturalistic |

Saxony to produce an evaluation report which was made available to the platform owner. This also applies to the evaluation guidance (RO 3).

## 5.3. Critiques and Prospects

Since this work follows the design-science research paradigm, the research results in this doctoral thesis inherit the limitations that arise from this paradigm. In particular, the utility of artefacts depends on their context of usage and the specificity of the problem context (Gregor and Hevner, 2013). Consequently, the research outcomes are limited to this explicated problem context. Even though the applicability and adaptability (Prat et al., 2015) of the Platform Design Framework was demonstrated in three different domains, it's adaptability and applicability in other domains and by other stakeholders is not guaranteed. However, the DREEM and the Ecosystems Modelling Framework offer possibilities for extension and tailoring. This allows the evolution of the artefacts provided by this work.

The application of the DREEM and the Ecosystems Modelling Framework was evaluated through case studies situated in different domains. The evaluation results are restricted to the case studies and can only be generalised by argumentative positions of the researcher (Benbasat et al., 1987, p. 371). In further research the application of the DREEM could be analysed by an experimental setting. A set of product managers and platform owners could apply the DREEM to their own product landscape in order to identify obstacles or ambiguities in the usage of the method. The evaluation of the efficient usage in practice settings different from the given case studies is pending and must be done in further research.

Since platform and ecosystem theories originated from the field of economics and organisation sciences (Moore, 1993; Rochet and Tirole, 2003), the kernel theories that guide the research work were mainly influenced by these fields of science. This doctoral thesis uses the postulates from these theories as premises. The existence of network effects, value-co-creation and coevolution were used as leading design criteria. However, the doctoral thesis does not question whether these effects really lead to positive effects in the healthcare domain. Nevertheless, there is evidence for these effects in the healthcare sector (Fürstenau and Auschra, 2016). Furthermore, the applicability of the methodology does not depend on the existence of these effects.

With regard to the proposed evaluation approach in RO 3, the focus has been on interoperability which is one of the major characteristics for the openness of platforms. However, the concrete evaluation of other characteristics is pending and needs to be conducted in further research. The framework proposed in paper 9 may provide an entry point for further evaluation approaches. The proposed evaluation guidance supports the analysis of whether a platform architecture and strategy lead to specific characteristics and effects in the ecosystem. However, the evaluation approaches do not question whether a platform architecture leads to economical efficency or to a reliable prediction of platform success. Other factors than specific characteristics may influence the success of platforms. According to the framework of Venable et al. (2012), a naturalistic ex post evaluation may provide insights into the efficiency and success of platforms created with the provided Platform Design Framework.

Further research work can be conducted in the field of conceptual modelling of ecosystems. Modelling languages for the different views of the Ecosystems Modelling Framework need to be identified. A mapping of ecosystem concepts to these modelling languages is needed in order to analyse whether existing modelling languages can be used for the modelling of platform-based ecosystems. The development and integration of metamodels for ecosystem and platform modelling is there a prospect challenge for research. The representation of ecosystem effects (e.g. network effects, coevolution) in existing modelling languages is one specific research challenge which also should be addressed in further research.

# Bibliography

Aanestad, Margunn, Miria Grisot, Ole Hanseth, and Polyxeni Vassilakopoulou 2017. Information Infrastructures for eHealth. In Aanestad, Margunn, Miria Grisot, Ole Hanseth, and Polyxeni Vassilakopoulou (eds), Information Infrastructures within European Health Care, pages 11–23. Springer International Publishing, Cham.

Accenture 2016. Digital Health Technology Vision 2016 - Top 5 Digital Health Trends Show the Power of People.

Adner, Ron 2017. Ecosystem as Structure: An Actionable Construct for Strategy. Journal of Management, 43(1):39–58.

Agboola, Stephen O., David W. Bates, and Joseph C. Kvedar 2016. Digital Health and Patient Safety. JAMA, 315(16):1697.

Alexandrou, D., and G. Mentzas 2009. Research Challenges for Achieving Healthcare Business Process Interoperability. In 2009 International Conference on eHealth, Telemedicine, and Social Medicine, pages 58–65.

Alkraiji, Abdullah, Thomas Jackson, and Ian Murray 2013. Barriers to the Widespread Adoption of Health Data Standards: An Exploratory Qualitative Study in Tertiary Healthcare Organizations in Saudi Arabia. Journal of Medical Systems, 37(2):9895.

Alstyne, Marshall W. Van, Geoffrey G. Parker, and Sangeet Paul Choudary 2016. Pipelines, Platforms, and the New Rules of Strategy. Harvard Business Review, 94(4):54–62.

Amelung, Volker, Sascha Wolf, and Helmut Hildebrandt 2012. Integrated Care in Germany – a Stony but Necessary Road! International Journal of Integrated Care, 12(1):1–5.

Andreassen, Hege K., Lars Erik Kjekshus, and Aksel Tjora 2015. Survival of the Project: A Case Study of ICT Innovation in Health Care. Social Science & Medicine, 132:62–69.

Anvaari, Mohsen, and Slinger Jansen 2010. Evaluating Architectural Openness in Mobile Software Platforms. In Proceedings of the Fourth European Conference on Software Architecture, page 85, Copenhagen, Denmark. ACM Press.

Auschra, Carolin 2018. Barriers to the Integration of Care in Inter-Organisational Settings: A Literature Review. International Journal of Integrated Care, 18(1):5.

Baldwin, Carliss Y., and C. Jason Woodard 2008. The Architecture of Platforms: A Unified View. SSRN Electronic Journal.

Baller, Silja, Soumitra Dutta, and Bruno Lanvin 2016. Global Information Technology Report 2016. Ouranos Geneva.

Becker, Jörg, Roland Holten, Ralf Knackstedt, and Björn Niehaves 2003. Forschungsmethodische Positionierung in Der Wirtschaftsinformatik: Epistemologische, Ontologische Und Linguistische Leitfragen. Technical report, Arbeitsberichte des Instituts für Wirtschaftsinformatik, Westfälische Wilhelms-Universität Münster.

Becker, Jörg, Roland Holten, Ralf Knackstedt, and Björn Niehaves 2004. Epistemologische Positionierungen in Der Wirtschaftsinformatik Am Beispiel Einer Konsensorientierten Informationsmodellierung. In Frank, Ulrich (ed), Wissenschaftstheorie in Ökonomie Und Wirtschaftsinformatik: Theoriebildung Und -Bewertung, Ontologien, Wissensmanagement, pages 335–336. Deutscher Universitätsverlag, Wiesbaden.

Benbasat, Izak, David K. Goldstein, and Melissa Mead 1987. The Case Research Strategy in Studies of Information Systems. MIS Quarterly, 11(3):369–386.

Bender, D., and K. Sartipi 2013. HL7 FHIR: An Agile and RESTful Approach to Healthcare Information Exchange. In Proceedings of the 26th IEEE International Symposium on Computer-Based Medical Systems, pages 326–331.

Benedict, Martin, Martin Burwitz, and Hannes Schlieter 2015. Certification of Service-Oriented eHealth Platforms - Derivation of Structured Criteria for Interoperability and Expandability:. In Proceedings of 8th International Conference On Health Informatics (HEALTHINF), pages 114–122, Lisbon, Portugal. SCITEPRESS - Science and and Technology Publications.

Benedict, Martin, Hanno Herrmann, and Werner Esswein 2018. eHealth-Platforms - The Case of Europe. In Building Continents of Knowledge in Oceans of Data: The Future of Co-Created eHealth - Proceedings of MIE 2018, volume 247 of *Studies in Health Technology and Informatics*, pages 241–245, Gothenburg, Sweden. IOS Press.

Benlian, Alexander, Daniel Hilkert, and Thomas Hess 2015. How Open Is This Platform? The Meaning and Measurement of Platform Openness from the Complementors' Perspective. Journal of Information Technology, 30(3):209–228.

Benson, Tim, and Grahame Grieve 2016. Why Interoperability Is Hard. In Benson, Tim, and Grahame Grieve (eds), Principles of Health Interoperability: SNOMED CT, HL7 and FHIR, pages 19–35. Springer International Publishing, Cham.

Beštek, Mate, and Peter Eklund 2019. Is National eHealth in Slovenia on Track to Be an Open eHealth Platform? European Journal of Biomedical Informatics.

Bianco, Vittorio Dal, Varvana Myllarniemi, Marko Komssi, and Mikko Raatikainen 2014. The Role of Platform Boundary Resources in Software Ecosystems: A Case Study. In Proceedings of 2014 IEEE/IFIP Conference on Software Architecture, pages 11–20, Sydney, NSW, Australia. IEEE.

Bittner, Kurt, and Ian Spence 2002. The Relationship Between Use Cases and Requirements. In Use Case Modeling. Addison-Wesley Professional.

Blaschke, Michael, Kazem Haki, Stephan Aier, and Robert Winter 2019. Taxonomy of Digital Platforms: A Platform Architecture Perspective. In Proceedings of the International Conference on Wirtschaftsinformatik 2019, Siegen, Germany.

Böhm, Katharina, Achim Schmid, Ralf Götze, Claudia Landwehr, and Heinz Rothgang 2013. Five Types of OECD Healthcare Systems: Empirical Results of a Deductive Classification. Health Policy (Amsterdam, Netherlands), 113(3):258–269.

Boudreau, Kevin, and Andrei Hagiu 2008. Platform Rules: Multi-Sided Platforms as Regulators. SSRN Scholarly Paper ID 1269966, Social Science Research Network, Rochester, NY.

Braun, Richard, Martin Benedict, Hannes Wendler, and Werner Esswein 2015. Proposal for Requirements Driven Design Science Research. In Donnellan, Brian, Markus Helfert, Jim Kenneally, Debra VanderMeer, Marcus Rothenberger, and Robert Winter (eds), New Horizons in Design Science: Broadening the Research Agenda, volume 9073 of *Lecture Notes in Computer Science*, pages 135–151, Dublin, Ireland. Springer International Publishing.

Breslin, Dermot 2016. What Evolves in Organizational Co-Evolution? Journal of Management & Governance, 20(1):45–67.

Brinkkemper, S. 1996. Method Engineering: Engineering of Information Systems Development Methods and Tools. Information and Software Technology, 38(4):275–280.

Briscoe, Gerard, and Alexandros Marinos 2009. Digital Ecosystems in the Clouds: Towards Community Cloud Computing. In Digital Ecosystems and Technologies, 2009. DEST'09. 3rd IEEE International Conference On, pages 103–108. IEEE.

Bundesministerium für Gesundheit 2019. Das E-Health-Gesetz. http://www.bundesgesundheitsministerium.de/themen/krankenversicherung/e-health-gesetz/e-health.html.
visited:14-03-2019.

Burkard, Christoph, Thomas Widjaja, and Peter Buxmann 2012. Software Ecosystems. Business & Information Systems Engineering, 4(1):41–44.

Chandra, Leona, Stefan Seidel, and Shirley Gregor 2015. Prescriptive Knowledge in IS Research: Conceptualizing Design Principles in Terms of Materiality, Action, and Boundary Conditions. In 2015 48th Hawaii International Conference on System Sciences, pages 4039–4048, HI, USA. IEEE.

Chertow, Marian R. 2000. Industrial Symbiosis: Literature and Taxonomy. Annual Review of Energy and the Environment, 25(1):313–337.

Chesbrough, Henry W., and Melissa M. Appleyard FAL 2007. Open Innovation and Strategy. California Management Review, 50(1):57–+.

Chowdhury, Jeeshan 2012. Hacking Health: Bottom-up Innovation for Healthcare. Technology Innovation Management Review, 2(7).

Christensen, Henrik Bærbak, Klaus Marius Hansen, Morten Kyng, and Konstantinos Manikas 2014. Analysis and Design of Software Ecosystem Architectures – Towards the 4S Telemedicine Ecosystem. Information and Software Technology, 56(11):1476–1492.

Cleary, M., E. Peters, and L. Keane 2017. DRAFT Report on EU State of Play on Patient Access on eHealth Data. Joint Action to support the eHealth Network.

Cleven, A., P. Gubler, and K. M Hüner 2009. Design Alternatives for the Evaluation of Design Science Research Artifacts. In Proceedings of the 4th International Conference on Design Science Research in Information Systems and Technology, pages 1–8.

Coiera, E. 2009. Building a National Health IT System from the Middle Out. Journal of the American Medical Informatics Association, 16(3):271–273.

Coorevits, Pascal, Georges De Moor, Jos Devlies, Karima Bourquard, Georg Heidenreich, Stefan Sauermann, and Cor Loef 2011. D4.2 Processing Interoperability Testing, Semantic and Functional Criteria. Deliverable D4.2, EU Project HITCH.

Cusumano, Michael 2010. The Evolution of Platform Thinking. Communications of the ACM, 53(1):32.

de Bont, Antoinette, and Roland Bal 2008. Telemedicine in Interdisciplinary Work Practices: On an IT System That Met the Criteria for Success Set out by Its Sponsors, yet Failed to Become Part of Every-Day Clinical Routines. BMC Medical Informatics and Decision Making, 8(1):47.

Drechsler, Andreas, and Alan R. Hevner 2018. Utilizing, Producing, and Contributing Design Knowledge in DSR Projects. In Chatterjee, Samir, Kaushik Dutta, and Rangaraja P. Sundarraj (eds), Designing for a Digital and Globalized World, volume 10844, pages 82–97. Springer International Publishing, Cham.

Eaton, Ben, Silvia Elaluf-Calderwood, and Carsten Sorensen 2015. Distributed Tuning of Boundary Resources: The Case of Apple's Ios Service System. Mis Quarterly, 39(1):217–+.

Eisenmann, Thomas R., Geoffrey Parker, and Marshall W. Van Alstyne 2008. Opening Platforms: How, When and Why? SSRN Electronic Journal.

Ekeland, Anne G., Alison Bowes, and Signe Flottorp 2010. Effectiveness of Telemedicine: A Systematic Review of Reviews. International Journal of Medical Informatics, 79(11):736–771.

Elaluf-Calderwood, S. M., B. D. Eaton, C. Sörensen, and Y. Yoo 2011. Control as a Strategy for the Development of Generativity in Business Models for Mobile Platforms. Intelligence in Next Generation Networks (ICIN), 2011 15th International Conference on, pages 271–276.

Elmer, Arno 2016. eHealth in Deutschland–Probleme, Projekte, Perspektiven. Gesundheit+ Gesellschaft Wissenschaft, 16(3):7–13.

Evans, David S. 2003. Some Empirical Aspects of Multi-Sided Platform Industries. Review of Network Economics, 2(3).

Fanta, Getnet Bogale, Leon Pretorius, and Louwrence Erasmus 2015. An Evaluation of eHealth Systems Implementation Frameworks for Sustainability in Resource Constrained Environments: A Literature Review. In IAMOT 2015 Conference Proceedings, Cape Town.

Fedorowicz, Jane, Janis L. Gogan, and Amy W. Ray 2004. The Ecology of Interorganizational Information Sharing. Journal of International Information Management, 13(2):1.

Frank, U 2006. Towards a Pluralistic Conception of Research Methods in Information Systems Research (Arbeitsbericht). Arbeitsbericht 7, Universität Duisburg-Essen, Duisburg-Essen.

Fürstenau, Daniel, and Carolin Auschra 2016. Open Digital Platforms in Health Care: Implementation and Scaling Strategies. In ICIS 2016 Proceedings, Dublin.

Gawer, Annabelle 2014. Bridging Differing Perspectives on Technological Platforms: Toward an Integrative Framework. Research Policy, 43(7):1239–1249.

Gawer, Annabelle, and Michael A. Cusumano 2014. Industry Platforms and Ecosystem Innovation: Platforms and Innovation. Journal of Product Innovation Management, 31(3):417–433.

Gersch, Martin, and Tilman Rüsike 2011. Diffusionshemmnisse Innovativer E-Health Anwendungen Im Deutschen Gesundheitswesen. Technical report, Projekt E-Health@Home, Berlin.

Ghazawneh, Ahmad, and Ola Henfridsson 2010. Governing Third-Party Development Through Platform Boundary Resources. In ICIS 2010 Proceedings, volume Proceedings ICIS, St. Louis.

Ghazawneh, Ahmad, and Ola Henfridsson 2011. Micro-Strategizing in Platform Ecosystems: A Multiple Case Study. In ICIS 2011 Proceedings, Shanghai.

Ghazawneh, Ahmad, and Ola Henfridsson 2013. Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model. Information Systems Journal, 23(2):173–192.

Gnyawali, Devi R., and Byung-Jin (Robert) Park 2011. Co-Opetition between Giants: Collaboration with Competitors for Technological Innovation. Research Policy, 40(5):650–663.

Grant, Gabriel B., Thomas P. Seager, Guillaume Massard, and Loring Nies 2010. Information and Communication Technology for Industrial Symbiosis. Journal of Industrial Ecology, 14(5):740–753.

Gregor, Shirley, and Alan R. Hevner 2013. Positioning and Presenting Design Science Research for Maximum Impact. MIS Quarterly, 37(2):337–A6.

Gregor, S., and D. Jones 2007. The Anatomy of a Design Theory. Journal of the Association for Information Systems, 8(5):312–335.

Grigsby, Jim, Michael Rigby, Amy Hiemstra, Max House, Silas Olsson, and Pamela Whitten 2002. Chapter 7: The Diffusion of Telemedicine. Telemedicine Journal and e-Health, 8(1):79–94.

Guédria, Wided, Hanan Bouzid, Guido Bosh, Yannick Naudet, and David Chen 2012. eHealth Interoperability Evaluation Using a Maturity Model. Studies in Health Technology and Informatics, 180:333–337.

Guédria, Wided, David Chen, and Yannick Naudet 2009. A Maturity Model for Enterprise Interoperability. In On the Move to Meaningful Internet Systems: OTM 2009 Workshops, pages 216–225. Springer.

Hanseth, Ole, and Kalle Lyytinen 2010. Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet. Journal of Information Technology, 25(1):1–19.

Henfridsson, Ola, and Bendik Bygstad 2013. The Generative Mechanisms of Digital Infrastructure Evolution. MIS Quarterly, 37(3):907–931.

Hevner, Alan, Jan vom Brocke, and Alexander Maedche 2019. Roles of Digital Innovation in Design Science Research. Business & Information Systems Engineering, 61(1):3–8.

Hevner, A. R, S. T March, J. Park, and S. Ram 2004. Design Science in Information Systems Research. Management information systems quarterly, 28(1):75–106.

Hoerbst, A., and M. Schweitzer 2015. A Systematic Investigation on Barriers and Critical Success Factors for Clinical Information Systems in Integrated Care Settings. Yearbook of Medical Informatics, 24(01):79–89.

Hwang, Jason, and Clayton M. Christensen 2008. Disruptive Innovation In Health Care Delivery: A Framework For Business-Model Innovation. Health Affairs, 27(5):1329–1335.

Iansiti, M., and R. Levien 2004. Strategy as Ecology. Harvard Business Review, 82(3):68–+.

IHE Deutschland e. V. 2019. Öffentliche Stellungnahme: Sicherstellen Der Interoperabilität Im Eigentlichen Sinn: IHE Deutschland e.V. Bemängelt Proprietäre Verwendung Internationaler Standards in Aktueller ePA-Spezifikation.

Iivari, Juhani 2007. A Paradigmatic Analysis of Information Systems As a Design Science. Scandinavian Journal of Information Systems, 19(2).

International Standardization Organisation 2011. ISO/IEC/IEEE 42010:2011 - Systems and Software Engineering – Architecture Description.

Iyawa, Gloria Ejehiohen, Marlien Herselman, and Adele Botha 2016. Digital Health Innovation Ecosystems: From Systematic Literature Review to Conceptual Framework. Procedia Computer Science, 100:244–252.

Jacobides, Michael G., Carmelo Cennamo, and Annabelle Gawer 2018. Towards a Theory of Ecosystems. Strategic Management Journal, 39(8):2255–2276.

Kanellis, P., and R.J. Paul 1997. On the Nature of Inter-Organisational Information Systems and the Issue of Adaptability. In Proceedings of the Thirtieth Hawaii International Conference on System Sciences, volume 3, pages 391–397, Wailea, HI, USA, USA. IEEE Comput. Soc. Press.

Kazman, Rick, Mark Klein, and Paul Clements 2000. ATAM: Method for Architecture Evaluation. Technical Reoirt CMU/SEI-2000-TR-004, Software Engineering Institute, Carnegie Mellon University, Pittsburgh.

Kelly, Christopher J., and Antony J. Young 2017. Promoting Innovation in Healthcare. Future Hospital Journal, 4(2):121–125.

Kierkegaard, Patrick 2013. eHealth in Denmark: A Case Study. Journal of Medical Systems, 37(6):1–10.

Knöppler, Karsten, and Pia Stendera 2019. Transfer von Digital Health in den Versorgungsalltag. In Haring, Robin (ed), Gesundheit digital, pages 83–97. Springer Berlin Heidelberg, Berlin, Heidelberg.

Kuechler, William, and Vijay Vaishnavi 2012. A Framework for Theory Development in Design Science Research: Multiple Perspectives. Journal of the Association for Information Systems, 13(6).

Labrique, Alain B., Christina Wadhwani, Koku Awoonor Williams, Peter Lamptey, Cees Hesp, Rowena Luk, and Ann Aerts 2018. Best Practices in Scaling Digital Health in Low and Middle Income Countries. Globalization and Health, 14(1):103.

Lauterbach, Marc, and Kathrin Hörner 2019. Erfolgsfaktoren in der Digitalisierung der Gesundheitsversorgung. In Haring, Robin (ed), Gesundheit digital: Perspektiven zur Digitalisierung im Gesundheitswesen, pages 123–142. Springer Berlin Heidelberg, Berlin, Heidelberg.

Leppert, Florian, and Wolfgang Greiner 2016. Finanzierung und Evaluation von eHealth-Anwendungen. In Fischer, Florian, and Alexander Krämer (eds), eHealth in Deutschland: Anforderungen und Potenziale innovativer Versorgungsstrukturen, pages 101–124. Springer Berlin Heidelberg, Berlin, Heidelberg.

