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Christoph Peters

Modularization of Services

A Modularization Method for the Field of Telemedicine

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Prof. Dr. Jan Marco Leimeister

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Christoph Peters

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Co-Supervisor: Prof. Dr. Tilo Böhmann
Co-Supervisor: Prof. Dr. Helmut Krcmar

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Preface

The digital transformation changes how we work, live, communicate, and interact. In the health sector, telemedicine is one paragon for this phenomenon.

On the one hand, the development of telemedical services is of high relevance on a global scale, considering aspects such as security of supply, spatial distribution, and demographic development. On the other hand, it is also highly complex due to difficulties related to the state of development in service engineering, characteristics of the health care system, and the general integration of IT and communication technologies into engineering and the generation of knowledge-intense and person-oriented services as well as the inclusion of medical devices.

Dr. Christoph Peters presents an adequate solution for the design and provision of telemedical services which are both, efficient and customer-centric. It outlines a systematic approach for the modularization of telemedical services: the SMART method.

Following a design science research approach, this method was iteratively designed and evaluated. Thereby, the three overarching research questions could be answered successfully, addressing the requirements elicitation, the design and the evaluation of the method. The method is not only suitable for the modularization of telemedical services, its application also shows the intended effects, e.g., higher efficiencies due to reuse of service modules.

Dr. Christoph Peters' findings are of high relevance for practice and research. He is able to illustrate very clearly the overall picture of telemedical and personal services as well as the SMART method for the application domain. Dr. Peters condenses very persuasively the state of research, his own overall approach, and the single components, as well as the evaluation of several services. His work shows the great innovative potential of connecting modularization theories and methods with elements from service research and information systems research for sustainable, resource-friendly, and more efficient telemedical services. Suppliers of such IT-supported health services may systematically leverage these potentials using the SMART method and the overall approach.

The SMART method is the core of this dissertation. The development of SMART resulted from several interactions and it has been applied in twenty services, thus demonstrating great potential to significantly enhance scientific discussion.

With his work, Dr. Peters reaches new research-related ground and provides significant suggestions for the scientific discussion, the practical implementation in the context of service modularization, as well as service research in the telemedicine field.

My best wishes for Dr. Christoph Peters' work and its due distribution throughout science and practice.

Prof. Dr. Jan Marco Leimeister

Acknowledgements

By means of this dissertation, I am very pleased to present a contribution in the area of telemedical services. Having fascinated me from the very beginning of my research career, the field of telemedicine motivated me throughout the entire dissertation process.

The journey is the destination.

On my thesis journey, I particularly enjoyed working at the intersection of IT and health, service research, and method design. As design-oriented information systems researcher with a business informatics background, I constantly conceived of technically solid solutions that are economically feasible and sustainable, as well as socially desirable and relevant. It makes me happy to be able to accordingly contribute with the core of my dissertation, the SMART method - a modularization method for telemedical services. At this point, I would like to take the