Lin, Chi-Hung, I-Chun Lin, Jin-Sheng Roan, and Jehn-Shan Yeh 2012. Critical Factors Influencing Hospitals' Adoption of HL7 Version 2 Standards: An Empirical Investigation. Journal of Medical Systems, 36(3):1183–1192.

Luthe, Ernst-Wilhelm 2017. Dimensionen von „Integration", „Kooperation" und „Dezentralisierung". In Brandhorst, Andreas, Helmut Hildebrandt, and Ernst-Wilhelm Luthe (eds), Kooperation und Integration – das unvollendete Projekt des Gesundheitssystems, Gesundheit. Politik - Gesellschaft - Wirtschaft, pages 33–82. Springer Fachmedien Wiesbaden, Wiesbaden.

Lux, Thomas, Bernhard Breil, Michael Dörries, Daniel Gensorowsky, Wolfgang Greiner, Doris Pfeiffer, Felix G. Rebitschek, Gerd Gigerenzer, and Gert G. Wagner 2017. Digitalisierung im Gesundheitswesen — zwischen Datenschutz und moderner Medizinversorgung. Wirtschaftsdienst, 97(10):687–703.

Lyytinen, Kalle, and Jan Damsgaard 2011. Inter-Organizational Information Systems Adoption – a Configuration Analysis Approach. European Journal of Information Systems, 20(5):496–509.

MacNeil, Maggie, Melissa Koch, Ayse Kuspinar, Don Juzwishin, Pascale Lehoux, and Paul Stolee 2019. Enabling Health Technology Innovation in Canada: Barriers and Facilitators in Policy and Regulatory Processes. Health Policy, 123(2):203–214.

Maedche, Alexander, Shirley Gregor, Stefan Morana, and Jasper Feine 2019. Conceptualization of the Problem Space in Design Science Research. In Tulu, Bengisu, Soussan Djamasbi, and Gondy Leroy (eds), Extending the Boundaries of Design Science Theory and Practice, pages 18–31. Springer International Publishing.

Majchrzak, Ann, Sirkka L. Jarvenpaa, and Mehdi Bagherzadeh 2015. A Review of Interorganizational Collaboration Dynamics. Journal of Management, 41(5):1338–1360.

March, Salvatore T., and Gerald F. Smith 1995. Design and Natural Science Research on Information Technology. Decision Support Systems, 15(4):251–266.

Moody, Daniel 2003. The Method Evaluation Model: A Theoretical Model for Validating Information Systems Design Methods. ECIS 2003 Proceedings.

Moore, James F. 1993. Predators and Prey: A New Ecology of Competition. Harvard business review, 71(3):75–83.

Murray, Elizabeth, Joanne Burns, Carl May, Tracy Finch, Catherine O'Donnell, Paul Wallace, and Frances Mair 2011. Why Is It Difficult to Implement E-Health Initiatives? A Qualitative Study. Implementation Science, 6(1):6.

Nijeweme-d'Hollosy, W. O., L. van Velsen, M. Huygens, and H. Hermens 2015. Requirements for and Barriers towards Interoperable eHealth Technology in Primary Care. IEEE Internet Computing, 19(4):10–19.

Nohl-Deryk, Pascal, Jesaja Brinkmann, Ferdinand Gerlach, Jonas Schreyögg, and Dmitrij Achelrod 2018. Hürden bei der Digitalisierung der Medizin in Deutschland – eine Expertenbefragung. Das Gesundheitswesen, 80(11):939–945.

Ofe, Hosea, and Johan Sandberg 2019. Digital Platform Establishment: Navigating Competing Concerns in Emerging Ecosystems. In Proceedings of the 52nd Hawaii International Conference on System Sciences, Maui, USA.

Omachonu, Vincent K., and Norman G. Einspruch 2010. Innovation in Healthcare Delivery Systems: A Conceptual Framework. Innovation Journal, 15(1):2–20.

Organization, World Health 2019. eHealth at WHO. http://www.who.int/ehealth/about/en/. visited: 21-03-2019.

Ossebaard, Hans C., and Lisette Van Gemert-Pijnen 2016. eHealth and Quality in Health Care: Implementation Time. International Journal for Quality in Health Care, 28(3):415–419.

Österle, Hubert, Jörg Becker, Ulrich Frank, Thomas Hess, Dimitris Karagiannis, Helmut Krcmar, Peter Loos, Peter Mertens, Andreas Oberweis, and Elmar J Sinz 2011. Memorandum on Design-Oriented Information Systems Research. European Journal of Information Systems, 20(1):7–10.

Peffers, Ken, Tuure Tuunanen, Marcus A Rothenberger, and Samir Chatterjee Winter2007 2007. A Design Science Research Methodology for Information Systems Research. Journal of Management Information Systems, 24(3):45–77.

Peltoniemi, Mirva, and Elisa Vuori 2004. Business Ecosystem as the New Approach to Complex Adaptive Business Environments. In Proceedings of eBusiness Research Forum, pages 267–281.

Pendharkar, Sachin R., Jaana Woiceshyn, Giovani J. C. da Silveira, Diane Bischak, Ward Flemons, Finlay McAlister, and William A. Ghali 2016. What Happens When Healthcare Innovations Collide? BMJ Qual Saf, 25(1):9–13.

Petrik, Dimitri, Felix Schönhofen, David Straub, Georg Herzwurm, and Harald Kuolt 2018. Application of a Software Ecosystem Framework for Connected Vacuum Gripping Systems. Procedia CIRP, 72:580–585.

Prat, Nicolas, Isabelle Comyn-Wattiau, and Jacky Akoka 2015. A Taxonomy of Evaluation Methods for Information Systems Artifacts. Journal of Management Information Systems, 32(3):229–267.

Rescher, Nicholas 1996. Studien zur naturwissenschaftlichen Erkenntnislehre. Königshausen & Neumann.

Riedl, Christoph, Tilo Böhmann, Jan Marco Leimeister, and Helmut Krcmar 2009. A Framework for Analysing Service Ecosystem Capabilities to Innovate. SSRN Scholarly Paper ID 1650662, Social Science Research Network, Rochester, NY.

Rochet, Jean-Charles, and Jean Tirole 2003. Platform Competition in Two-Sided Markets. Journal of the European Economic Association, pages 990–1029.

Ruotsalainen, P.S. 2017. Privacy, Trust and Security in Two-Sided Markets. In E-Health Two-Sided Markets, pages 65–89. Elsevier.

Saarikko, Ted 2016. Platform Provider by Accident: A Case Study of Digital Platform Coring. Business & Information Systems Engineering, 58(3):177–191.

Saner, Hugo 2016. eHealth: From Unfulfilled Promises to Large-Scale Application. European Journal of Preventive Cardiology, 23(2_suppl):3–4.

Schilling, Melissa A. 2000. Toward a General Modular Systems Theory and Its Application to Interfirm Product Modularity. Academy of Management Review, 25(2):312–334.

Schreieck, Maximilian, Manuel Wiesche, and Helmut Krcmar 2016. Design and Governance of Platform Ecosystems – Key Concepts and Issues for Future Research. Research Papers.

Schütte, Reinhard 1999. Für Eine Gemäßigt Konstruktivistische Orientierung Der Wirtschaftsinformatik. In Becker, Jörg (ed), Wirtschaftsinformatik Und Wissenschaftstheorie. Bestandsaufnahmen Und Perspektiven, pages 211–245. Gabler, Wiesbaden.

Schweitzer, Julian, and Christina Synowiec 2012. The Economics of eHealth and mHealth. Journal of Health Communication, 17(sup1):73–81.

Sein, Henfridsson, Purao, Rossi, and Lindgren 2011. Action Design Research. MIS Quarterly, 35(1):37.

Serbanati, Luca Dan, Fabrizio L. Ricci, Gregorio Mercurio, and Andrei Vasilateanu 2011. Steps towards a Digital Health Ecosystem. Journal of Biomedical Informatics, 44(4):621–636.

Stroetmann, Karl A. 2013. Achieving the Integrated and Smart Health and Wellbeing Paradigm: A Call for Policy Research and Action on Governance and Business Models. International Journal of Medical Informatics, 82(4):e29–e37.

Stroetmann, Karl A., Jörg Artmann, Veli N. Stroetmann, Denis Protti, Jos Dumortier, Sarah Giest, Uta Walossek, and Diane Whitehouse 2011. European Countries on Their Journey towards National eHealth Infrastructures. Luxembourg: Office for Official Publications of the European Communities.

Thiel, Rainer, Lucas Deimel, Daniel Schmidtmann, Klaus Piesche, Tobias Hüsing, Jonas Rennoch, Veli Stroetmann, and Karl Stroetmann 2018. #SmartHealthSystems - Digitalisierungsstrategien im internationalen Vergleich.

Thun, Sylvia 2015. Digitalisierte Medizin: Die Zukunft der Medizin mit IT-Standards und einer weltweit gültigen Medizinfachsprache. Informatik-Spektrum, 38(1):22–27.

Tilson, David, Kalle Lyytinen, and Carsten Sørensen 2010. Research Commentary—Digital Infrastructures: The Missing IS Research Agenda. Information Systems Research, 21(4):748–759.

Tilson, D., C. Sorensen, and K. Lyytinen 2011. The Paradoxes of Change and Control in Digital Infrastructures: The Mobile Operating Systems Case. In 2011 10th International Conference on Mobile Business, pages 26–35.

Tiwana, Amrit 2014. Platform Ecosystems: Aligning Architecture, Governance, and Strategy. Morgan Kaufmann Publishers.

Tiwana, Amrit 2015. Evolutionary Competition in Platform Ecosystems. Information Systems Research, 26(2):266–281.

Tiwana, Amrit, Benn Konsynski, and Ashley A. Bush 2010. Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics. Information Systems Research, 21(4):675–687.

Ullah, Azmat, and Richard Lai 2011. Modeling Business Goal for Business/It Alignment Using Requirements Engineering. Journal of Computer Information Systems, 51(3):21–28.

Venable, John, Jan Pries-Heje, and Richard Baskerville 2012. A Comprehensive Framework for Evaluation in Design Science Research. In Design Science Research in Information Systems. Advances in Theory and Practice, pages 423–438. Springer.

Vernadat, François B. 2010. Technical, Semantic and Organizational Issues of Enterprise Interoperability and Networking. Annual Reviews in Control, 34(1):139–144.

Vimarlund, Vivian 2016. E-Health Two-Sided Markets: Implementation and Business Models. Academic Press.

Walls, Joseph G., George R. Widmeyer, and Omar A. El Sawy 1992. Building an Information System Design Theory for Vigilant EIS. Information Systems Research, 3(1):36–59.

Wand, Y., and R. Weber 2002. Research Commentary: Information Systems and Conceptual Modeling-a Research Agenda. Information Systems Research, 13(4):363–376.

Weber-Jahnke, Jens, Liam Peyton, and Thodoros Topaloglou 2012. eHealth System Interoperability. Information Systems Frontiers, 14(1):1–3.

Webster, Jane, and Richard T. Watson 2002. Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Q., 26(2):xiii–xxiii.

Wessel, Lauri, and Martin Gersch 2015. From ICT to Integrated Care: The Performative Cohesion of Organizing Visions. ECIS 2015 Completed Research Papers.

West, Joel 2003. How Open Is Open Enough?: Melding Proprietary and Open Source Platform Strategies. Open Source Software Development, 32(7):1259–1285.

Winter, R. 2008. Design Science Research in Europe. European Journal of Information Systems, 17(5):470–475.

Winter, Robert, Anke Gericke, and Tobias Bucher 2009. Method Versus Model – Two Sides of the Same Coin? In Albani, Antonia, Joseph Barjis, and Jan L. G. Dietz (eds), Advances in Enterprise Engineering III, pages 1–15. Springer Berlin Heidelberg.

Woodard, C. Jason, and Eric K. Clemons 2014. Modeling the Evolution of Generativity and the Emergence of Digital Ecosystems. In Proceedings of the International Conference on Information Systems - Building a Better World through Information Systems, ICIS 2014, Auckland, New Zealand, December 14-17, 2014, Auckland.

Worden, R., and P. Scott 2011. Simplifying HL7 Version 3 Messages. Studies in health technology and informatics, 169:709–713.

Yin, R. K. 2003. Applications of Case Study Research. SAGE, Newbury Park.

Yoo, Youngjin, Ola Henfridsson, and Kalle Lyytinen 2010. Research Commentary —The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. Information Systems Research, 21(4):724–735.

Zeng, Y., and G. D. Cheng 1991. On the Logic of Design. Design Studies, 12(3):137–141.

Zhu, Feng, and Nathan Furr 2016. Products to Platforms: Making the Leap. Harvard Business Review, 94(4)(April 2016).

Zimmermann, Alfred, Rainer Schmidt, Dierk Jugel, and Michael Möhring 2015. Evolving Enterprise Architectures for Digital Transformations. In Zimmermann, Alfred, and Alexander Rossmann (eds), DEC15, volume 15 of *Lecture Notes in Informatics - Proceedings*, pages 25–26, Böblingen. Gesellschaft für Informatik.

# Appendices

## a. Barriers for Digital Health Implementation

1. **Organisational and regulatory specialities of the healthcare industry lead to complex business models for innovators.** The healthcare sector can be subdivided into different socio-economical subsystems (sectors). Different players provide different services to the patient in different phases of treatment. In most healthcare systems, there are different regulations for different players (e.g. different reimbursement regulations for outpatient versus inpatient care facilities) (Böhm et al., 2013; Hwang and Christensen, 2008; Nohl-Deryk et al., 2018). eHealth solutions often aim to support inter-sectoral care. The market introduction and widespread diffusion of technological innovations that fit the demands of the different partners from the different sectors may be difficult due to different intentions, complex relationships between actors and cultural differences (Auschra, 2018; Kelly and Young, 2017). Furthermore, complex regulations regarding data protection, medical product regulations and reimbursement mechanisms lead to high user adaption efforts for the innovators (Grigsby et al., 2002; Stroetmann et al., 2011; Saner, 2016; MacNeil et al., 2019). For example, the integration into existing reimbursement mechanisms is a very long-term process which often gets outpaced by innovation cycles (Leppert and Greiner, 2016). Furthermore, stakeholders in healthcare are very quality sensitive and patient safety is not negotiable (de Bont and Bal, 2008; Ossebaard and Van Gemert-Pijnen, 2016; Agboola et al., 2016). This makes it hard for innovators to transfer a pilot into operative care (Knöppler and Stendera, 2019).

2. **There is a lack of interoperability in existing healthcare information systems.** Interoperabilty issues may occur on enterprise (organisational) level, on application system (logical) level as well as on IT-infrastructural level (Guédria et al., 2012). On the enterprise level, missing coordinated intersectoral processes and pathways as well as mutual legal agreements are major interoperability issues (Alexandrou and Mentzas, 2009; Weber-Jahnke et al., 2012; Benson and Grieve, 2016). On the application system level, interoperability issues result from missing interoperability standards (Auschra, 2018; Hoerbst and Schweitzer, 2015) and missing implementation of existing standards (Thun, 2015; Nohl-Deryk et al., 2018; Hoerbst and Schweitzer, 2015) in these systems. There are plenty of different interoperability standards like Integrating the Healthcare Enterprises (IHE), the family of HL7 standards or ISO 13606. However, their adoption works not as expected due to inappropriate IT architectures of the application systems or the complexity of the specification that leads to high learning

efforts (Alkraiji et al., 2013; Lin et al., 2012; Bender and Sartipi, 2013). For example, the Health Level Seven Version 3 (HL7v3) standard has been criticised for its very complex design (Worden and Scott, 2011). At the infrastructural level, interoperability issues result from immature technology, security issues and incompatible hardware (Nijeweme-d'Hollosy et al., 2015). For example in Germany, the national infrastructure for health communication (telematics infrastructure) as well as national electronic health records have not reached sufficient maturity yet (Thiel et al., 2018) and are criticised for inappropriate application of existing standards (IHE Deutschland e. V., 2019).

3. **eHealth projects are problem-seeking rather than solution-seeking.** Andreassen et al. (2015) state that eHealth projects are often "technology-deterministic" and try to reconstruct a perceived problem setting. Top-down-innovation approaches for healthcare modernisation have also failed (Chowdhury, 2012; Stroetmann, 2013). However, bottom-up innovation is difficult caused by missing social integration of innovators and demanders. Chowdhury (2012) states: "Fundamentally, those with the technical skills to build solutions are separated from those who have the frontline experience and understanding to know which solutions should be built." Another problem with bottom-up innovation approaches results from collisions of innovation projects (Pendharkar et al., 2016). This may lead to higher efforts due to post hoc integration. Because of the problems with top-down as well as bottom-up approaches, middle-out approaches (Stroetmann, 2013; Coiera, 2009) and innovation-friendly environments are requested (Kelly and Young, 2017). In middle-out approaches, a central authority provides a basic set of infrastructural components and standards for the healthcare sector and enables innovators to provide their innovations in an innovation-friendly context.

4. **Interorganisational networks are unstable regarding their structure and management** (Majchrzak et al., 2015). For example, decision making is often distributed and actors may enter or leave the networks. The relationships between institutions vary in a continuum of cooperation and competition and are unstable (Gnyawali and Park, 2011). Dynamic and continuous changes in these networks function as a stimulus for the underlying IOIS which must be able to continuously adapt to these changes (Kanellis and Paul, 1997). IOIS are created by using digital services which electronically connect the actors and help to create application systems (Lyytinen and Damsgaard, 2011). However, the creation of application systems requires high efforts and investments. Reconfigurations can be costly and as a consequence IOIS tend to reach fixed system stability which does not respond to changed environmental conditions (Kanellis and Paul, 1997). There is a tension between the dynamism of interorgan-

isational networks and the reconfigurability of the IOIS. In the healthcare sector, the variability of interorganisational networks results from different, very discontinuous patient flows, variable cooperations and networks as well as from the decentralised or missing coordination between the different stages of intersectoral care (Luthe, 2017, pp. 52 f., 57 f.)

## b. Contribution Overview

| | RO 2: Prescriptive Knowledge for eHealth-Platforms | | |
|---|---|---|---|
| **Design Artefact** | **Governance Guidelines for Platform Creation** | **Organisational Design Principles** | **Platform Ecosystem Model for Healthcare** |
| Purpose and scope | Describe how platform theory applies to eHealth-platforms | | |
| Constructs | Integrated care networks, eHealth-services, stakeholders of the healthcare sector, healthcare information systems, eHealth platform models, organisational specialities | | |
| Principle of form and function | Governance guidelines and four-phase process for platform design | Description of relationships of organisational measures and ecosystem effects | Mapping of health (IS) concepts to platform theory |
| Artefact mutability | Variable instantiation depending on stakeholders and roles | Translation to other interorganisational networks in healthcare and related social domains | |
| Testable propositions | Provision of statements about the applicability for the healthcare domain based on case examples. | | |
| Justificatory knowledge | Application of ecosystem model of Briscoe and Marinos 2009 | Application of existing platform theory gained from literature review in paper 4, interorganisational healthcare information systems theories | |
| Principles of implementation | Four-phase process guides application of governance guidelines | Implicit in the design principles resp. requirements, and the application of the solution space model | |
| Expository instantiation | Examples for guideline instatiation | Scenario for organisational implementation | Instantiation of ecosystem model, two-scenarios for socio-technological implementation |

Figure A.9.: Contributions of research outcome 2 - building blocks of the prescriptive knowledge for eHealth platforms, adapted from (Gregor and Jones, 2007)

| | RO 3: Evaluation Guidance for eHealth-Platforms | | |
|---|---|---|---|
| **Design Artefact** | **Evaluation Framework for Platform Openness** | **Application of Maturity Model for Enterprise Interoperability** | **Structural Evaluation Model** |
| Purpose and scope | Describe which aspects of eHealth platforms need to be evaluated and how | | Describe how to operationalize the evaluation of specific evaluation criteria |
| Constructs | Evaluation objectives, evaluation critera and methods for determination, modules of platforms, interoperability concepts and barriers, eHealth platform models | | |
| Principle of form and function | Objectives, criteria and measures and their application to interoperabilty layer models | Provision of methodical support and a mapping of numerical explanatory models | Ontological representation of stakeholders, indicators and evaluation goals |
| Artefact mutability | Application of alternative quality objectives, criteria and measures for the defined layers | Replacement of interoperability by different evaluation criteria, different explanatory models | Flexible integration of quality indicators |
| Testable propositions | Provision of feasibility and applicability statements for early-state evaluations based on the application in an existing eHealth platform. | | |
| Justificatory knowledge | Application of interoperability layer models and platform theories gained from paper 4, application of existing maturity models, theory on interoperability potentials | | |
| Principles of implementation | Suggestion of existing evaluation measures, implicit by dependency of objectives, criteria and measures | Suggestion of explanatory models and possible justifications for them, differentiation of standardisation phase and evaluation phase | |
| Expository instantiation | Instantiation of objectives, criteria and measures | Application for selected criteria in a selected case context | |

Figure A.10.: Contributions of research outcome 3 - building blocks of the evaluation guidance for eHealth platforms, adapted from (Gregor and Jones, 2007)

## c. Evaluation Criteria for Ecosystem Characteristics

Table A.7.: Evaluation Criteria and Questions, Criteria 1 to 4

| | **Characteristic** | **Criterion** | **Question** |
|---|---|---|---|
| 1 | Emergence | Narrowness | Does the platform define any alignment regulations? |
| | | Uncertainty | Are the actions and reactions to changing platform conditions determinable by platform participants? |
| 2 | Co-Evolution | Continuous Development | 1) Does the platform support individual and independent development cycles?<br>2) Can platform components be changed autonomously by participants?<br>3) Can platform components be interdependent? |
| | | Effectual Actors | Does the platform allow a notification of changes of individual platform components? |
| 3 | Coopetition | Coopetition | Is cooperation and competition possible? |
| 3.1 | Cooperation | Shared view, Social Rules | Are there mandatory rules to share common objectives or a common world view? Or can they emerge during interaction? |
| | | Community-Orientation | 1) Are there incentives to share own solutions to reach a common objective?<br>2) Is it possible to restrict utilization of components for other participants? |
| | | Cocreation | Can platform participants create and provide platform components collaboratively? |
| 3.2 | Competition | Performance orientation | 1) Does the platform provide a performance valuation and are the valuation results comparable?<br>2) Are there incentives that lead to performance orientation? |
| | | Market orientation | 1) Can platform participants decide which platform components they use?<br>2) Can different participants offer components for the same purpose?<br>3) Can platform participants act either as demand or supply side users or both? |
| 4 | Network Orientation | Connected Actors | 1) Can platform participants mutually interact?<br>2) Are there defined interaction channels? |
| | | Organizational Independence | Are the platform participants independent concerning their interactions with others? |
| | | Dynamism | Are the relationships between the participants of a dynamic nature (emerging, disappearing)? |

Table A.8.: Evaluation Criteria and Questions, Criteria 5 to 7

| | Characteristic | Criterion | Question |
|---|---|---|---|
| 5 | Openness | Accessibility | Can new platform participants access existing platform components? |
| | | Expandability | Can new or existing platform participants add new components to the platform? |
| | | Voluntariness | 1) Can platform components be removed without negating the existence of the platform ecosystem?<br>2) Can platform participants cancel the relation to the platform? |
| | | Neutrality | Are standards, participation- and access-rules for platform-components formulated neutrally regarding individual platform participants? |
| | | Transparency | 1) Does the platform provide an open component catalogue?<br>2) Does the platform provide an open participants catalogue?<br>3) Are the regulations, standards and access rules documented and accessible? |
| | | Interoperability | 1) Is the participation based on standardised interface and access rules?<br>2) Can participants share information about their components interaction abilities?<br>3) Are there rules or standards for interaction abilities? |
| 6 | Recombination | Combinability | 1) Does the platform foster the reusability of components?<br>2) Can existing platform components use other platform components? |
| | | Modularity | 1) Does the platform support the decomposition of solutions?<br>2) Can parts of components be used in other components? |
| 7 | Self-Organization | Individual Independence | 1) Does the platform allow participants to make their decisions on their own? (decentralised decisions)<br>2) Can platform participants define their own usage rules for their platform components?<br>3) Does the platform allow the participants to pursue their own interests and aims? |

## d. Validation of the Requirements

Table A.9.: Validation of the requirements for research outcome 1

| **Req.-ID** | **Validation** |
|---|---|
| FuR 1 | The Solution Space Model defines the relationships of the environmental context, the platform and the ecosystem. The DREEM supports the analysis of the different objectives of market actors that result from the environmental context. |
| FuR 2 | The Ecosystems Modelling Framework provides two types of objectives (internal, environmental) and the DREEM method uses these two types of goals in order to describe the needs of ecosystem actors and the platform owner. |
| FuR 3 | The definition of views in the Ecosystems Modelling Framework provides entry-points for the definition of modelling languages. The DREEM identifies where the different views should be used in a platform construction process. In paper 6 it has been shown how concrete semi-formal languages can be used when applying the DREEM. |
| FuR 4 | DREEM uses the results of an organisational ecosystem analysis to determine possible technological products and services. Based on this socio-technological setting, it allows the definition of both technological boundary resources as well as organisational measures for platform management. |
| FuR 5 | DREEM analyses the potential relationship between ecosystem actors as input for the analysis of value-creation logics. The Ecosystems Modelling Framework supports this by defining structural actor and product views and defines also dynamical modelling views for the relationship of actors and the resulting ecosystem effects as well as for the resulting product combination. |
| FuR 6 | The DREEM method provides the brown-field entry as an entry point for product transformation. |
| FuR 7 | Due to the cyclical applicability of DREEM and the modular integration of modelling views the entry to methodical approach can vary. The method allows backtraces and partial development pathways. |
| FuR 8 | The Ecosystems Modelling Framework does not predefine how the concrete aspects have to be modelled. It allows a domain and technological adaption of modelling approaches. The DREEM can be extended by domain specific activities in the individual method steps. |
| FeR 1 | The Ecosystems Modelling Framework as well as the DREEM has been applied to three different domains (healthcare, maintenance analytics, industrial symbiosis). |
| TR 1 | The Ecosystems Modelling Framework supports the disaggregation of platforms and ecosystems by defining modelling views. This also allows the definition of partial models. The DREEM allows the focus on special development pathways. For example, the boundary resources may be derived for a specific role in an ecosystem. |

Table A.10.: Validation of the requirements for research outcome 2

| **Req.-ID** | **Validation** |
|---|---|
| FeR 3 | The field of integrated care is addressed by the design principles. For example, the role of the care management in integrated care networks is made explicit. |
| FeR 4 | The organisational aspects are addressed by paper 2 and extended by technological considerations in paper 3. In paper 3 the information systems and application systems view is described. |
| TR 5 | Design principles, governance guidelines, an adapted healthcare platform ecosystem model and scenarios are used to describe the design knowledge. |
| TR 6 | The governance guidelines, design principles and information system considerations can be described without having a fully specified platform. For example recommendations for price models may be applied to specific price related goverance measures of the platform without knowing the full architecture of the platform. |

Table A.11.: Validation of the requirements for research outcome 3

| **Req.-ID** | **Validation** |
|---|---|
| FuR 9 | It has been shown how specific criteria (for example interoperability and extensibility) can be evaluated and how specifics of the domain can be integrated by applying healthcare interoperability models. |
| FuR 10 | The provided measures in paper 9 show different methods for evaluation of models as well as instances. For example, the maturity model applied in paper 10 can be used both for architectural descriptions as well as for running platforms. |
| FeR 2 | The provided measures in paper 9 (e.g. Architecture Tradeoff Analysis Method, Maturity Models) help to identify improvement aspects. |
| TR 2 | The evaluation framework for interoperability and extensibility provides objectives, criteria and measures for the evaluation of eHealth platforms which disaggregate the criteria of interoperability and extensibility. The structural evaluation model described in paper 10 provides an indicator-based analysis, which makes the evaluation comprehensible. |
| TR 3 | The suggested measures in paper 9 provide a pre-selection of possible evaluation approaches, which can also be applied for criteria other than interoperability and extensibility. The structural evaluation framework in paper 10 separates the definition of indicators for evaluation from the analysis. This enables an efficient evaluation of platform models and instances. The applied maturity model provides a comprehensible overview of strengths and weaknesses. |
| TR 4 | The provided evaluation approaches do not assume a technical preconfiguration. The identified criteria and indicators are technology agnostic. |

## e. Overview of the Papers and Declaration of Authorship

Table A.12: Papers of the doctoral thesis and declaration of authorship

| | |
|---|---|
| **P1** | **Governance Guidelines for Digital Healthcare Ecosystems** |
| Authors | Martin Benedict (MB), Hannes Schlieter (HS) |
| Publication | D. Hayn, G. Schreier, E. Ammenwerth, A. Hörbst (Eds.): eHealth 2015 - Health Informatics Meets eHealth. Proceedings of eHealth 2015, Vienna, Austria, June 18 - 19, 2015: 233 - 240. |
| Authors' contribution | MB: problem definition, theories on digital ecosystems, research method, case example, governance guidelines, governance process<br>HS: challenges in healthcare sector, research method, governance process, conclusion |
| **P2** | **Revise your eHealth Platform! – Design Principles for a Descriptive Case Study** |
| Authors | Martin Benedict (MB), Hannes Schlieter (HS) |
| Publication | Proceedings of 23rd Americas Conference on Information Systems, AMCIS 2017, Boston, MA, USA, August 10-12, 2017. |
| Authors' contribution | MB: conception of paper, research challenge, platform theory, Solution Space Model, design principles, case study<br>HS: conception of paper, research challenge, research method, case study, conclusion |
| **P3** | **Geschäftsmodell Offene „E-Health-Plattform" – Anforderungen und Potenziale** |
| Authors | Hannes Schlieter (HS), Martin Benedict (MBe), Martin Burwitz (MBu) |
| Publication | S. Müller-Mielitz, B. Sottas, A. Schachtrupp (Eds.): Innovationen in der Gesundheitswirtschaft - Theorie und Praxis von Businesskonzepten, Bibliomed, 2017: 170 - 195. |
| Authors' contribution | HS: conception of paper, motivation, roles and relationships in healthcare platform strategies, interorganisational networks and processes, requirements for platform business models, case study, conclusion<br>MBe: conception of paper, motivation, theory on ecosystems, Solution Space Model, roles and relationships in healthcare platform strategies, interorganisational information systems, adapted platform ecosystem model, requirements for platform business models, scenarios<br>MBu: roles and relationships in healthcare platform strategies, interorganisational processes and networks, requirements for platform, business models |
| **P4** | **Modelling Ecosystems in Information Systems – A Typology Approach** |
| Author | Martin Benedict (MB) |
| Publication | Proceedings of Multikonferenz Wirtschaftsinformatik 2018, Lüneburg, Germany, March 06-09, 2018: 453 - 464. |
| Authors' contribution | MB: complete paper |

continued on next page...

Table A.12: Papers of the doctoral thesis and declaration of authorship [continued]

| | |
|---|---|
| **P5** | **Designing Industrial Symbiosis Platforms – from Platform Ecosystems to Industrial Ecosystems** |
| Authors | Martin Benedict (MB), Linda Kosmol (LK), Werner Esswein (WE) |
| Publication | Proceedings of Pacific Asia Conference on Information Systems 2018, PACIS 2018, Yokohama, Japan, June 26 - 30, 2018: 306. |
| Authors' contribution | MB: conception of paper, motivation, research challenge, roles and relationships, theory on ecosystems, mapping of ecosystem roles, streams of innovation and routine, ecosystem modelling framework, information system model, boundary resources model, conclusion<br>LK: conception of paper, motivation, platforms in industrial symbiosis, barriers for ICT in industrial symbiosis, roles and relationships, theory on industrial symbiosis, streams of innovation and routine, phase model on industrial symbiosis, boundary resources model, conclusion<br>WE: research conception |
| **P6** | **Management Digitaler Ökosysteme mit der DREEM-Methode am Beispiel einer Virtual-Coaching-Plattform** |
| Authors | Martin Benedict (MB), Hannes Schlieter (HS), Carola Gißke (CG) |
| Publication | HMD Praxis der Wirtschaftsinformatik, 2019 |
| Authors' contribution | MB: conception of paper, digital ecosystems in healthcare, design an management of ecosystems (structural perspective), ecosystem management method (DREEM), modelling of case example, conclusion<br>HS: conception of paper, motivation, design and management of ecosystems (dynamic perspective, ecosystem dilemma), modelling of case example, conclusion<br>CG: description of case example |
| **P7** | **Guiding the Development of Digital Ecosystems** |
| Authors | Martin Benedict (MB), Hannes Schlieter (HS), Carola Gißke (CG), Kai Gand (KG) |
| Publication | working paper |
| Authors' contribution | MB: conception of paper, motivation, kernel theories, method and research design, design and management of ecosystems, ecosystem management method (DREEM), modelling of case example, conclusion<br>HS: conception of paper, motivation, method and research design, modelling of case example, conclusion<br>CG: description of case example<br>KG: description of case example |

continued on next page...

Table A.12: Papers of the doctoral thesis and declaration of authorship [continued]

| **P8** | **Towards Maintenance Analytics Ecosystems: A Conceptual Role-Relationship Model** |
|---|---|
| Authors | Patrick Zschech (PZ), Martin Benedict (MB) |
| Publication | working paper |
| Authors' contribution | PZ: conception of paper, motivation and problem setting, multi-case description, ecosystem roles and relationships, discussion and further research<br>MB: conception of paper, motivation and problem setting, research agenda and research method, phase model, ecosystem roles and relationships, discussion and further research |
| **P9** | **Nachhaltigkeit von E-Health-Projekten** |
| Authors | Hannes Schlieter (HS), Martin Benedict (MBe), Martin Burwitz (MBu) |
| Publication | S. Müller-Mielitz, T. Lux (eds) E-Health-Ökonomie. Springer Gabler, Wiesbaden: 99 - 116. |
| Authors' contribution | HS: conception of paper, background, sustainability dimensions, case example, conclusion<br>MBe: conception of paper, digital ecosystem theory, openness of eHealth platforms, framework, criteria and control measures, case example<br>MBu: sustainability dimensions, case example, control measures |
| **P10** | **ISO 11354-2 for the Evaluation of eHealth Platforms** |
| Authors | Martin Benedict (MBe), Hannes Schlieter (HS), Martin Burwitz (MBu), Werner Esswein (WE) |
| Publication | Proceedings of Pacific Asia Conference on Information Systems 2016, PACIS 2016, Chiayi, Taiwan, June 27 - July 1, 2016. |
| Authors' contribution | MBe: conception of paper, motivation, theory on interoperability potential, introduction of maturity model and ISO standard, structural evaluation model, explanatory models, application of evaluation model, evaluation<br>HS: conception of paper, motivation, requirement analysis, case example description, evaluation, conclusion<br>MBu: requirement analysis, case example description, evaluation<br>WE: research conception |

## f. Overview of All Publications of the Author

Table A.13: Complete list of publications

| Publication | Ranking[11] |
|---|---|
| ***2019*** | |
| Martin Benedict, Hannes Schlieter, Martin Burwitz, Tim Scheplitz, Marcel Susky, and Peggy Richter. A Reference Architecture Approach for Pathway-based Patient Integration. In Proceedings of EDOC 2019. Paris, France, 2019. | VHB: - WKWI: B |
| Martin Benedict, Hannes Schlieter, Martin Burwitz, Tim Scheplitz, Marcel Susky, Peggy Richter, and Tjalf Ziemssen. Patientenintegration durch Pfadsysteme. In Proceedings of WI 2019, 927–41. Siegen, Germany, 2019. | VHB: C WKWI: B (34 % AR) |
| Martin Benedict, Hannes Schlieter, and Carola Gißke. Management Digitaler Ökosysteme mit der DREEM-Methode am Beispiel einer Virtual-Coaching-Plattform. HMD Praxis der Wirtschaftsinformatik, 2019. | VHB: C WKWI: B |
| Tim Scheplitz, Stefanie Kaczmarek, and Martin Benedict. The Critical Role of Hospital Information Systems in Digital Health Innovation Projects. In Proceedings of CBI 2019. Moscow, Russia, 2019. | VHB: - WKWI: B (CEC-Con.) |
| ***2018*** | |
| Benedict, Martin. Modelling Ecosystems in Information Systems – A Typology Approach. In Drews P., B. Funk, P. Niemeyer, and L. Xie (eds), Proceedings of the Multikonferenz Wirtschaftsinformatik 2018, 2:453–64. Lüneburg, Germany: Leuphana Universität Lüneburg, 2018. | VHB: D WKWI: C |
| Martin Benedict, Hanno Herrmann, and Werner Esswein. EHealth-Platforms - The Case of Europe. In Ugon, A., D. Karlsson, G. O. Klein, and A. Moen (eds), Building Continents of Knowledge in Oceans of Data: The Future of Co-Created EHealth - Proceedings of MIE 2018, 247:241–45. Studies in Health Technology and Informatics. Gothenburg, Sweden: IOS Press, 2018. | - |
| Martin Benedict, Linda Kosmol, and Werner Esswein. Designing Industrial Symbiosis Platforms - from Platform Ecosystems to Industrial Ecosystems. In Proceedings of the 22nd Pacific Asia Conference on Information Systems, 306. Yokohama, Japan, 2018. | VHB: C WKWI: B |
| Kümmel, Michéle, Martin Benedict, and Werner Esswein. Prozessanalytische Betrachtung Notfallmedizinischer Vorsichtungsalgorithmen. In Drews P., B. Funk, P. Niemeyer, and L. Xie (eds), Proceedings of the Multikonferenz Wirtschaftsinformatik 2018, 5:1959–70. Lüneburg, Germany: Leuphana Universität Lüneburg, 2018. | VHB: D WKWI: C |

continued on next page...

[11] VHB: VHB-JORQUAL 3 (2015);
(http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3)
WKWI: "WI-Orientierungsliste der WKWI" (2008);
(http://www.kaifischbach.net/wkwi/orientierungslisten.pdf)
AR: acceptance rate , if relevant
if conference and publication name has changed, the abbreviation of the publication is named in brackets

Table A.13: Complete list of publications [continued]

| Publication | Ranking |
| --- | --- |
| ***2018 (continued)*** | |
| Tim Scheplitz, Martin Benedict, and Werner Esswein. Patientenkompetenz durch Online-Portale - eine Funktionsanalyse. In Drews P., B. Funk, P. Niemeyer, and L. Xie (eds), Proceedings Multikonferenz Wirtschaftsinformatik 2018, 2:744–55. Lüneburg, Germany: Leuphana Universität Lüneburg, Institut für Wirtschaftsinformatik, 2018. | VHB: D<br>WKWI: C |
| ***2017*** | |
| Martin Benedict, and Hannes Schlieter. Revise Your EHealth-Platform! – Design Principles for a Descriptive Case Study. In AMCIS 2017 Proceedings. Boston, MA, USA, 2017. | VHB: D<br>WKWI: B |
| Hannes Schlieter, Martin Benedict, and Martin Burwitz. Geschäftsmodell Offene 'E-Health-Plattform' - Anforderungen und Potenziale. In Müller-Mielitz, S., and A. Schachtrupp (eds), Theorie Und Praxis von Businesskonzepten - 10 Jahre B. Braun-Stiftung Mentoringprogramm, 170–95. Bibliomed - Medizinische Verlagsgesellschaft mbH, 2017. | - |
| Hannes Schlieter, Martin Benedict, and Martin Burwitz. Nachhaltigkeit von E-Health-Projekten. In Müller-Mielitz, S., and T. Lux (eds), E-Health-Ökonomie, 99–116. Springer Fachmedien Wiesbaden, 2017. | - |
| Hannes Schlieter, Martin Benedict, Kai Gand, and Martin Burwitz. Towards Adaptive Pathways: Reference Architecture for Personalized Dynamic Pathways. In Loucopoulos, P., Y. Manolopoulos, O. Pastor, B. Theodoulidis, and J. Zdravkovic (eds), Proceedings of CBI 2017, 1:359–68. Thessaloniki, Greece: IEEE Comput. Soc., 2017. | VHB: -<br>WKWI: B (CEC-Con.) |
| Hannes Schlieter, Martin Burwitz, Martin Benedict, and Oliver Schönherr. Modellgestützte Softwareentwicklung im Gesundheitswesen. In Business-IT-Alignment: Gemeinsam zum Unternehmenserfolg, edited by Stefan Reinheimer and Susanne Robra-Bissantz, 252–269. Edition HMD. Wiesbaden: Springer Fachmedien Wiesbaden, 2017. | - |
| ***2016*** | |
| Martin Benedict, and Werner Esswein. Adaption von ISO 11354-2 zum Assessment von EHealth-Plattformen. Karlsruhe, 2016. Martin Benedict, Hannes Schlieter, Martin Burwitz, and Werner Esswein. ISO 11354-2 for the Evaluation of EHealth Platforms. In PACIS 2016 Proceedings, 23. Chiayi, Taiwan, 2016. | VHB: C<br>WKWI: B |
| Richard Braun, Hannes Wendler, Martin Benedict, Martin Burwitz, Kai Gand, Peggy Richter, Richard Rößler, Hannes Schlieter, Jeannette Stark, and Werner Esswein. Integrated Enterprise Modeling Lectures for Master Classes. In Betz S., and U. Reimer (eds), Modellierung 2016 - Workshopband, 53–61. Karlsruhe: Gesellschaft für Informatik, 2016. | VHB: C<br>WKWI: B (LNI-Proc.) |

continued on next page...

Table A.13: Complete list of publications [continued]

| Publication | Ranking |
|---|---|
| ***2016 (continued)*** | |
| Martin Burwitz, Martin Benedict, and Hannes Schlieter. CDA Templates - Utilizing the MediCUBE. In Hörbst, A., W. O. Hackl, N. Keizer, H.-U. Prokosch, M. Hercigonja-Szekeres, and S. Lusignan (eds), Exploring Complexity in Health: An Interdisciplinary Systems Approach - Proceedings of MIE2016 at HEC2016, 228:481–485. Studies in Health Technology and Informatics. München: IOS Press, 2016. | - |
| ***2015*** | |
| Martin Benedict, Martin Burwitz, and Hannes Schlieter. Certification of Service-Oriented EHealth Platforms - Derivation of Structured Criteria for Interoperability and Expandability: In Verdier, C., M. Bienkiewicz, A. L. N. Fred, H. Gamboa, and D. Elias (eds), Proceedings of 8th International Conference On Health Informatics (HEALTHINF), 114–22. Lisbon, Portugal: SCITEPRESS - Science and and Technology Publications, 2015. | - |
| Martin Benedict, and Hannes Schlieter. Governance Guidelines for Digital Healthcare Ecosystems. In Hayn, D., G. Schreier, E. Ammenwerth, A. Hörbst (eds), Health Informatics Meets EHealth - Innovative Health Perspectives: Personalized Health, 212:233–240. Studies in Health Technology and Informatics. Vienna, Austria: IOS Press, 2015. | - |
| Richard Braun, Martin Benedict, Hannes Wendler, and Werner Esswein. Proposal for Requirements Driven Design Science Research. In Donnellan, B., M. Helfert, J. Kenneally, D. VanderMeer, M. Rothenberger, and R. Winter (eds), New Horizons in Design Science: Broadening the Research Agenda, 9073:135–51. Lecture Notes in Computer Science. Dublin, Ireland: Springer International Publishing, 2015. | VHB: C<br>WKWI: - |
| Richard Braun, Martin Burwitz, Hannes Schlieter, and Martin Benedict. Clinical Processes from Various Angles - Amplifying BPMN for Integrated Hospital Management. In Zheng, J. H., W. Dubitzky, X. Hu, J. Hao, D. P. Berrar, K. Cho, Y. Wang, and D. R. Gilbert (eds), Proceedings of BIBM 2015, 837–45. Washington, DC, USA: IEEE, 2015. | - |
| Hannes Schlieter, Martin Burwitz, Oliver Schönherr, and Martin Benedict. Towards Model Driven Architecture in Health Care Information System Development. In In Thomas, O., and F. Teuteberg (eds), Smart Enterprise Engineering. Proceedings of the WI 2015, 497–511. Osnabrück, Germany: Universität Osnabrück, 2015. | VHB: C<br>WKWI: A |
| ***2014*** | |
| Hannes Schlieter, Martin Burwitz, Oliver Schönherr, and Martin Benedict. Modellgestützte Softwareentwicklung im Gesundheitswesen. HMD Praxis der Wirtschaftsinformatik 51, no. 5 (October 1, 2014): 669–84. | VHB: D<br>WKWI: B |
| ***2013*** | |
| Martin Benedict, Anke Häber, Georg Beier, and Jürgen Ilchmann. Eine Modellbasierte Vergleichsmethodik für Kommunikationsstandards. In Ammenwerth, E., A. Hörbst, D. Hayn, and G. Schreier (eds), Proceedings of the EHealth2013. Vienna, Austria: books@ocg, 2013. | - |

## g. Overview of All Conference Presentations of the Author

Table A.14: Complete list of conference presentations

| Title, Conference | Date | Venue |
|---|---|---|
| Using Pathway Systems for Patient Integration. *23rd IEEE International EDOC Conference - The Enterprise Computing Conference, EDOC 2019* | 28.10. - 31.10.2019 | Paris, France |
| Patientenintegration durch Pfadsysteme. *14th International Conference on Wirtschaftsinformatik, WI 2019* | 23.02. - 27.02.2019 | Siegen, Germany |
| eHealth-platforms the case of Europe. *Medical Informatics Europe 2018* | 24.04. - 26.04.2018 | Gothenburg, Sweden |
| Modelling Ecosystems in Information Systems – A Typology Approach. *Multikonferenz Wirtschaftsinformatik, MKWI 2018* | 06.03. - 09.03.2018 | Lüneburg, Germany |
| Revise your eHealth Platform! – Design Principles for a Descriptive Case Study. *Americas Conference on Information Systems, AMCIS 2017* | 10.08. - 12.08.2017 | Boston, MA, USA |
| Adaption von ISO 11354-2 zum Assessment von eHealth-Plattformen. *Workshop Modelling in Healthcare, Modellierung 2016* | 02.03. - 04.03.2016 | Karlsruhe, Germany |
| Clinical Processes from Various Angles - Amplifying BPMN for Integrated Hospital Management. *IEEE International Conference on Bioinformatics and Biomedicine, BIBM 2015* | 09.11. - 12.11.2015 | Washington DC, USA |
| Governance Guidelines for Digital Healthcare Ecosystems. *eHealth Summit Austria 2015* | 23.05. - 24.05.2015 | Vienna, Austria |
| Certification of Service-oriented eHealth Platforms - Derivation of Structured Criteria for Interoperability and Expandability. *8th International Conference on Health Informatics, HEALTHINF 2015* | 12.01. - 15.01.2015 | Lisbon, Portugal |
| Transformation von HL7v3-Modellen zu XÖV-Modellen. *58. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie e.V. (GMDS)* | 01.09. - 05.09.2013 | Lübeck, Germany |
| Eine Modellbasierte Vergleichsmethodik für Kommunikationsstandards. *eHealth Summit Austria 2013* | 23.05. - 24.05.2013 | Vienna, Austria |
| Konzeptuelle Vorarbeiten zur Entwicklung eines Kommunikationsstandard für den Öffentlichen Gesundheitsdienst im Rahmen der XÖV-Projekte (Poster). *56. Jahrestagung der Deutschen Gesellschaft für Medizinische Informatik, Biometrie und Epidemiologie (gmds)* | 26.09. - 29.09.2011 | Mainz, Germany |

# B. Paper 1 - Governance Guidelines for Digital Healthcare Ecosystems

| **Title** | **Governance Guidelines for Digital Healthcare Ecosystems** |
|---|---|
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Hannes Schlieter (hannes.schlieter@tu-dresden.de) |
| Publication | D. Hayn, G. Schreier, E. Ammenwerth, A. Hörbst (Eds.): eHealth 2015 - Health Informatics Meets eHealth. Proceedings of eHealth 2015, Vienna, Austria, June 18 - 19, 2015: 233 - 240. |
| Available at | `http://ebooks.iospress.nl/volumearticle/39727` |


### *Abstract*

Advanced Information and Communication Technologies (ICT) solutions are the key instrument to enable modern integrated care. They are not limited the traditional boundaries. Moreover, their aim is to provide medical care at the right point, in the right manner, at the right time without technological, institutional boundaries or integration issues, esp. for comorbidity treatment cases. Open digital ecosystems enabled by eHealth platforms can help to create a prospering eHealth environment. However, the creation of digital ecosystems in the health care domain is an ambitious task. The conditions how an open system can be achieved are often consented in complex projects, but they are not often scientific questioned. Conducting an action design research process, the paper contributes 13 guidelines for implementing eHealth platforms by reflection of the work in an EU-funded infrastructure project, which can be used as input for further research to provide generic guidelines for eHealth ecosystem projects.

# C. Paper 2 - Revise your eHealth Platform!

| Title | Revise your eHealth Platform! – Design Principles for a Descriptive Case Study |
|---|---|
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Hannes Schlieter (hannes.schlieter@tu-dresden.de) |
| Publication | Proceedings of 23rd Americas Conference on Information Systems, AMCIS 2017, Boston, MA, USA, August 10-12, 2017. |
| Available at | `https://aisel.aisnet.org/amcis2017/Healthcare/Presentations/28/` |
| Full-Text at | `https://www.researchgate.net/publication/317342067_Revise_your_eHealth_Platform_-_Design_Principles_for_a_Descriptive_Case_Study` |


### *Abstract*

The innovation processes of Health IT are characterized by a high inertia regarding IT-adoption. A major reason is the costly implementation of the IT infrastructure for new IT-based care scenarios. Particularly for resident practitioners, the efforts are too cost- and time-consuming. This results in a gap between the expected value of eHealth and the intention to adopt ICT in the healthcare sector. A common model which allows an easier allocation of ICT solutions is to create a platform for eHealth services. Beyond the technical basis, platforms establish market functions for eHealth services. Their aim is to overcome traditional monopolistic and isolated solutions by providing a component based service architecture. However, for the healthcare sector, it remains unclear how these artifacts can foster the creation of integrated care information systems. Addressing this gap, we present design principles for platform construction by the mean of a descriptive case study.

# D. Paper 3 - Business Model Open "E-Health-Platform"

| Title | Business Model Open "E-Health-Platforms" - Requirements and Potentials |
|---|---|
| **Title (German)** | **Geschäftsmodell Offene „E-Health-Plattform" – Anforderungen und Potenziale** |
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Hannes Schlieter (hannes.schlieter@tu-dresden.de)<br>Martin Burwitz (martin.burwitz@tu-dresden.de) |
| Publication | S. Müller-Mielitz, B. Sottas, A. Schachtrupp (Eds.): Innovationen in der Gesundheitswirtschaft - Theorie und Praxis von Businesskonzepten, Bibliomed, 2017: 170 - 195. |
| Available at | `https://books.google.de/books?hl=de&lr=&id=tU5LDwAAQBAJ&oi=fnd&pg=PA170` |


### *Abstract*

In the healthcare sector, the adoption of modern IT technology tends to be very stagnant. The difficult market situation for digital health solutions and the regulatory barriers are impediments which negatively influence the adoption of digital healthcare-solutions. Open eHealth platforms provide a promising approach to overcome these adoption barriers. They can provide a foundation for the creation of complementary products which are used to design interorganisational information systems in the field of integrated care. The paper contributes by the description of a platform ecosystem model for the healthcare sector. It describes how platform strategies can be utilized to gain improvements in the construction of interorganisational information systems and describes requirements for the resulting platformised business model. Based on a case example with two scenarios, the paper demonstrates how a platform business model can be instantiated in the field of integrated care.

# E. Paper 4 - Modelling Ecosystems in Information Systems

| **Title** | **Modelling Ecosystems in Information Systems – A Typology Approach** |
|---|---|
| Authors | Martin Benedict (martin.benedict@tu-dresden.de) |
| Publication | Proceedings of Multikonferenz Wirtschaftsinformatik 2018, Lüneburg, Germany, March 06-09, 2018: 453 - 464. |
| Available at | `http://mkwi2018.leuphana.de/wp-content/uploads/MKWI_61.pdf` |


### *Abstract*

Ecosystems as a modern concept of interorganisational networks are often discussed in current information systems research. There is a lot of investigation in the field of behaviouristic information system research. However, when designing ecosystems there is not much guidance and methodical support. In particular, modelling methods as a specific methodical support for ecosystem design are rare. Based on a literature review, this paper introduces specific types and characteristics of ecosystems. As a first step towards a comprehensive modelling framework, we use these types to propose views for the modelling of ecosystems. The framework organizes the modelling of ecosystems in three aspects: goal modelling, ecosystem modelling and platform modelling.

# F. Paper 5 - Designing Industrial Symbiosis Platforms

| **Title** | **Designing Industrial Symbiosis Platforms – from Platform Ecosystems to Industrial Ecosystems** |
|---|---|
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Linda Kosmol (linda.kosmol@tu-dresden.de)<br>Werner Esswein (werner.esswein@tu-dresden.de) |
| Publication | Proceedings of Pacific Asia Conference on Information Systems 2018, PACIS 2018, Yokohama, Japan, June 26 - 30, 2018: 306. |
| Available at | `https://aisel.aisnet.org/pacis2018/306/` |
| Full-Text at | `https://www.researchgate.net/publication/325397155_Designing_Industrial_Symbiosis_Platforms_-_from_Platform_Ecosystems_to_Industrial_Ecosystems` |


### *Abstract*

Industrial Symbiosis describes cooperations between industrial actors to create economic value from waste and to reduce its environmental impact. Although the advantages of such cooperations have been demonstrated in research and practice through many case studies it is not an established concept yet. The concept of Industrial Symbiosis is supported by the development of information and communication technologies, which increasingly take the form of online platforms, and help to mitigate information and social barriers. However, most tools are not comprehensively documented, not accessible for new participants, not operational or not used. Motivated by the potentials of platforms to provide support for the emergence of Industrial Symbiosis and the number of unsuccessful platforms, we analyze the relationships, roles and phases in Industrial Symbiosis against the background of the current platform ecosystems theory. Based on these findings, we give a design guidance for Industrial Symbiosis Platforms.

# G. Paper 6 - Management of Digital Ecosystems with DREEM

| **Title** | **Management of Digital Ecosystems with the DREEM-Method – the Case of a Virtual Coaching Platform** |
|---|---|
| **Title (German)** | **Management Digitaler Ökosysteme mit der DREEM-Methode am Beispiel einer Virtual-Coaching-Plattform** |
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Hannes Schlieter (hannes.schlieter@tu-dresden.de)<br>Carola Gißke (carola.gisske@tu-dresden.de) |
| Publication | HMD Praxis der Wirtschaftsinformatik, 2019. |
| Available at | `https://aisel.aisnet.org/pacis2018/306/` |
| Full-Text at | `https://rdcu.be/bGzpo` |


### *Abstract*

A major challenge for the implementation of modern healthcare delivery approaches is the integration of digital technologies. In order to achieve an ease of this integration and to foster the development of innovations in healthcare, digital ecosystems are being implemented. However, the conception and development of digital ecosystems is accompanied by the dilemma that on the one hand a dynamic development of solutions should be promoted, on the other hand a certain predictability of the ecosystem should be achieved. Unintended effects that occur in the ecosystem need to be managed systematically. In this paper, the Dresden Ecosystem Management Method is presented which addresses the conflict between emergence and predictability. The method guides the design and management of digital ecosystems and defines aspects for the formal modelling of the overall system. The method presented has been applied to a case study in order to demonstrate its applicability by developing an eHealth platform for a virtual coaching solution in the field of domestic rehabilitation.

# H. Paper 7 - Guiding the Development of Digital Ecosystems



| **Title** | **Guiding the Development of Digital Ecosystems** |
|---|---|
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Hannes Schlieter (hannes.schlieter@tu-dresden.de)<br>Carola Gißke (carola.gisske@tu-dresden.de<br>Kai Gand (kai.gand@tu-dresden.de) |
| Publication | Working Paper |



## Contents

### *Abstract*

Digital ecosystems offer a promising way for better integration of innovative digital solutions into existing organizational networks and thereby foster the accessibility and reutilization of innovative technologies. Yet, due to the participative nature of a platform design, dynamic changes and unintentional effects might occur during the life cycle of the ecosystem. This unpredictability leads to difficulties in planning and managing digital ecosystems, since ecosystem dynamics need to be considered during the development process. In this paper, an Ecosystem Management Method is presented, providing guidance on the design and management of digital ecosystems. The method integrates modelling aspects and orders them in a logical flow. It considers dynamic changes in the ecosystem at different design steps and describe strategies to deal with these changes. The applicability of the method is demonstrated with a case study concerning the development of an eHealth platform for domestic rehabilitation. Thereby, the article demonstrates a useful artifact for the systematic development and management of digital ecosystems.

# Guiding the Development of Digital Ecosystems

*Completed Research Paper*

## Introduction

Digital solutions for the healthcare sector are addressing different fields of innovation. Overcoming geographical distances (e.g., by implementing telemedicine), the continuous, automated, non-invasive monitoring of a patient's general condition (e.g., by implementing contactless sensor systems), the analytical interpretation of complex health data from patients' domestic surroundings through artificial intelligence as well as new forms of social interaction on the basis of modern information technology can be mentioned as examples. Digital solutions facilitate innovative care concepts and the development of new branches within the health economy. However, innovative developments need to be designed in due consideration of the already existing technology landscape and have to be integrated into existing infrastructures (Barrett et al. 2015). Therefore, platform-based approaches within digitization projects are proposed and implemented to guarantee better access to existing solutions and to improve the reusability of innovations. These platforms are supposed to provide basic functions and principles of communication in a reusable manner as a basis for so-called "digital ecosystems" in which new solutions can be developed (Chesbrough and Appleyard 2007; Gawer and Cusumano 2014). Although ecosystems successfully proliferate in the industry and the consumer market, the setup of ecosystems in specific sectors of the economy, like the healthcare sector, remains a challenge. Special regulatory, cultural and social conditions of the participating actors of those sectors may lead to different intra-ecosystem behaviors than in the ecosystems situated in the generic consumer market. For example, in the healthcare sector, the revenue streams and the customer-provider relationships are quite different than in conventional market settings (Furstenau and Auschra 2016).

Design principles of digital ecosystems for the healthcare sector have already been researched and described within literature (Serbanati et al. 2011; Christensen et al. 2014; Benedict and Schlieter 2017). However, questions remain about how platform owners can develop ecosystems systematically. In particular, when considering the specifics of a definite domain like the healthcare sector, there is a gap for systematic platform development methodologies. Our paper addresses this gap by asking how the modeling of digital ecosystems ("ecosystem blueprint" by Tiwana et al. (2010)) based on sector-specific aspects could be methodically guided. It addresses this issue by presenting and using a model-based management method which supports the domain-specific construction of ecosystems and platforms. Therefore, the contribution addresses the following research question (RQ):

*RQ: How can domain-specific digital ecosystems be managed and developed systematically?*

To answer this question, section 2 explains the role of digital ecosystems within the healthcare sector and introduces the kernel theory that informs the construction of the management method. In section 3, we explain the basic methodical setting, followed by a description of already existing design approaches in section 4. Following this, the fifth chapter presents the *Dresden Ecosystem Management Method (DREEM)*. The development of this method follows a design-oriented research approach (March and Smith 1995; Peffers et al. 2007). Using a real-world case in the field of homecare rehabilitation, the method is demonstrated in section 6. The final chapter concludes the construction and application of the DREEM, shows practical implications and points out further perspectives for this research field.

## Theoretical Foundation

### *Informing Kernel Theory*

The consideration of complex organizational networks as ecosystems arose in the 1990th in the field of organizational theory and management literature. Moore characterizes the term Business Ecosystems as networks of companies, which extend their business competencies around a central innovation (Moore 1993). In the course of the development of digital innovation strategies, these networks have gained significant importance (Yoo et al. 2010). Within ecosystems, one or more central products are being supplemented by additional products or services of other ecosystem participants. The relations between the products and services are also being referred to as specific complementary relations, which require a higher level of coordination than in generic markets but a lower level than in supply chains (Jacobides et al. 2018). Governance measures and controlling regulations are typically made for groups of actors. Platforms are often representing the core of the digital ecosystem and, thereby, allowing this kind of coordination. The topic of Platform Ecosystems is, in turn, intensively discussed within literature (Jacobides et al. 2018). Platforms are the core products, which can be consumed by the end users (demand-side user). Third-party providers (supply-side user) can establish complementary relations with the platforms to complement them with own services and products (Eisenmann et al. 2008). For these types of digital ecosystems, it is essential to implement a digital marketplace, where third-party providers and end users can get in touch with each other (Ghazawneh and Henfridsson 2015).

Gawer (2014) has identified two main research perspectives on platforms: the engineering and the market perspective. The *market perspective* focuses on the relationships and the dependencies between platform providers, complementors and end users (e.g., Rochet and Tirole 2003). The *engineering perspective* relates to the effects of the platform strategy, governance and architecture on the ecosystems (e.g., Baldwin and Woodard 2008). These two views can be integrated by the dependency of the effects in ecosystems (network effects: Burkard et al. 2012; co-creation: Ceccagnoli et al. 2012; co-evolution: Tiwana et al. 2010) and the design of the platform. Regarding the design of platforms, a seminal model which describes the dependencies between the economic environment, the platform design and the effects that occur in an ecosystem is provided by Tiwana et al. (2010). Effects in ecosystems arise from the option potentials that a platform provides (Baldwin and Woodard 2008). From this relationship, two solution spaces can be described. The *ecosystem solutions space* and the *platform solution space* (Benedict 2018). The platform solution space can be directly designed by the platform owner. The ecosystem solution space can only be designed indirectly. The intended ecosystem design is influenced by the central value proposition and the goals the platform owner defines for the ecosystem. This follows the *ecosystem-as-a-structure* perspective of Adner (2017). The starting point is the ecosystem's value proposition. The participating roles result from this value proposition and an alignment structure determines how these roles may interact (Adner 2017). The alignment structure consists of different measures and constructs. For example, Schreieck et al. (2016) name eight central concepts of design and governance of platforms: *Roles, Pricing and Revenue sharing, Boundary Resources, Openness, Control, Technical Design, Competitive Strategy,* and *Trust*. These can be seen as central parameters of the platforms solution space that influence the ecosystem solution space. We argue that these concepts are also interdependent. For example, a decision in technological design leads to different possible candidates for boundary resources. Methodical guidance can help to manage these interdependencies.

### *Digital Ecosystems and their Implementation in the Healthcare Sector*

The applicability of the platform approach in the healthcare sector (eHealth platforms) has been demonstrated by Benedict and Schlieter (2017). They focus on the design of cross-institutional supply networks. Open eHealth platforms build the basis for the technical and organizational networking of actors within health networks and enable a simplified use of electronic services based on a common IT infrastructure (following Hanseth and Lyytinen (2010)). The platform acts as a mediator between the various parties involved. It includes not only the technical components but also governance rules defined by the platform owner. These regulate how the platform components are to be used and how individual partners can access them (Gawer and Cusumano 2014; Tiwana et al. 2010). This makes it easier for service providers to integrate electronic services into their supply concepts since the platform provides the necessary framework conditions (e.g., safety level, reimbursement mechanisms, adjusted pricing models). By defining the terms of use, the platform owner can also influence the behavior and relationships of ecosystem participants (Baldwin and Woodard 2008; Eisenmann et al. 2008; Tiwana et al. 2010).

The implementation of eHealth platforms should promote the modularization of eHealth solutions and simplify the integration of existing systems (Benedict and Schlieter 2017). Components of a platform are modules that interact with each other through well-defined interfaces (Baldwin and Woodard 2008). Unlike traditional approaches in which interfaces between application systems are defined for specific applications (e.g., the transmission of patient master data for patient admissions), the interfaces in digital platforms offer a wider range of functions. One applicable standard is, for example, HL7 FHIR (Health Level Seven -

Fast Healthcare Interoperability Resources). It defines generic resources that can be flexibly combined depending on the application (Bender and Sartipi 2013). This results in generic interfaces that allow a large number of use cases. Baldwin and Woodard (2008) refer to this variability as *option potentials*.

Interfaces on which third-party vendors can build their solutions are also referred to as *boundary resources*. However, these do not represent simple software interfaces but include all measures that enable third parties to develop their solutions based on the platform (Ghazawneh and Henfridsson 2013). In addition to application programming interfaces (APIs), these include supplementary technical components (e.g., software development kits), as well as so-called social boundary resources (e.g., tutorials, developer forums) (Bianco et al. 2014). The design of boundary resources has a significant influence on the further development capability and variability of digital ecosystems (Ghazawneh and Henfridsson 2013). Platform initiators must develop and update the boundary resources systematically. The planning is part of the platform strategy ("Resourcing" in Ghazawneh and Henfridsson (2011)), which cannot be predefined as a continuous and completed strategy due to an unpredictable development. Instead, Ghazawneh and Henfridsson (2011) propose micro-strategies as management measures to be introduced reactively and situationally. For example, eHealth platforms may provide generic FHIR interfaces as well as a test server that can be used by developers as boundary resources.

## Method & Research Design

The purpose of our research is to construct a method guiding the creation of platform ecosystems. According to Hevner et al (2019), we base the construction of our method on a set of informing theories (see section "Informing Kernel Theories") (Gregor and Hevner 2013). There is a broad range of descriptive knowledge as platform theories are widely investigated and discussed (Jacobides et al. 2018; Nischak et al. 2017). Thus, they can ideally inform the design process of the envisaged method. Concerning the positioning of the design process, the paper can be classified as an improvement (Gregor and Hevner 2013) aiming for developing a new solution for known problems.

The design procedure follows the framework of Peffers et al. (2007). Within that, the method is informed by the body of theories and thereby represents a generic artifact in terms of an operational principle (Gregor and Hevner 2013). The evaluation is done in an exemplary use case from the healthcare sector. As depicted in Figure 1 and also proposed by Hevner (2004), the design phase comprises several iterations continuously evaluating the envisaged artifact during ongoing build cycles. The scope of the evaluation is to demonstrate the applicability of the method in a real-world case and showing the feasibility of the artifact outlined in principle (Venable et al. 2012). The method will be applied to an EU-funded project in the field of virtual coaching for home care rehabilitation (*VCP*). By conducting a case-based demonstration, this method is utilized to show the artifact's feasibility to solve more problem instances (Prat et al. 2015). In the same breath, the expository demonstration instantiates the design theory, underpinning the artifact's consistency with the design precepts (Gregor and Jones 2007). Using a case study, it can be observed how the method is applied in a specific situation. Case studies provide the opportunity to apply existing theories to a specific case and to demonstrate that a theory is appropriate (Yin 2003). Additionally, we use the design concepts of Schreieck et al. (2016) to evaluate the ability of the method to create a comprehensive set of design outputs in the platform solution space. This outlines whether the method is feasible to create ecosystem blueprints.

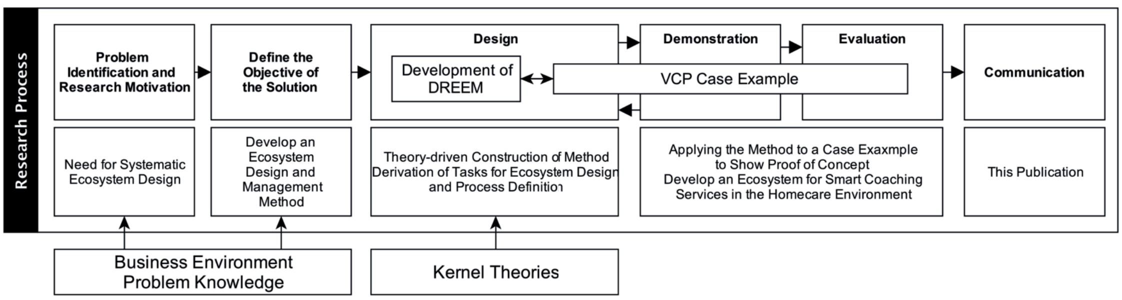


**Figure 1. Research Design, adapted from Peffers et al. (2007)**

## Design and Management of Ecosystems

The design and control of digital ecosystems require the clarification of various aspects such as the determination of the value proposition as the basis of the ecosystem (Adner 2017) as well as corresponding objectives, which are determined for both the ecosystem and the initiator of the ecosystem (Benedict 2018). These objectives form a target system, which in turn determines the basic structure of the ecosystem with regard to the actors involved and their roles, products, and services available as well as the associated business models.

The complexity in digital ecosystems arises in particular from the intended emergence of the entire system and its evolutionary development (Tiwana et al. 2010; Woodard and Clemons 2014). Concrete system characteristics must be anticipated and actors can only be defined at the type level. The development (dynamics of evolution) of digital ecosystems does not follow a deterministic path, which in turn must be considered in the conception of digital ecosystems. For example, potential actors are described by role models granting certain degrees of freedom in the course of platform design (Riedl et al. 2009; Schreieck et al. 2016). The focus of the system conception is therefore on the prognosis of individual, intended development paths. This is dedicated, for example, to the actors, the value-added approaches and possible interactions (Ofe and Sandberg 2019).

A well-known approach for structuring complex systems is to focus on an overall system using defined viewpoints that describe a partial aspect of the overall system (Finkelstein et al. 1992). The development paths can end along with these views in concrete management measures for platforms. Christensen et al. (2014) suggest, for example, the use of the architecture description standard ISO 42010 for the development of a platform architecture. Benedict (2018) describes a framework according to which a platform-based ecosystem is structured. The framework defines the following structural aspects: goal system, ecosystem structure, and platform design (see Figure 2). A tuple of these aspects allows the description of development paths of a platform-based ecosystem. However, the handling of management tasks and the dynamic further development are not addressed yet.

Conceptual modeling has established itself as one of the central methods in the description and development of information systems and is also applied to the description of digital ecosystems (Boucharas et al. 2009; Yu and Deng 2011). Figure 2 already indicates the model system that can be formed for the management of platform ecosystems (ecosystem model). It thus systematizes design aspects and the necessary sub-models of digital ecosystems, whereas the methodological reduction in a management process is still open (corresponding to Winter et al. (2009)). Regarding the necessary integration of method and reference model, the development of digital ecosystems requires not only a conceptual definition of the result dimension (ecosystem model) but also a description of the procedure for its creation and management (management method) (Winter et al. 2009). Since ecosystems emerge both in the end customer market and in specific industries, such a method should allow the analysis of different sectors and support method users to apply the analyzed domain-specific concepts in the resulting ecosystem model. The ecosystem model comprises the following aspects that need to be created by a management method.

In the *context focus* (Aspect 1 in Figure 2), the objectives of the overall system are disclosed and cataloged. In this way, the platform owner records his own (entrepreneurial) goals and describes the intended development goals for the entire ecosystem. The formulation of objectives also includes restrictions (view: "Restrictions") that apply to the ecosystem and ultimately determine its degrees of freedom (e.g., laws or company conventions).

In the e*cosystem focus* (Aspect 3 in Figure 2), the organizational aspects of the ecosystem are considered first. Among other concepts, the actors involved and their relationships (value-added relationships, cooperative or competitive behavior) are described. Additionally, connections to ecosystem objectives are established which are operationalized in concrete roles and interactions.

Secondly, the view of the actual service provision, i.e. the products and services, is placed in the context of business models. Thirdly, technical implementation and integration depend on the positioning of the intended business models of the ecosystem and their product or service configuration. At the technological level, it is described how the technical components are to be embedded in a larger system and what role they play in it. In describing the technical infrastructure, the platform plays the role of the focal product (Jacobides et al. 2018). The platform is viewed from a requirements point of view (external view).

The *platform focus* (Aspect 2 in Figure 2) defines the platform architecture (Tiwana 2014) and the usage rules (Baldwin and Woodard 2008; Tiwana 2014). The aspect thus represents the implementation of the requirements of individual actors identified in Aspect 3. This aspect describes the internal view of the platform. The boundary resources that are available to the actors in the ecosystem are part of the platform architecture (Bianco et al. 2014). The definition of usage rules includes, for example, economic aspects such as the design of price models for platform usage.

Although Figure 2 may suggest a certain invariability regarding the management of a platform-based ecosystem, such a system is in a permanent process of change and adaptation. Conflicts arise due to conflicting interests of the actors, which can have a negative impact on the entire ecosystem so that the platform owner has to take countermeasures (Ofe and Sandberg 2019). This can be done, for example, through the continuous adaptation of boundary resources and related governance rules. In doing so, possible new business models must also be considered and the underlying technology stack must be adapted to the current state of the art (Eaton et al. 2015).

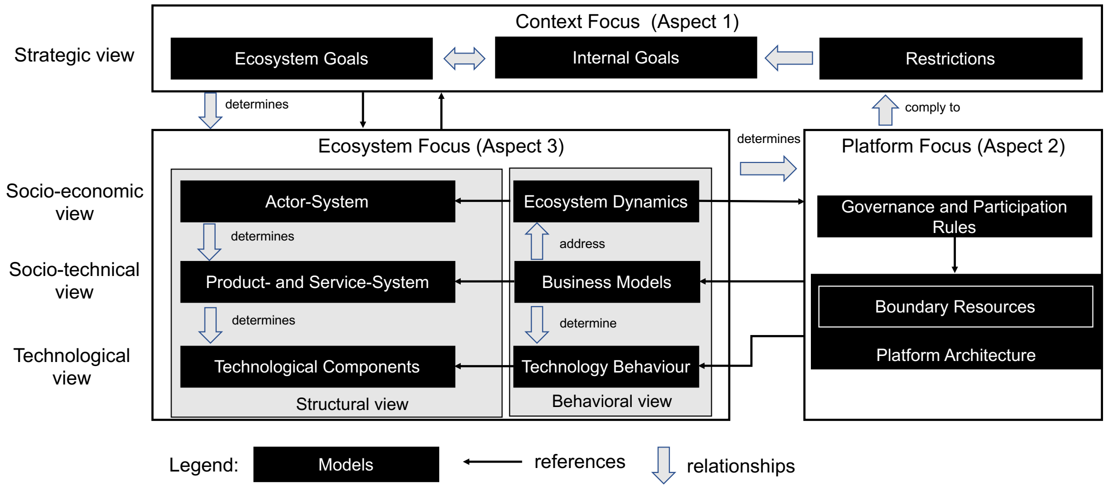


**Figure 2. Ecosystem Management - Overview of design levels, adapted from (Benedict 2018)**

## Ecosystem Management Method

In the following, the Dresden Ecosystem Management Method (DREEM) is defined. The initial design of the method is based on the preliminary work on the design of platform ecosystems by Benedict et al. (2018) and Schreieck et al. (2016). Figure 3 shows the entire management process including subtasks. The method definition is based on evolutionary approaches from method engineering (Rossi et al. 2004). The process covers the phases *"ecosystem design", "platform design*" and *"ecosystem monitoring*", which correspond to the ideal management cycle of platform ecosystems (black arrow). In the case of the emergence of unintended effects (so-called tension situations like the occurrence of a conflict situation or the emergence of unintended use models), the process also permits a direct rebound. In this case, a modification of the platform or ecosystem design would take place, so that either the development area is expanded, or the compliance with the development area is enforced. This decision is a management measure of the platform owner.

Two different types of platform concepts are envisaged in this management process. A platform can be built completely from scratch, as is often the case with eHealth platforms (e. g. Christensen et al. 2014). Alternatively, platforms can also emerge from existing product landscapes (Saarikko 2016). These options are indicated by two different starting points in the present process: *Green-Field-Entry* (starting at the "greenfield") and *Brown-Field-Entry* (further development of an existing product system). The individual steps will be documented in conceptual models (black boxes). These models are used in subsequent steps to derive concepts based on them and need to be based on a common model repository which implements meta-model integration. They are taken from the framework of Benedict (2018).

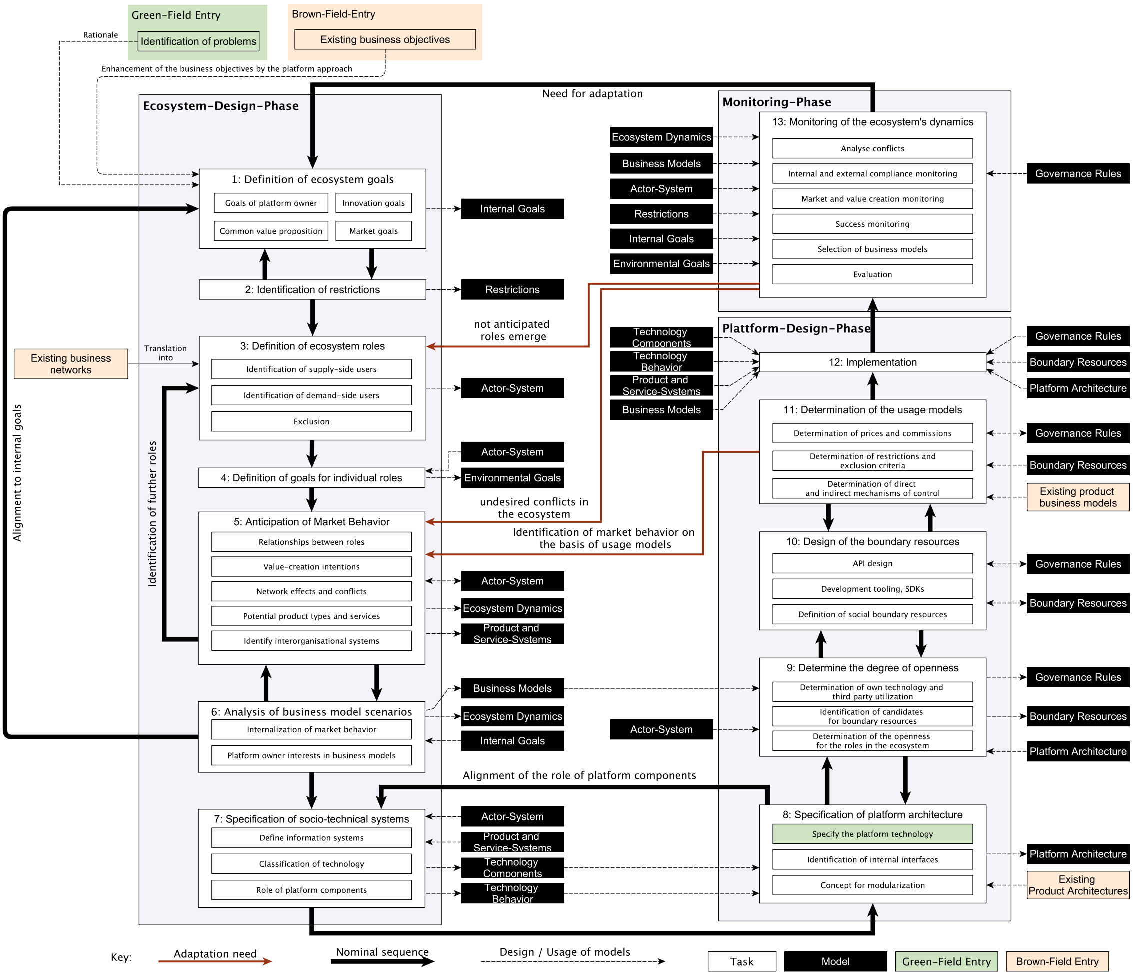


**Figure 3. Dresden Ecosystem Management Method (DREEM) for digital ecosystems**

**Ecosystem design phase**: Table 1 justifies the several steps of the ecosystem design phase. In this phase, the focus is on the conception of the intended ecosystem. The platform owner defines the general goals for the ecosystem and can also integrate preexistent business goals (brownfield entry). Possible target areas are financial targets, as well as own market-associated targets (market share, market expansion), but also the development of external innovation capacities and the commitment of external developers to a product. The creation of a product-related regulated market can also lead to platform projects. Potential platform participants result from the goal definition (step 3). If an existing product is transferred to a platform, existing business networks must be considered (brownfield entry). The modeling of the actor-individual objectives (step 4) forms a basis for the description of the anticipated market behavior and thus for the concrete design of promotional or restrictive measures to harmonize the target systems of the various actors. The anticipation of market behavior (step 5) comprises the description of the resulting interdependencies between the actors, their transactions, expected behavior and the resulting complementary relationships among themselves and with the platform. The business models (resulting from step 6) are implemented by describing socio-technical (sub)systems that implement product and service types (step 7). This can be done, for example, by specifying the inter-organizational information systems that enable the defined market relationships.

| Concept | Informing Theory | Justification | Resulting Design Step |
|---|---|---|---|
| Core value proposition, ecosystem goals | (Adner 2017; Gawer and Cusumano 2014) | Ecosystem construction should start by questioning which value proposition leads the ecosystem construction. The platform owner has to define why he sets up an ecosystem. This may also be formulated as a vision for the platform. | 1: Definition of Ecosystem Goals (and Internal Goals of the Platform Owner) |
| Environmental conditions | (Boudreau and Hagiu 2008; Tiwana et al. 2010) | Ecosystems may target specific parts of the economy (different spatial orientation, societal orientation, sectorial orientation) that have specific regulations and conditions for value creation. The explicit (public regulations) and the implicit (societal and cultural conditions) restrictions have to be considered when implementing an ecosystem. | 2: Identification of Restrictions |
| Classification of actors in the ecosystem | (Schreieck et al. 2016; Eisenmann et al. 2008; Adner 2017; Riedl et al. 2009) | The identification and definition of roles in the ecosystem help to identify the different sides of the platform and creates a foundation for further analysis of relationships, of resulting network effects, and of actor-individual goals. | 3: Definition of Roles |
| Diversity of platform users and individual goals | (Adner 2017; Bergvall-Kareborn and Howcroft 2014; Nambisan and Baron 2013; Peltoniemi 2006) | Ecosystems are created through decentralized decision making. The participation in platforms is driven by different motivations of the individual actors. Actors are autonomous entities in the ecosystem. Their participation in an ecosystem depends on how well they can achieve their own goals and how much they gain a specific amount of self-control. | 4: Definition of goals for the individual roles |
| Variability in inter-actor relationships and different value creation approaches | (Burkard et al. 2012; Gawer 2014; Jacobides et al. 2018; Kapoor 2018; Peltoniemi 2006) | The value creation in ecosystems may occur cooperatively as well as competitively. The platform owner has to identify intentions for value creation. Direct and indirect network effects need to be anticipated. Different non-generic relationships need to be identified to analyze how the value-co-creation and the market situation in the ecosystem are operationalized. | 5: Anticipation of market behavior |
| Operationalization of value creation | (Gawer 2009; Kapoor 2018; Nambisan and Baron 2013) | The internalization of external market behavior is done by the supply side users by implementing own business models. The platform owner has to anticipate the opportunities that emerge for the actors to evaluate if they fit the value proposition of the platform and to create a context to allow new business models on that basis. | 6: Anticipation of business model scenarios |

| | | | |
|---|---|---|---|
| Integrating services and products and managing the integration | (Fedorowicz et al. 2004; Hanseth and Lyytinen 2010; Rehm et al. 2017) | The multilateral relationships between actors in the ecosystem and their usage of products and services to implement these relationships need to be managed. This management should be supported by interorganizational information systems. The platform owner can use this to determine the role of the platform in these systems and define how the platform supports the integration of products and services provided by the actors. | 7: Specification of socio-technical systems |

**Table 1. Justification of Steps for the Ecosystem Design Phase**

**Platform design phase**: The conception of the platform is based on the intended system design from step 7 (see Table 2). The development of the platform architecture (step 8) must follow the principle of modularization and layer formation since this is an essential prerequisite for opening up the platform to third parties. Modularity enables variable recombination of the various platform components. The specification of the platform architecture should be iterative in interaction with the conception of the overall system (see step 7). It forms the transition point between the conception of the digital ecosystem and the platform design. When redesigning a platform, fundamental technology decisions must also be made that go hand in hand with a technology evaluation against the background of the intended technologies in the ecosystem. The determination of the degree of openness (step 9) is based on the modularity of architecture of the platform. This, in turn, determines which components form the stable generic components of the platform and which can be integrated as complements. The definition of openness requires the definition of how much technological sovereignty the platform owner wants to transfer to other actors in the digital ecosystem. This does not have to be discrete, but can also be done dynamically. The degree of openness may diverge for different roles within the digital ecosystem. It makes sense to define these roles based on the role models. Openness is not determined solely by accessibility but is also influenced by transparent access (perceived openness) (Benlian et al. 2015).

A major step in creating an open platform is the design of Boundary Resources (Step 10) (Ghazawneh and Henfridsson 2013). Technical interfaces (e.g., APIs) as well as documenting materials and interaction possibilities (social boundary resources) will be defined (Bianco et al. 2014). Building on this, it must be determined under which conditions the platform is accessible and how the boundary resources may be used (step 11). Three essential design features are relevant in this step: the distribution of decision-making rights in the use of boundary resources, the formal and informal mechanisms of control, and the determination of ownership and participation rights (Tiwana et al. 2010). Specific manifestations of these design features are reflected, for example, in conditions of use, price models and the introduction of market restrictions (Schreieck et al. 2016). In the course of the implementation (step 12), the conceptual platform architecture and the associated boundary resources will be realized. At the organizational level, for example, the fulfillment of necessary regulations in the context of distinct market situations (e.g., implementation in a national healthcare market) is necessary. In order to be implemented, the operational integration of actors must also take place to achieve the intended network and market effects and thus make the platform attractive for other actors (Burkard et al. 2012; Furstenau and Auschra 2016).

| Concept | Informing Theory | Justification | Resulting Design Step |
|---|---|---|---|
| Developing the core of the ecosystem and define its inner structure. | (Baldwin and Woodard 2008; Gawer and Cusumano 2014; Tiwana et al. 2010; Yoo et al. 2010) | The platform owner has to define core components that create the capabilities to implement complements. This also comprises both the specification of the basic components as well as the definition of potential interfaces for third-parties. The architecture is crucial for the success of the ecosystem. The architecture should be modular and stable to create a context which provides the necessary flexibility and continuity for innovation and variable products and services. | 8: Specification of platform architecture |
| Finding the right level of participation for the ecosystem actors. | (Benlian et al. 2015; Eisenmann et al. 2008; Parker and Alstyne 2008) | Openness is not a binary state which is reached or not. Rather, it is a continuum that needs adequate leveling. The degree of openness can be regulated differently for different platform users. The platform owner has to define how platform users can access the platform. The degree of openness may diverge for different roles within the digital ecosystem. Furthermore, openness can address different aspects like technological or organizational ones. It is also important that these participants in the ecosystem can perceive the degree of openness. | 9: Definition of the degree of openness |
| Provide capabilities to access the platform. | (Bianco et al. 2014; Ghazawneh and Henfridsson 2013) | The provision of resources enables third parties to design their application and enables platform users to access the stable core of the platform. The design of adequate boundary resources is a strategic decision and should consider the needs of the different user groups of the platform. | 10: Concept for boundary resources |
| Define the level of control and regulate the level of autonomy. | (Hein et al. 2016; Parker and Van Alstyne 2014; Schreieck et al. 2016; Tiwana et al. 2010) | Governance aims to specify the level of how decisions are made, and how much autonomy and control is given to the platform users. Also, ownership questions, pricing, and documentation are crucial design parameters of governance. The platform owner has to define the right level of governance. | 11: Definition of usage models and governance |
| Distribute the platform in the market. | (Evans 2008; Parker and Van Alstyne 2014) | The concepts for platform architecture, as well as the governance regulations, have to be operationalized both in technological implementations (technology, stack, Application Programming Interfaces) and in organizational constructs (contracts, support facilities). A launch strategy is necessary which regulates how the access of the initial users leads to the intended ecosystem effects. Furthermore, the platform has to be positioned in the market and an initial seed of platform users (critical mass) needs to be acquired. | 12: Implementation |

**Table 2. Justification of Steps for the Platform Design Phase**

**Monitoring phase** (see Table 3): During the life cycle of the ecosystem, conflicts can arise in the objectives of individual ecosystem actors, leading to actors leaving the ecosystem. This can even endanger the existence of the ecosystem. Therefore, the platform owner must introduce mechanisms to monitor the success of the ecosystem and identify unintended developments. One example of such monitoring measures could be rating systems. The identification of unintended dynamics should lead to a new platform configuration. To this end, the platform owner may have to adjust the objectives or influence the observed behavior of ecosystem participants through control measures. In the life cycle of ecosystems, business models of platform users can also occur to develop such dominance and success that it is worth incorporating these and the underlying technologies into the core of the platform.

| Concept | Informing Theory | Justification | Resulting Design Step |
|---|---|---|---|
| Observe positive and negative dynamics and manage emergence. | (Eaton et al. 2015; Ghazawneh and Henfridsson 2011, 2013; Ofe and Sandberg 2019) | Ecosystems are designed to be emergent. Their final structure cannot be anticipated or deterministically derived. Consequently, the management of ecosystems should allow reactions to positive or negative effects in the ecosystem. These effects must be identifiable. Therefore, monitoring of the ecosystem is necessary. | 13: Monitoring |

**Table 3.** Justification of the Monitoring Phase

## Case Study on Virtual Coaching

### *Introducing the Case Study Context*

VCP aims to establish a virtual coaching system that supports patients in implementing rehabilitation measures in their home environment. For this purpose, the patient is provided with a virtual coach (tablet-based avatar) with whom he/she can interact. This coach supports the patient in adhering to rehabilitation plans, which are initialized as individualized clinical pathways by the service provider (Schlieter et al. 2017) upon discharge into the home environment and are successively personalized based on analyzed action patterns and vital data. For example, the intensity of the training program can be adjusted to suit the needs of the patients and to prevent risk situations. The medical service provider receives information on therapy adherence and can thus intervene in the rehabilitation process if necessary. Preferences and individual behavior patterns are included in the rehabilitation plan as well. Serious Games are a major rehabilitative measure and are part of the coaching triggered by the Virtual Coach in this regard.

The concept of *VCP-as-a-Service* (*VCPaaS)* opens the virtual coaching system to new participants, new use cases and new therapeutic indications, letting VCP act as a platform for coaching services in general. The existing services are intended to be designed as generic and reusable services. The implementation of the coaching services and the realization of VCPaaS as an open platform should, above all, open up the possibility for third-party providers to develop their solutions by using the functionalities of the virtual coach or to extend them with new functions. For every module in the VCP system, an API calling the authentication and authorization layer will be provided, where - based on the platform policies - access will be granted. VCP acts as a content and knowledge provider as well as reasoner for third-party systems providing data to and retrieving from VCP. By allowing third-party products to easily integrate with VCP considerable value can be added to one's product and the user's experience can be improved.

### *Application of DREEM in VCP*

In the following, the application of DREEM to the case study context will be used to demonstrate the design process of the virtual coaching ecosystem. In the course of the case description, we also identify the resulting design concepts according to Schreieck et al. (2016). Some partial aspects of the project have been selected to demonstrate their documentation utilizing conceptual models and their correlated design. Figure 4 illustrates the usage of different modeling languages in extracts for the case study context. These languages are not mandatory, but can rather be chosen according to individual preferences or organizational standards.

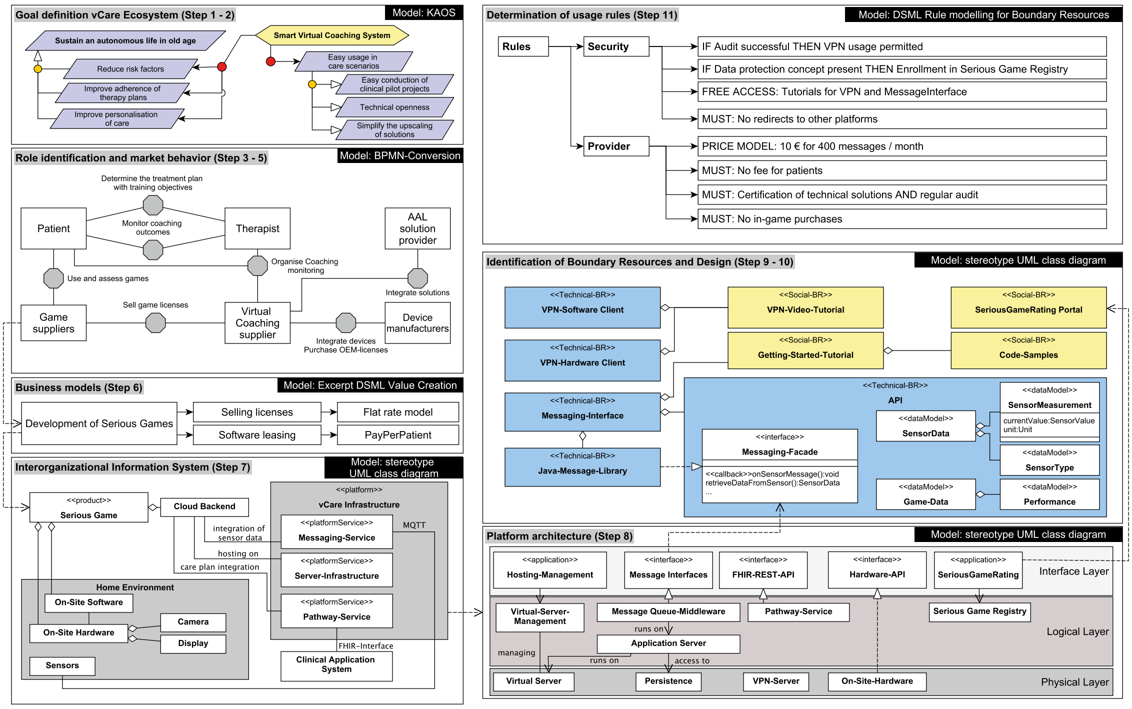


**Figure 4. Application of the ecosystem management method to VCP, abridged presentation**

The target modeling language KAOS (Van Lamsweerde 2001) was used to model the target system (*steps 1 and 2* of DREEM). From a technical perspective, the virtual coaching solution pursues medical goals such as improving adherence to therapy plans and personalizing care to enable a self-determined life in old age. From a socio-technical perspective, the aim is to use the solutions as easy as possible in care scenarios, which is facilitated, for example, by the derived sub-objective "technical openness". Structuring the project goals like this is beneficial for the identification of roles as a next step in the design process.

The modeling of roles and transactions (*steps 3 to 5)* is carried out using BPMN conversation diagrams (Object Management Group 2011). In addition to the provider of the virtual coaching solution (the platform owner), there are demand-side users who apply the solutions of the virtual coaching environment in the medical context. For example, therapists specify the training plan of a patient. In doing so, they make use of digital care solutions offered by supply-side users. These are manufacturers of smart devices, providers of AAL solutions and developers of Serious Games. Their solutions are used in care networks to create a product combination that supports the patient's rehabilitation. Thereby, step 3 generates the corresponding design concept of *Roles*.

The integration of Serious Games into the VCP ecosystem is an example of distinct design measures: The game manufacturers make Serious Games available to the patients (*step 6*). However, the games should not be made available directly, but via the supply networks. The billing is made to the care providers and not to the patients. The game manufacturer must consider the cost structures of the care networks and their refinancing, for example through integrated supply contracts, and appropriate licensing models (e.g., PayPerPatient). The platform owner must anticipate potential revenue models on the part of the actors and check whether these are compatible with the platform's business objectives. Elsewise, he or she must design the platform in the subsequent steps (e.g., in *step 11*) in such a way that certain revenue models are prevented. For example, patients should not bear any costs for the provision of the games. Step 6 addresses the design concept of *Pricing and Revenue Sharing*.

The Serious Games will be integrated as applications into the information system of home care. This forms an inter-organizational information system (Fedorowicz et al. 2004) and also includes other application systems, such as the specialist documentation systems of the participating care institutions. The information system concept (*step 7*) must identify how the single products (Serious Game, other domestic application systems, clinical application systems) interact with each other. The platform role is defined and its components are formulated as services (external view). In order, for example, to transfer the results of the game session to the clinical documentation systems, it is necessary to implement a communication component (messaging service). This service should enable the communication of VCP subsystems across all institutions. The Serious Game manufacturers can operate their back-ends in addition to the concrete technical systems in the domestic environment (on-site) and these should achieve a certain degree of security. So these can also be hosted within the platform infrastructure (server infrastructure). The technical integration of training plans and medical documentation is in turn carried out via the Pathway Service, which also organizes the assignment of Serious Games.

The platform components identified in *step 7* are concretized in *step 8* (inside view). In the case study, a conventional system architecture based on UML was described introducing a layer model. Architecture patterns for distributed systems were used (Buschmann 1996) as the basis for the necessary modularization (Jacobides et al. 2018). For example, system interfaces for messaging and the necessary underlying components were identified. The technical basis for system integration is realized by platform access via Virtual Private Network (VPN). Since patients should also evaluate games, an application for evaluation is foreseen as well. Hereby, the design concept of *Technical Design* is addressed, since the aspects of modularity, interfaces, and compatibility are being covered.

Based on the architecture, the components accessible to Serious Game manufacturers (*step 9*) and the realization of the accessibility will be defined (design of boundary resources - *step 10*). For example, the messaging interface's API includes both a messaging facade (Buschmann 1996) and a corresponding data model. In order to simplify access to this API for Serious Game manufacturers, a Getting Started tutorial with code examples and a Java library are offered. This library can integrate games directly. Serious Games from the domestic IT infrastructure can communicate with and integrate into the VCP platform by providing game developers with a VPN client. Alternatively, a hardware solution for the domestic environment will be provided. Steps 9 and 10 of the management method address the design concepts of *Openness* and *Boundary Resources*.

*Step 11* defines the rules for the actors. Apart from the business behavior and pricing models, it is also planned that the game manufacturers will have to undergo certification. Once the certification process (audit) has been completed, the game manufacturer receives access information to the platform and is included in the Serious Game Repository. This makes the game visible to patients in the evaluation portal. This process is also represented in a business process model (not displayed in Figure 4), which systematizes the necessary steps for platform access. Hereby, control mechanisms as required in the design concept of *Control* are addressed. The design concept of *Trust* is also addressed by the certification. The implementation of the platform (*step 12*) will initially take place in two clinical domains (neurological and cardiological), each in two rehabilitation centers. After the end of the project, the product will be made accessible to other clinics as well as to private individuals. In this first phase of implementation of the platform, the collaboration between the platform users will be the best *Competitive Strategy* for the establishment in the market. Competition can occur through different Serious Games.

The derived conceptual models can be used to derive monitoring measures (*step 13*) for the ecosystem's dynamics. For example, the Serious Games Rating Portal is a suitable instrument for evaluating the perceived added value of the individual games both for the patient and for the medical service providers. Thereby, the design concept of *Trust* is being implemented under the aspect of end-user – platform relationship. In case of the acceptance of the games in the neurological but not in the cardiological field, alternative service providers must be searched for and new roles (e.g., fitness tracking providers) need to be identified (*step 3*). An alternative measure could also be to adjust the internal goals (*step 1*) by focusing on the neurological domain and expanding the range of offered neurological games.

## Conclusion and Further Research

This paper addressed one of the challenges of dealing with the emergence in digital ecosystems (Woodard and Clemons 2014). Due to the dynamic and volatile development paths of digital ecosystems, it is not possible to fully anticipate the system that will emerge during the planning phase. Nevertheless, the platform owner needs development and reliable planning of these systems. Based on existing kernel theories, the DREEM method was proposed and applied based on a case study in the healthcare sector.

The DREEM method, consisting of a process model and the reference to specific modeling concepts, supports product managers and developers in systematically developing and documenting their platform approaches. It is a theory-based tool for the step-by-step development of a platform and its ecosystem. The underlying model system provides indications of the necessary system elements to be considered in the single design phases. Utilizing the model-oriented description, platform owners can formalize reactions to undesired effects and associate them with triggering and affecting system components. Based on this, appropriate measures can be derived systematically.

Using a case study from the field of home rehabilitation, it was shown how the DREEM method contributes to the implementation of a platform ecosystem model in healthcare. Along with the individual design steps, the developers were guided in the implementation of a virtual coaching solution as a platform. The focus was on practical support for the definition of specific platform aspects such as the anticipation of business models, roles involved, the target system and undesired effects. In the course of the case study, the applicability of the DREEM method could be demonstrated in the context of a concrete domain. In the course of the case example, the method can create the necessary design concepts of platform ecosystems.

At the same time, a limitation of the present contribution has to be named. The described case study is still in a comparatively early phase of the ecosystem's life cycle. Therefore, the dynamic development of the intended management steps (especially monitoring) can currently only be understood as recommendations whose effectiveness will have to be evaluated in the course of further research and which may have to be adapted. An answer can only be given in the course of the further life cycle of the virtual coaching ecosystem. The transferability to other domains must also be examined while its practical application. Therefore, the authors call for applying the DREEM method in practice as well as in science in the context of different domains.

Further perspectives for research result from the selection of adequate modeling languages. In this paper, the modeling languages for the different steps were selected pragmatically and fit the VCP case. Currently, for each case, it must be analyzed if a modeling language fits for a particular step in the method. A broader ontological analysis of ecosystems and a mapping to the metamodels of possible modeling languages can improve the method by providing a generic collection of usable modeling languages study. The design of an integrated model system with a common metamodel must be considered in the course of further research.

## References

Adner, R. 2017. "Ecosystem as Structure: An Actionable Construct for Strategy," Journal of Management (43:1), pp. 39–58. (https://doi.org/10.1177/0149206316678451).

Baldwin, C. Y., and Woodard, C. J. 2008. "The Architecture of Platforms: A Unified View," SSRN Electronic Journal. (https://doi.org/10.2139/ssrn.1265155).

Barrett, M., Davidson, E., Prabhu, J., and Vargo, S. L. 2015. "Service Innovation in the Digital Age: Key Contributions and Future Directions," Mis Quarterly (39:1), pp. 135–154.

Bender, D., and Sartipi, K. 2013. "HL7 FHIR: An Agile and RESTful Approach to Healthcare Information Exchange," in Proceedings of the 26th IEEE International Symposium on Computer-Based Medical Systems, , June, pp. 326–331. (https://doi.org/10.1109/CBMS.2013.6627810).

Benedict, M. 2018. "Modelling Ecosystems in Information Systems–A Typology Approach," in Multikonferenz Wirtschaftsinformatik (MKWI) 2018, Lüneburg: Leuphana Universität Lüneburg, March 6.

Benedict, M., and Schlieter, H. 2017. "Revise Your EHealth-Platform! – Design Principles for a Descriptive Case Study," in AMCIS 2017 Proceedings, , August 10. (http://aisel.aisnet.org/amcis2017/Healthcare/Presentations/28).

Benlian, A., Hilkert, D., and Hess, T. 2015. "How Open Is This Platform? The Meaning and Measurement of Platform Openness from the Complementors' Perspective," Journal of Information Technology (30:3), pp. 209–228. (https://doi.org/10.1057/jit.2015.6).

Bergvall-Kareborn, B., and Howcroft, D. 2014. "Persistent Problems and Practices in Information Systems Development: A Study of Mobile Applications Development and Distribution," Information Systems Journal (24:5), pp. 425–444. (https://doi.org/10.1111/isj.12036).

Bianco, V. D., Myllarniemi, V., Komssi, M., and Raatikainen, M. 2014. "The Role of Platform Boundary Resources in Software Ecosystems: A Case Study," in Proceedings of 2014 IEEE/IFIP Conference on Software Architecture, Sydney, NSW, Australia: IEEE, April, pp. 11–20. (https://doi.org/10.1109/WICSA.2014.41).

Boucharas, V., Jansen, S., and Brinkkemper, S. 2009. "Formalizing Software Ecosystem Modeling," in Proceedings of the 1st International Workshop on Open Component Ecosystems, IWOCE '09, New York, NY, USA: ACM, pp. 41–50. (https://doi.org/10.1145/1595800.1595807).

Boudreau, K., and Hagiu, A. 2008. "Platform Rules: Multi-Sided Platforms as Regulators," SSRN Scholarly Paper No. ID 1269966, SSRN Scholarly Paper, Rochester, NY: Social Science Research Network, September 18. (https://papers.ssrn.com/abstract=1269966).

Burkard, C., Widjaja, T., and Buxmann, P. 2012. "Software Ecosystems," Business & Information Systems Engineering (4:1), pp. 41–44. (https://doi.org/10.1007/s12599-011-0199-8).

Buschmann, F. 1996. Pattern-Oriented Software Architecture: A Pattern Language for Distributed Computing, Chichester [England]; New York: Wiley.

Ceccagnoli, M., Forman, C., Huang, P., and Wu, D. J. 2012. "Cocreation of Value in a Platform Ecosystem: The Case of Enterprise Software," Mis Quarterly (36:1), pp. 263–290.

Chesbrough, H. W., and Appleyard, M. M. 2007. "Open Innovation and Strategy," California Management Review (50:1), pp. 57-+.

Christensen, H. B., Hansen, K. M., Kyng, M., and Manikas, K. 2014. "Analysis and Design of Software Ecosystem Architectures – Towards the 4S Telemedicine Ecosystem," Information and Software Technology (56:11), pp. 1476–1492. (https://doi.org/10.1016/j.infsof.2014.05.002).

Eaton, B., Elaluf-Calderwood, S., and Sorensen, C. 2015. "Distributed Tuning of Boundary Resources: The Case of Apple's Ios Service System," Mis Quarterly (39:1), pp. 217-+.

Eisenmann, T. R., Parker, G., and Van Alstyne, M. W. 2008. "Opening Platforms: How, When and Why?," SSRN Electronic Journal. (https://doi.org/10.2139/ssrn.1264012).

Evans, D. S. 2008. "How Catalysts Ignite: The Economics of Platform-Based Start-Ups," SSRN Scholarly Paper No. ID 1279631, SSRN Scholarly Paper, Rochester, NY: Social Science Research Network, October 7. (https://papers.ssrn.com/abstract=1279631).

Fedorowicz, J., Gogan, J. L., and Ray, A. W. 2004. "The Ecology of Interorganizational Information Sharing," Journal of International Information Management (13:2), p. 1.

Finkelstein, A., Kramer, J., Nuseibeh, B., Finkelstein, L., and Goedicke, M. 1992. "Viewpoints: A Framework for Integrating Multiple Perspectives in System Development," International Journal of Software Engineering and Knowledge Engineering (02:01), pp. 31–57. (https://doi.org/10.1142/S0218194092000038).

Furstenau, D., and Auschra, C. 2016. "Open Digital Platforms in Health Care: Implementation and Scaling Strategies," in ICIS 2016 Proceedings, Dublin, December 11. (https://aisel.aisnet.org/icis2016/ISHealthcare/Presentations/19).

Gawer, A. 2009. "Platform Dynamics and Strategies: From Products to Services," Platforms, Markets and Innovation (45), p. 57.

Gawer, A. 2014. "Bridging Differing Perspectives on Technological Platforms: Toward an Integrative Framework," Research Policy (43:7), pp. 1239–1249. (https://doi.org/10.1016/j.respol.2014.03.006).

Gawer, A., and Cusumano, M. A. 2014. "Industry Platforms and Ecosystem Innovation: Platforms and Innovation," Journal of Product Innovation Management (31:3), pp. 417–433. (https://doi.org/10.1111/jpim.12105).

Ghazawneh, A., and Henfridsson, O. 2011. "Micro-Strategizing in Platform Ecosystems: A Multiple Case Study," in ICIS 2011 Proceedings, Shanghai, December 6. (http://aisel.aisnet.org/icis2011/proceedings/generaltopics/3).

Ghazawneh, A., and Henfridsson, O. 2013. "Balancing Platform Control and External Contribution in Third-Party Development: The Boundary Resources Model," Information Systems Journal (23:2), pp. 173–192. (https://doi.org/10.1111/j.1365-2575.2012.00406.x).

Ghazawneh, A., and Henfridsson, O. 2015. "A Paradigmatic Analysis of Digital Application Marketplaces," Journal of Information Technology (30:3), pp. 198–208. (https://doi.org/10.1057/jit.2015.16).

Gregor, S., and Hevner, A. R. 2013. "Positioning and Presenting Design Science Research for Maximum Impact," MIS Quarterly (37:2), pp. 337-A6.

Gregor, S., and Jones, D. 2007. "The Anatomy of a Design Theory," Journal of the Association for Information Systems (8:5), pp. 312–335.

Hanseth, O., and Lyytinen, K. 2010. "Design Theory for Dynamic Complexity in Information Infrastructures: The Case of Building Internet," Journal of Information Technology (25:1), pp. 1–19. (https://doi.org/10.1057/jit.2009.19).

Hein, A., Schreieck, M., Wiesche, M., and Krcmar, H. 2016. Multiple-Case Analysis on Governance Mechanisms of Multi-Sided Platforms, presented at the Multikonferenz Wirtschaftsinformatik.

Hevner, A., vom Brocke, J., and Maedche, A. 2019. "Roles of Digital Innovation in Design Science Research," Business & Information Systems Engineering (61:1), pp. 3–8. (https://doi.org/10.1007/s12599-018-0571-z).

Hevner, A. R., March, S. T., Park, J., and Ram, S. 2004. "Design Science in Information Systems Research," Management Information Systems Quarterly (28:1), pp. 75–106.

Jacobides, M. G., Cennamo, C., and Gawer, A. 2018. "Towards a Theory of Ecosystems," Strategic Management Journal (39:8), pp. 2255–2276. (https://doi.org/10.1002/smj.2904).

Kapoor, R. 2018. "Ecosystems: Broadening the Locus of Value Creation," Journal of Organization Design (7:1). (https://doi.org/10.1186/s41469-018-0035-4).

March, S. T., and Smith, G. F. 1995. "Design and Natural Science Research on Information Technology," Decision Support Systems (15:4), pp. 251–266. (https://doi.org/10.1016/0167-9236(94)00041-2).

Moore, J. F. 1993. "Predators and Prey: A New Ecology of Competition," Harvard Business Review (71:3), pp. 75–83.

Nambisan, S., and Baron, R. A. 2013. "Entrepreneurship in Innovation Ecosystems: Entrepreneurs' Self-Regulatory Processes and Their Implications for New Venture Success," Entrepreneurship Theory and Practice (37:5), pp. 1071–1097. (https://doi.org/10.1111/j.1540-6520.2012.00519.x).

Nischak, F., Hanelt, A., and Kolbe, L. M. 2017. "Unraveling the Interaction of Information Systems and Ecosystems-A Comprehensive Classification of Literature," in International Conference on Information Systems, Seoul, Korea.

Object Management Group. 2011. OMG Unified Modeling LanguageTM (OMG UML), Superstructure, Version 2.4.1. (http://www.omg.org/spec/UML/2.4.1/Superstructure/PDF/).

Ofe, H., and Sandberg, J. 2019. "Digital Platform Establishment: Navigating Competing Concerns in Emerging Ecosystems," in Proceedings of the 52nd Hawaii International Conference on System Sciences, Maui, USA, January 8. (http://scholarspace.manoa.hawaii.edu/handle/10125/59583).

Parker, G. G., and Alstyne, M. W. van. 2008. "Managing Platform Ecosystems.," in Proceedings of the International Conference on Information Systems, ICIS 2008, Paris, France, December 14-17, 2008, p. 53. (http://aisel.aisnet.org/icis2008/53).

Parker, G., and Van Alstyne, M. W. 2014. "Platform Strategy," SSRN Electronic Journal. (https://doi.org/10.2139/ssrn.2439323).

Peffers, K., Tuunanen, T., Rothenberger, M. A., and Chatterjee, S. 2007. "A Design Science Research Methodology for Information Systems Research," Journal of Management Information Systems (24:3), pp. 45–77. (https://doi.org/10.2753/MIS0742-1222240302).

Peltoniemi, M. 2006. "Preliminary Theoretical Framework for the Study of Business Ecosystems.," Emergence: Complexity & Organization (8:1), pp. 10–19.

Prat, N., Comyn-Wattiau, I., and Akoka, J. 2015. "A Taxonomy of Evaluation Methods for Information Systems Artifacts," Journal of Management Information Systems (32:3), pp. 229–267. (https://doi.org/10.1080/07421222.2015.1099390).

Rehm, S.-V., Goel, L., and Junglas, I. 2017. "Using Information Systems in Innovation Networks: Uncovering Network Resources," Journal of the Association for Information Systems (18:8), pp. 577–604.

Riedl, C., Tilo Böhmann, Leimeister, J., and Krcmar, H. 2009. "A Framework for Analysing Service Ecosystem Capabilities to Innovate," ECIS 2009 Proceedings. (https://aisel.aisnet.org/ecis2009/237).

Rochet, J.-C., and Tirole, J. 2003. "Platform Competition in Two-Sided Markets," Journal of the European Economic Association, pp. 990–1029.

Rossi, M., Ramesh, B., Lyytinen, K., and Tolvanen, J. P. 2004. "Managing Evolutionary Method Engineering by Method Rationale," Journal of the Association for Information Systems (5:9), pp. 356–391.

Saarikko, T. 2016. "Platform Provider by Accident: A Case Study of Digital Platform Coring," Business & Information Systems Engineering (58:3), pp. 177–191. (https://doi.org/10.1007/s12599-016-0426-4).

Schlieter, H., Benedict, M., Gand, K., and Burwitz, M. 2017. Towards Adaptive Pathways: Reference Architecture for Personalized Dynamic Pathways, presented at the CBI, IEEE, July, pp. 359–368. (https://doi.org/10.1109/CBI.2017.55).

Schreieck, M., Wiesche, M., and Krcmar, H. 2016. "Design and Governance of Platform Ecosystems – Key Concepts and Issues for Future Research," Research Papers. (https://aisel.aisnet.org/ecis2016_rp/76).

Serbanati, L. D., Ricci, F. L., Mercurio, G., and Vasilateanu, A. 2011. "Steps towards a Digital Health Ecosystem," Journal of Biomedical Informatics (44:4), pp. 621–636. (https://doi.org/10.1016/j.jbi.2011.02.011).

Tiwana, A. 2014. Platform Ecosystems: Aligning Architecture, Governance, and Strategy. (http://www.books24x7.com/marc.asp?bookid=62211).

Tiwana, A., Konsynski, B., and Bush, A. A. 2010. "Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics," Information Systems Research (21:4), pp. 675–687. (https://doi.org/10.1287/isre.1100.0323).

Van Lamsweerde, A. 2001. "Goal-Oriented Requirements Engineering: A Guided Tour," in Requirements Engineering, 2001. Proceedings. Fifth IEEE International Symposium On, IEEE, pp. 249–262.

Venable, J., Pries-Heje, J., and Baskerville, R. 2012. "A Comprehensive Framework for Evaluation in Design Science Research," in Design Science Research in Information Systems. Advances in Theory and Practice, Springer, pp. 423–438. (http://link.springer.com/chapter/10.1007/978-3-642-29863-9_31).

Winter, R., Gericke, A., and Bucher, T. 2009. "Method Versus Model – Two Sides of the Same Coin?," in Advances in Enterprise Engineering III, A. Albani, J. Barjis, and J. L. G. Dietz (eds.), Springer Berlin Heidelberg, pp. 1–15.

Woodard, C. J., and Clemons, E. K. 2014. "Modeling the Evolution of Generativity and the Emergence of Digital Ecosystems.," in Proceedings of the International Conference on Information Systems - Building a Better World through Information Systems, ICIS 2014, Auckland, New Zealand, December 14-17, 2014, Auckland. (http://aisel.aisnet.org/icis2014/proceedings/BreakthroughIdeas/9).

Yin, R. K. 2003. Applications of Case Study Research, Newbury Park: SAGE.

Yoo, Y., Henfridsson, O., and Lyytinen, K. 2010. "Research Commentary —The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research," Information Systems Research (21:4), pp. 724–735. (https://doi.org/10.1287/isre.1100.0322).

Yu, E., and Deng, S. 2011. "Understanding Software Ecosystems: A Strategic Modeling Approach," in IWSECO-2011 Software Ecosystems 2011. Proceedings of the Third International Workshop on Software Ecosystems. Brussels, Belgium, pp. 65–76.

# I. Paper 8 - Towards Maintenance Analytics Ecosystems



| **Title** | **Towards Maintenance Analytics Ecosystems: A Conceptual Role-Relationship Model** |
|---|---|
| Authors | Patrick Zschech (patrick.zschech@tu-dresden.de)<br>Martin Benedict (martin.benedict@tu-dresden.de) |
| Publication | Working Paper |



## Contents




### *Abstract*

The industrial internet of things facilitates the emergence of value co-creation networks and inter-organizational resource sharing. Data-driven maintenance analytics (MA) benefits from this evolution, as different players can interact with each other on emerged digital platforms to pursue their individual interests while realizing mutual synergies. However, there is still a lack of open ecosystems that allow flexible participation and new innovative business models based on data-driven resource sharing and analytical capabilities. This is where we add to the field with the overall research goal to derive prescriptive design knowledge that supports the creation of such open MA ecosystems. Specifically, we start with the extraction of a conceptual role-relationship model to identify relevant actors and their pursued interests by drawing on a multiple-case study. We describe the selected cases in detail and present preliminary findings, followed by a discussion of the results and opportunities for future research.

# Towards Maintenance Analytics Ecosystems: A Conceptual Role-Relationship Model

*Short Paper*

## Introduction

The industrial internet of things (IIoT) covers a plethora of technologies to establish digitized manufacturing facilities, where an important focus is on the integration of different manufacturing and service-providing companies in larger inter-firm networks (Boyes et al. 2018; Kiel et al. 2017). This involves information as well as knowledge-sharing through digitized cross-institutional information systems (Lasi et al. 2014). One area that could strongly benefit from this interconnected utilization of resources is the field of industrial maintenance based on data-driven analytical capabilities, hereinafter referred to as 'maintenance analytics' (MA) (Zschech 2018). Bringing together different actors, such as manufacturing and maintenance operators as well as analytical service providers and data science innovators within an inter-firm network could positively impact the way of their individual value-creation, which is hard to achieve in isolation (Hausladen and Bechheim 2004; Kiel et al. 2017; Weking et al. 2018). However, the integration of these players in a digitized environment is a complex task that comprises challenges at different layers from data handling at equipment level to cross-organizational information system design and last but not least negotiating multi-lateral value creation models. At this point, different types of digital platforms have emerged in recent years that help to bundle functions of adjacent interests in a modular way to make them available to different interacting target groups via suitable infrastructure components. Such platforms range from traditional data and application integration platforms (e.g., Muller et al. 2008) to company-specific IIoT/IoT platforms providing analytical capabilities across heterogenous participants of the same supply chain network (e.g., Gröger 2018) to industry-independent data science platforms offering the acquisition of external crowdsourcing-based data analysis expertise (e.g., Kaggle 2019). Nevertheless, current platforms in the field of MA show several limitations. They are either restricted to static approaches with isolated narrow functionalities, they refer to closed and proprietary networks or they primarily focus on purely technological aspects. Furthermore, traditional platforms are still limited to business models for singular companies but not enabling the negotiation of multi-lateral value creation models in the sense of platform ecosystems (Gawer 2014). On this background, we observe a lack of guidance supporting the implementation of platforms that may foster the emergence of such viable MA ecosystems to allow dynamic value co-creation between actors and the evolution of new innovative business models based on data-driven resource sharing and analytical capabilities. For this reason, the goal of our research is to provide a useful artifact that supports platform development and the creation of open MA ecosystems. In this particular paper, as part of a bigger research project, we start with the proposal of a conceptual role-relationship model (RRM). Such an RRM is intended to specify the different MA actors with their individual interests and interactions to each other, which can be considered as a pivotal part in designing ecosystems (Schreieck et al. 2016). To carry out the overall research process, we follow a design science research (DSR) approach (Gregor and Hevner 2013) and build on fundamental aspects of ecosystem theories (Nischak et al. 2017). For the derivation of the RRM, we draw on a multiple-case study by examining cases of previously emerged platforms relevant to the field. Even though they show the aforementioned limitations when viewed individually, they still refer to essential properties, such as stakeholders involved or resources and capabilities to be shared. Following this line of argumentation, the remaining paper is structured as follows: In the next section, we introduce the background of MA and refer to related work in terms of existing platforms. We then outline the overall research process and position the current research efforts. Subsequently, we describe the selected cases to derive reusable platform models towards open MA ecosystems. On this basis, we present our preliminary results focusing on the extraction of the RRM, followed by a discussion and an outlook for future research.

## Background & Related Work

The maintenance function plays a crucial role in today's industrial value creation as it helps manufacturing companies to guarantee high reliability, human safety and low environmental risks (Muchiri et al. 2011). Therefore, modern production environments increasingly focus on proactive strategies that implement data-driven MA approaches to make efficient use of given resources and avoid redundant expenditures

(Bousdekis et al. 2018; Elattar et al. 2016). The situation is favored by the ubiquitous use of advanced ICT that simplifies the collection of large and multifaceted data, such as condition monitoring data, configuration parameters, processing messages or error logs (Horn and Zschech 2019; Manyika et al. 2011). This can be considered as an ideal starting point towards the realization of various benefits, including higher transparency, a better understanding of technical processes for health assessment or the replacement of subjective decision-making (Zschech et al. 2019). Simultaneously, there is a broad set of analytical techniques available originating from various converging disciplines, such as statistics or machine learning (ML) that allow accessing the diversity of data from multiple perspectives (Kaisler et al. 2013; Manyika et al. 2011). Depending on the problem to be solved and the data given at hand, the complexity of MA may range from simple tasks, e.g., the summarization of univariate machine indicators, up to more sophisticated tasks, e.g., the identification of non-linear, high-level interactions between extensive sensor data and critical failure events (Zschech 2018). The latter case, for example, can particularly be addressed with the help of ML algorithms by extracting regularities from massive datasets to either detect and classify divergent system behavior at an early stage or to predict a machine's remaining useful life in an anticipatory manner (Elattar et al. 2016). However, "smart" algorithms alone do not automatically deliver valuable insights. It rather requires a cross-disciplinary data science skillset which not only covers the expertise of machine operators and maintenance professionals with their respective domain understanding but also includes further competencies, such as know-how with different data structures, various analytical techniques and multiple data analysis frameworks, programming languages and software tools (Mikalef et al. 2018; Schumann et al. 2016). In industrial practice, however, such fully equipped data scientists are often scarce, as they are in high demand and their qualification process is a time-consuming endeavor (Huber et al. 2019).

On the one hand, this leads to a situation where the big data assets generated, represent a highly valuable asset for multiple target groups that expect individual value creation opportunities from its utilization. This includes, for example, manufacturers expecting to stabilize their production processes, equipment suppliers trying to eliminate construction errors based on insights from their customers' machine behavior under real operating conditions or research institutions looking for real-world data samples instead of relying on synthetic datasets to enhance modern data analysis methods (Bock et al. 2019; Zschech et al. 2019). On the other hand, this joint data exploitation also requires further resources (i.e., technological components, data, human experts) and capabilities (i.e., data science competencies, MA expertise). For this purpose, different types of digital platforms have emerged in recent years that either provide technological infrastructure components to enable and automate certain data lifecycle tasks or bring together different actors for resource sharing and cooperation purposes. A first group to mention in this context is that of **e-maintenance platforms**, which emerged almost a decade ago. They primarily aimed at the technical integration of maintenance-related data from heterogeneous source systems and different application layers to present them in a coherent view for the support of operational maintenance activities and strategic decision-making (Muller et al. 2008). However, even though conceptual frameworks highlight the use of e-maintenance for inter-organizational interaction relationships (Levrat et al. 2008), platforms, such as CASIP, PROTEUS or TELMA (Muller et al. 2008), mainly stayed at an intra-organizational level and were not used for open cooperation purposes. In the meantime, more advanced approaches have been developed under the umbrella term **IoT platforms**. They are based on modern cloud computing technologies, where providers like IBM, Microsoft or Bosch offer platform solutions with standardized services, e.g., for distributed databases, data security, identity management or analytical solution development (Guth et al. 2018; Hodapp et al. 2019; Lade et al. 2017). Such platforms are also successfully applied in current manufacturing and maintenance environments and enable data-driven innovations and new business models (e.g., Lade et al. 2017). A prominent example of such a platform-enabled business model can be found in the case of KAESER, where the company changed its market role from a pure equipment vendor to an innovative service operator (Bock et al. 2019). Another prominent example is Bosch's internal analytics platform, where data assets from Bosch's worldwide production network are gathered and analyzed to generate new business values (Gröger 2018). These representative cases demonstrate the high maturity of technological infrastructure components and the opportunities to drive innovations by learning from inter-organizational networks. Nevertheless, they are still limited to closed and proprietary networks and do not allow flexible alliances between different participating actors within an open ecosystem. That open cooperation principles can be promising though, is shown by **data science collaboration platforms** like Kaggle or crowdAI. Such platforms offer an environment for companies to get their challenging data analysis problems solved by external professionals, as well as for researchers and data science communities to enhance analytical methods based on real-world datasets (Kaggle 2019). On the downside, however, such platforms are limited to narrow functionalities with ex-post analytics support, as they are currently not intended to support operative maintenance processes in running environments, for example, by integrating data from distributed machines at multiple sites into a coherent view to build a common health assessment model.

## Research Agenda

Our research follows the DSR paradigm, as we aim to provide a purposeful artifact which supports scholars and practitioners to create MA platforms and open ecosystems. According to Gregor and Hevner's (2013) knowledge contribution framework, we address the improvement quadrant and aim to contribute to the design knowledge base by providing a conceptual RMM for MA ecosystems. We understand the RRM as a partial design artifact, which can be integrated into an overarching MA ecosystem model, following the view definitions for ecosystem modeling of Benedict (2018). The explication of DSR research agendas can be differentiated into the research process and into research methods that instantiate the different steps of the research process (Österle et al. 2011). Defining a research process (see Figure 1), we follow the design science process of Peffers et al. (2007). The problem identification (step 1) as well as the central design objective (step 2) have already been given and motivated in the introduction and the background section of this paper. In order to operationalize the design objective, we use an inductive approach based on real-world cases to create the RRM. The development of this model is part of a larger method for ecosystem modeling (step 3), which consists of four different phases. The four phases are derived from two kernel theories: Tiwana et al. (2010) and Adner (2017). We follow the ecosystem definition of Adner (2017) that an ecosystem is defined "*by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize*". Following this definition, the first phase comprises the value proposition and the central goals of the ecosystem. In this phase, also the specialties of the economic environment (environmental fit) have to be considered (Tiwana et al. 2010). Based on the central value proposition, in the second phase, the components of the ecosystems (i.e., roles and their relationships) are identified. Tiwana et al. (2010) define the platform design as the combination of architecture and governance and state that these two design parameters influence the evolutionary effects. We extend this view by arguing that the platform design generally is a central impact parameter for ecosystem dynamics. Consequently, in the third phase, the role of the platform in the ecosystem, its architecture, and its governance is defined (following Tiwana et al. 2010). In the fourth phase, the platform is implemented and monitored.

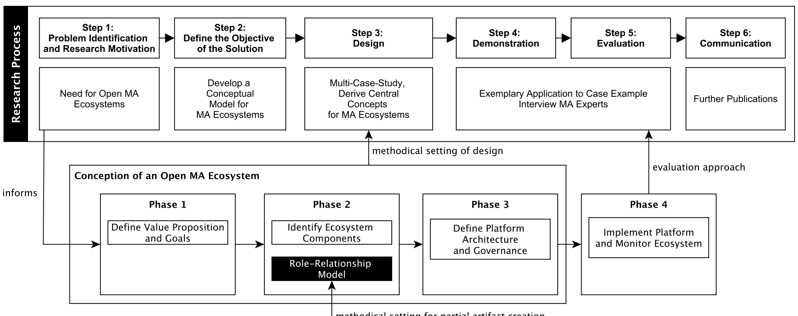


**Figure 1. Methodical Outline (Adapted from Peffers et al. 2007)**

In this paper, we are concerned with phases 1 and 2. While the central value proposition that guides the second phase was already explained in the introduction, the remaining focus is on the definition of roles and relationships as part of the ecosystem modeling according to Benedict (2018). He considers the platform and the ecosystem as two separate solution spaces, where the platform solution space can be designed directly while the ecosystem design can only be influenced by measures implemented in the platform design. The solution spaces are aimed to be designed by the platform owner. Additionally, Benedict's (2018) framework describe views for modeling ecosystems following the idea of multi-perspective modeling approaches (Frank 2002). The intended ecosystem design is influenced by the goals and restrictions that the platform owner defines. This conforms with the *ecosystem-as-a-structure* perspective of Adner (2017), who proposes the description of strategies for the different ecosystem participants (Adner 2017). Role modeling is central to ecosystem design (Schreieck et al. 2016). A popular generic role model for platforms/ecosystems is the role model of Eisenmann et al. (2008), which distinguishes between platform sponsor, platform provider, supply-side user, and demand-side user. We applied this role model as an orientation to identify corresponding domain-specific roles of MA ecosystems based on a multiple-case study.

## Selection of Cases

For the identification of MA ecosystem roles, as well as further aspects of subsequent ecosystem modeling steps (Benedict 2018), we relied on the investigation of multiple real-world cases where digital platforms were developed and used to support data-driven analytical maintenance. For this purpose, we screened the different streams of emerged platforms relevant to the field (i.e., e-maintenance, IoT, data science collaboration, cf. Section 2) and followed the principles of Yin (2014) to select appropriate cases. In particular, we aimed for choosing cases that shared common properties (e.g., relevance for MA, multiple actors involved, comprehensive documentation) while simultaneously differed from each other to obtain the required variance (e.g., platform function, platform scope, interaction types between actors). On this basis, we selected a total of four different cases with representative platforms, which we describe in the following more thoroughly for a better understanding. Moreover, we summarize their key characteristics in Table 1.

**PROTEUS/TELMA.** PROTEUS and TELMA are both representative and well-documented examples of e-maintenance platforms (Muller et al. 2008). PROTEUS is the result of an ITEA project (IT for European Advancement) that aimed at the vertical integration of existent applications and tools dedicated to maintenance-related activities. The integration is based on the cooperative and orchestrated execution of distributed processes via web services with the principal objective to move from co-existence of individual applications to their interoperability and cooperation within the same environment (Bangemann et al. 2006). TELMA, on the other hand, was developed for research and education purposes. Based on a laboratory scenario considering a physical process for unwinding metal strip, the platform demonstrates the feasibility of integrating, transforming and enriching data at different application levels to support maintenance processes such as monitoring, health assessment, prognosis and decision making (Levrat and Iung 2007).

**KAESER.** KAESER is a leading manufacturer of compressed air systems and services with worldwide operations in more than 140 countries. While KAESER's traditional focus was exclusively on selling tailored equipment to customers from a wide range of industries, it recently started to expand its market offerings by a new service-based operator model. In this model, customers no longer buy a physical product but instead pay a usage-based service fee for supplying them with compressed air. This also implies that KAESER has to perform all maintenance-related services, as it remains the owner of the physical equipment, which is still located at the customer's site. The technical driver of this non-ownership model is a digital platform that collects usage data from the customers via modern digital metering technology. This allows KAESER to better analyze and predict maintenance intervals and failure risks to increase their products' availability, operational lifetime and profitability (Bock et al. 2019).

**BOSCH.** Bosch is a global supplier of technology and services for automotive/mobility solutions, industrial technology, energy and building technology, and consumer goods. Bosch's manufacturing network consists of more than 270 factories across Europe, America and Pacific Asia that is responsible for manufacturing a variety of products ranging from sensors, electrical drives and battery systems to solar thermal systems and power tools. To guarantee global competitiveness, productivity, and agility, the company built a standardized Bosch-internal "Industry 4.0 Analytics Platform". The platform aims at enabling data-driven manufacturing capabilities by exploiting huge amounts of data and generating integrated insights from a broad variety of data sources across heterogeneous manufacturing processes, diverse technical machines and multifaceted information systems within Bosch's worldwide manufacturing network (Gröger 2018).

**KAGGLE.** Kaggle is an open, cross-sectoral data science community for users interested in modern data analysis tools. For this purpose, Kaggle provides a platform for related services, such as sharing public datasets and education material, hosting workbenches to view developed code snippets (called "kernels"), offering forums for topic-related discussions or listing job vacancies. The platform's primary service, however, is to organize public crowdsourcing-based competitions, where participating companies are able to post their challenging data science problems expressed via representative data samples and a concrete problem description. The community can then compete against each other to produce the best solution approaches.

Results are shared publicly to achieve transparent benchmarks and inspire novel ideas. After the competition's deadline, the best performing solutions are rewarded, for example, with prize money paid by the problem providing company. Since its launch of the first competition in 2010, Kaggle attracted more than 1 million users, which were actively involved in submitting and sharing more than 4 million solutions, over 170,000 posts, over 250,000 kernels and more than 1,000 datasets (Kaggle 2019).

| Case | PROTEUS/TELMA | KAESER | BOSCH | KAGGLE |
|---|---|---|---|---|
| Platform Function | Technical integration of maintenance-related data objects, applications and processes | Service-based operator model and non-ownership of equipment to improve maintenance | Standardized data integration and analytics capabilities for entire manufacturing network | Crowdsourcing-based data science competitions for external knowledge acquisition |
| Scope | Intra-organizational level | Internal customer network | Internal supply chain | Cross-sectoral community |
| Key References | Hausladen and Bechheim (2004), Iung et al. (2009) | Bock et al. (2019) | Gröger (2018) | Kaggle (2019) |

**Table 1. Summary of Cases for Representative Platforms in the Field of MA**

## Preliminary Results

When investigating the cases, we identified a broad set of interacting groups, as summarized in Table 2. The results demonstrate the variety of actors involved with their individual functions and interests, ranging from manufacturing and maintenance stakeholders to data science professionals and technology vendors. Based on these findings, it was then possible to derive a conceptual RRM, consisting of seven generic roles with their respective relationships as expected within an open MA ecosystem according to the role model of Eisenmann et al. (2008). In the following, we describe each role in more detail, refer to their ecosystem position and outline a few selected relationships between them. Moreover, we summarize the RRM in Table 3, using an adjacency matrix as a visual representation to depict important relationships.

| Case | Actors |
|---|---|
| PROTEUS/ TELMA | Production personnel (e.g., machine operator, production manager, quality manager), maintenance personnel (e.g., maintenance operator, maintenance area manager, method engineer), equipment supplier (e.g., machine manufacturer, sub-contractor, vendor), information system provider (e.g., for ERP, MES, SCADA), platform developer & operator |
| KAESER | Equipment manufacturer/supplier (e.g., technical engineer), machine service consumer/ customer, business/maintenance service operator (e.g., sales agent, service order manager, maintenance service technician, data analyst, logistic service provider), platform technology provider (e.g., for data loggers, network technology, control devices, databases) |
| BOSCH | manufacturing personnel (e.g., process engineer, manufacturing expert), analytical result consumer (e.g., business user), analytical result producer (e.g., data science expert), technology provider (e.g. for databases, analytical tools), platform provider & operator |
| KAGGLE | Competition hosts/dataset providers, competitors/solution providers (e.g., data science professionals, researchers), platform provider |

**Table 2. Identified Actors of Interest**

**Machine user.** The first role refers to actors who actually make use of technical machines and equipment to support or carry out their individual industrial operations. They can be considered as the primary demand-side users within an MA ecosystem as they aim to improve their operation's reliability, productivity, etc. based on data-driven insights that are derived from their generated data and analytical solutions provided by data routine analysts and data analysis innovators. However, this role may also act as a supply-side user, e.g., by selling or providing data for equipment suppliers to gain insights into machinery behavior under real operating conditions, for data analysis innovators to enhance existing data analysis methods, or for other machine users to enrich and supplement their datasets for additional insights.

**Maintenance operator.** The role of maintenance operators is in charge to support and carry out all maintenance-related activities. As such, they also act as demand-side users that benefit from data-driven analytical solutions developed and provided by data routine analysts and data analysis innovators. Moreover, they can also provide supplementary maintenance data to enrich data collections for further insights or they serve with their respective experiences and know-how as experts for knowledge transfer.

**Machine supplier.** The role of machine suppliers describes actors that are concerned with the design, manufacture, and supply of machines and equipment for the industrial purposes of their customers, i.e., the machine users. The strategic collection and exploitation of their customers' data enable them to improve their products or to offer new additional services for competitive advantages, which also positions them as potential demand-side users. However, similar to the role of the machine users, it is also conceivable that they sell or provide data assets to other actors from a supply-side perspective.

**Data routine analyst.** The role of data routine analysts serves as an important supply-side user as they are considered to be the actors with the required data science skills providing analytical solutions to machine users, maintenance operators and/or machine suppliers based on the respective data collections.

**Data analysis innovator.** Similar to the previous group, the role of data analysis innovators acts as an important supply-side user to provide analytical solutions for the different actors. The crucial difference, however, is that data routine analysts apply established approaches for solving known problems in the sense of routine tasks, while data analysis innovators seek to advance the field by applying novel approaches to known problems or by addressing new challenges. Thus, the role primarily consists of researchers and intrinsically-motivated data science pioneers that are expected to show different motives and incentives for a participation. For this reason, they can also be positioned as demand-side users with a high interest in available datasets reflecting real-world properties to enhance existing data analysis methods.

**Platform provider.** The role of the platform provider in its domain-independent function offers the digital environment with all required platform-related infrastructure components to connect the different ecosystem actors with their individual interests in the intended manner.

**Technology provider.** The last role refers to another group of supply-side users that provide different types of enabling technology to the remaining actors so that they can obtain all necessary technological components needed for full-featured participation within the ecosystem. This may include, e.g., sensors, network technology, databases, middleware or specific application systems for primary demand-side users to handle their data assets, but also data analysis technology for supply-side users to support solution development. Moreover, this role benefits from the ecosystem by receiving domain-specific requirements and feedback from their customers and partners to further improve their market offerings and stay competitive.

| from \ to | Machine user | Maintenance operator | Machine supplier | Data routine analyst | Data analysis innovator | Platform provider | Technology provider |
|---|---|---|---|---|---|---|---|
| **Machine user** | Data as supplement | Data for maintenance support | Data for product/service improvement | Data for solution development | Data for method enhancement | Customership | Domain requirements/ feedback |
| **Maintenance operator** | Maintenance support | Partnership | Knowledge transfer | Supplementary maintenance data | Supplementary maintenance data | Customership | Domain requirements/ feedback |
| **Machine supplier** | Improved products/ services | Knowledge transfer | Partnership | Data for solution development | Data for method enhancement | Customership | Domain requirements/ feedback |
| **Data routine analyst** | Solution for industrial operation support | Solution for maintenance support | Solution for product/service support | Partnership | Partnership | Complementary analytics services | Data analysis demands/ feedback |
| **Data analysis innovator** | Solution for industrial operation support | Solution for maintenance support | Solution for product/service support | Knowledge transfer | Partnership | Complementary analytics service/Innovation | Innovation demands/ feedback |
| **Platform provider** | Platform for analytical solution consumption | Platform for analytical solution consumption | Platform for analytical solution consumption | Platform for solution delivery | Platform for knowledge transfer | Partnership | Platform for technology distribution |
| **Technology provider** | Enabling technology for data handling | Enabling technology for data handling | Enabling technology for data handling | Enabling technology for data analytics | Enabling technology for data analytics | Platform-integrated technology | Partnership |

**Table 3. Conceptual Role-Relationship Model for Maintenance Analytics Ecosystems**

## Discussion & Future Research

Roles and relationships are crucial for the design of ecosystems as they describe their pivotal components (Schreieck et al. 2016). Therefore, our preliminary results with the proposed RRM provide a valuable basis for researchers and practitioners. One the one hand, it offers an overview to capture the different MA actors involved with their individual interests, functions and interaction relations. On the other hand, it helps to better understand and actively leverage the resulting synergy effects and opportunities for multi-lateral value creation. Thus, platform providers can use the results to consider elements that go beyond technological aspects, for example, to design governmental structures, such as role-specific rules and policies (Gröger 2018). Similarly, the results help to deliver new business model innovations, which have not evolved in the industry so far. This may include, for example, an open market place for trading data assets generated in industrial processes, where different participants can procure these resources for their individual interests.

IS scholars, on the other hand, can use the results to examine further platform-related issues, such as incentives and barriers that encourage or hamper individual roles to participate in open MA ecosystems.

Our findings are also subject to some limitations. First, the current results cannot be considered as fully exhaustive - especially with regard to the depicted relationships, as we only outlined higher prioritized exchange relationships while neglecting others, such as financial flows or secondary demand and supply-side relations. Thus, it is intended in future research to provide a more diffused and comprehensive presentation of all relationships. Second, despite the selection of four representative cases, the findings are still based on a small sample size, which is a general disadvantage of qualitative research. Nonetheless, more case studies are planned to either confirm the results or possibly identify further roles and relationships. Third, we acknowledge that some ecosystem scenarios (e.g., marketplaces for industrial data trading) appear somewhat illusionary, as we currently completely disregarded critical factors like data quality, integrity, security or sovereignty. Nonetheless, we are confident that such factors do not automatically mean to sacrifice th synergy effects of MA ecosystems. It is rather the responsibility of IS scholars and practitioners to develop suitable solutions to cope with such hurdles while ensuring all benefits for the participating ecosystem roles.

In future research, we will draw on the obtained findings and continue with the next steps as outlined in the research agenda (see Figure 1). In particular, the RRM forms the foundation for a conceptual design of a platform's architecture and governance model. Based on the relationships, it is possible, for example, to derive products and services as well as rules for cross-organizational cooperation. The design of the technical platform architecture is guided by the type of digital technology provided by the platform provider and the supply-side users, where a more detailed investigation is planned to determine the types and diversity of required technologies. Moreover, a thorough evaluation of the overall results is planned, consisting of demonstrative applications to case examples and interviews with experienced MA experts.

## References

Adner, R. 2017. "Ecosystem as Structure: An Actionable Construct for Strategy," *Journal of Management* (43:1), pp. 39–58.

Bangemann, T., Rebeuf, X., Reboul, D., Schulze, A., Szymanski, J., Thomesse, J.-P., Thron, M., and Zerhouni, N. 2006. "PROTEUS—Creating Distributed Maintenance Systems through an Integration Platform," *Computers in Industry* (57:6), pp. 539–551.

Benedict, M. 2018. "Modelling Ecosystems in Information Systems - A Typology Approach," in *Multikonferenz Wirtschaftsinformatik*.

Bock, M., Wiener, M., Gronau, R., and Martin, A. 2019. "Industry 4.0 Enabling Smart Air: Digital Transformation at KAESER COMPRESSORS," in *Digitalization Cases*, N. Urbach and M. Röglinger (eds.), Cham: Springer International Publishing, pp. 101–117.

Bousdekis, A., Magoutas, B., Apostolou, D., and Mentzas, G. 2018. "Review, Analysis and Synthesis of Prognostic-Based Decision Support Methods for Condition Based Maintenance," *Journal of Intelligent Manufacturing* (29:6), pp. 1303–1316.

Boyes, H., Hallaq, B., Cunningham, J., and Watson, T. 2018. "The Industrial Internet of Things (IIoT): An Analysis Framework," *Computers in Industry* (101), pp. 1–12.

Eisenmann, T. R., Parker, G., and Van Alstyne, M. W. 2008. "Opening Platforms: How, When and Why?," *SSRN Electronic Journal*.

Elattar, H. M., Elminir, H. K., and Riad, A. M. 2016. "Prognostics: A Literature Review," *Complex & Intelligent Systems* (2:2), pp. 125–154.

Frank, U. 2002. "Multi-Perspective Enterprise Modeling (MEMO) Conceptual Framework and Modeling Languages," in *Hawaii International Conference on System Sciences*.

Gawer, A. 2014. "Bridging Differing Perspectives on Technological Platforms: Toward an Integrative Framework," *Research Policy* (43:7), pp. 1239–1249.

Gregor, S., and Hevner, A. R. 2013. "Positioning and Presenting Design Science Research for Maximum Impact," *MIS Quarterly* (37:2), pp. 337–356.

Gröger, C. 2018. "Building an Industry 4.0 Analytics Platform: Practical Challenges, Approaches and Future Research Directions," *Datenbank-Spektrum* (18:1), pp. 5–14.

Guth, J., Breitenbücher, U., Falkenthal, M., Fremantle, P., Kopp, O., Leymann, F., and Reinfurt, L. 2018. "A Detailed Analysis of IoT Platform Architectures: Concepts, Similarities, and Differences," in *Internet of Everything*, B. Di Martino, K.-C. Li, L. T. Yang, and A. Esposito (eds.), Springer, pp. 81–101.

Hausladen, I., and Bechheim, C. 2004. “E-Maintenance Platform as a Basis for Business Process Integration,” in *IEEE International Conference on Industrial Informatics*, pp. 46–51.

Hodapp, D., Remane, G., Hanelt, A., and Kolbe, L. M. 2019. “Business Models for Internet of Things Platforms: Empirical Development of a Taxonomy and Archetypes,” in *International Conference on Wirtschaftsinformatik*.

Horn, R., and Zschech, P. 2019. “Application of Process Mining Techniques to Support Maintenance-Related Objectives,” in *International Conference on Wirtschaftsinformatik*.

Huber, S., Wiemer, H., Schneider, D., Ihlenfeldt, S. 2019. “DMME: Data Mining Methodology for Engineering Applications - Holistic Extension to the CRISP-DM Model,” *Procedia CIRP* (79), pp. 403-408.

Iung, B., Levrat, E., Marquez, A. C., and Erbe, H. 2009. “Conceptual Framework for E-Maintenance: Illustration by e-Maintenance Technologies and Platforms” *Annual Reviews in Control* (33:2), pp. 220-229.

Kaggle. 2019. “Kaggle: Your Home for Data Science.” (https://www.kaggle.com/, accessed April 25, 2019).

Kaisler, S. H., Espinosa, J. A., Armour, F., and Money, W. H. 2014. “Advanced Analytics - Issues and Challenges in a Global Environment,” in *Hawaii International Conference on System Sciences*.

Kiel, D., Arnold, C., Voigt, K.-I. 2017. “The Influence of the Industrial Internet of Things on Business Models of Established Manufacturing Companies: A Business Level Perspective,” *Technovation* (68), pp. 4–19.

Lade, P., Ghosh, R., and Srinivasan, S. 2017. “Manufacturing Analytics and Industrial Internet of Things,” *IEEE Intelligent Systems* (32:3), pp. 74–79.

Lasi, H., Fettke, P., Kemper, H.-G., Feld, T., and Hoffmann, M. 2014. “Industry 4.0,” *Business & Information Systems Engineering* (6:4), pp. 239–242.

Levrat, E., and Iung, B. 2007. “TELMA: A Full e-Maintenance Platform,” in *World Congress on Engineering Asset Management and International Conference on Condition Monitoring*, pp. 11–14.

Levrat, E., Iung, B., and Crespo Marquez, A. 2008. “E-Maintenance: Review and Conceptual Framework,” *Production Planning & Control* (19:4), pp. 408–429.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., and Byers, A. H. 2011. *Big Data: The next Frontier for Innovation, Competition, and Productivity*, McKinsey Global Institute.

Mikalef, P., Giannakos, M. N., Pappas, I. O., and Krogstie, J. 2018. “The Human Side of Big Data: Understanding the Skills of the Data Scientist in Education and Industry,” in *IEEE EDUCON*, pp. 503–512.

Muchiri, P., Pintelon, L., Gelders, L., and Martin, H. 2011. “Development of Maintenance Function Performance Measurement Framework and Indicators,” *International Journal of Production Economics* (131:1), pp. 295–302.

Muller, A., Crespo Marquez, A., and Iung, B. 2008. “On the Concept of E-Maintenance: Review and Current Research,” *Reliability Engineering & System Safety* (93:8), pp. 1165–1187.

Nischak, F., Hanelt, A., and Kolbe, L. M. 2017. “Unraveling the Interaction of Information Systems and Ecosystems - A Comprehensive Classification of Literature,” in *International Conference on Information Systems*.

Österle, H., Becker, J., Frank, U., Hess, T., Karagiannis, D., Krcmar, H., Loos, P., Mertens, P., Oberweis, A., and Sinz, E. J. 2011. “Memorandum on Design-Oriented Information Systems Research,” *European Journal of Information Systems* (20:1), pp. 7–10.

Peffers, K., Tuunanen, T., Rothenberger, M. A., Chatterjee, S. 2007. “A Design Science Research Methodology for Information Systems Research.,” *Journal of Management Information Systems* (24:3),pp. 45–77.

Schreieck, M., Wiesche, M., and Krcmar, H. 2016. “Design and Governance of Platform Ecosystems - Key Concepts and Issues for Future Research,” in *European Conference on Information Systems*.

Schumann, C., Zschech, P., and Hilbert, A. 2016. “Das aufstrebende Berufsbild des Data Scientist: Vom Kompetenzwirrwarr zu spezifischen Anforderungsprofilen,” *HMD Praxis der Wirtschaftsinformatik* (53:4), pp. 453–466.

Tiwana, A., Konsynski, B., and Bush, A. A. 2010. “Platform Evolution: Coevolution of Platform Architecture, Governance, and Environmental Dynamics,” *Information Systems Research* (21:4), pp. 675–687.

Weking, J., Stöcker, M., Kowalkiewicz, M., Böhm, M., and Krcmar, H. 2018. “Archetypes for Industry 4.0 Business Model Innovations,” in *Americas Conference on Information Systems*.

Yin, R. K. 2014. *Case Study Research - Design and Methods*, Los Angeles, CA: Sage.

Zschech, P. 2018. “A Taxonomy of Recurring Data Analysis Problems in Maintenance Analytics,” in *European Conference on Information Systems*.

Zschech, P., Heinrich, K., Bink, R., and Neufeld, J. S. 2019. “Prognostic Model Development with Missing Labels: A Condition-Based Maintenance Approach Using Machine Learning,” *Business & Information Systems Engineering* (61:3).

# J. Paper 9 - Sustainability of E-Health-Projects

| **Title** | **Sustainability of E-Health-Projects** |
|---|---|
| **Title (German)** | **Nachhaltigkeit von E-Health-Projekten** |
| Authors | Hannes Schlieter (hannes.schlieter@tu-dresden.de)<br>Martin Benedict (martin.benedict@tu-dresden.de)<br>Martin Burwitz (martin.burwitz@tu-dresden.de) |
| Publication | S. Müller-Mielitz, T. Lux (eds.) E-Health-Ökonomie. Springer Gabler, Wiesbaden: 99 - 116. |
| Available at | `https://link.springer.com/chapter/10.1007/978-3-658-10788-8_6` |
| Full-Text at | `https://books.google.de/books?hl=de&lr=&id=4MaSDQAAQBAJ&oi=fnd&pg=PA97` |


### *Abstract*

The use of information and communication technology in healthcare, so called eHealth technologies, promises to improve the provision of healthcare services in terms of efficiency and quality. However, the perpetuation of these technologies in the field of inter-sectoral care stays behind this promise. Projects did not reach a sufficient maturity to be translated into routine care. One reason is the lack of a sustainable infrastructural foundation for the creation of digitized healthcare business models. eHealth platforms and surrounding ecosystems can provide such infrastructural foundation. Addressing this gap, the paper questions the dimensions of eHealth sustainability and proposes the implementation of digital ecosystems as measure for business model perpetuation. The paper contributes by providing a framework for the evaluation open platforms in healthcare and proposes objectives and criteria as well as evaluation measures for technological, logical and organisational aspects of platform openness.

# K. Paper 10 - ISO 11354-2 for the Evaluation of eHealth-Platforms

| Title | ISO 11354-2 for the Evaluation of eHealth-Platforms |
|---|---|
| Authors | Martin Benedict (martin.benedict@tu-dresden.de)<br>Hannes Schlieter (hannes.schlieter@tu-dresden.de)<br>Martin Burwitz (martin.burwitz@tu-dresden.de)<br>Werner Esswein (werner.esswein@tu-dresden.de) |
| Publication | Proceedings of Pacific Asia Conference on Information Systems 2016, PACIS 2016, Chiayi, Taiwan, June 27 - July 1, 2016. |
| Available at | `https://aisel.aisnet.org/pacis2016/23/` |
| Full-Text at | `https://www.researchgate.net/publication/303944459_ISO_11354-2_for_the_Evaluation_of_eHealth_Platforms` |


### *Abstract*

Open software platforms are a recent innovation in the healthcare sector to foster integrated care scenarios. An important quality feature to facilitate innovation and to create an active platform ecosystem is openness. The openness is strongly influenced by the interoperability potential of the platforms. Hence, the assessment of the interoperability potential is a crucial task for evaluating the quality of platforms. However, there is a need for methodological support fostering the evaluation of eHealth platforms. Based on a design science research approach, the article shows, how the Maturity Model for Enterprise Interoperability (ISO 11353-2) can be instantiated in the healthcare domain. We describe a quantitative evaluation model which operationalizes the evaluation process of eHealth platforms. The contribution purposes to improve the transparency and reliability of the evaluation process. Furthermore, the introduced approach reduces the dependence on an evaluation team and facilitates the implementation of assessments.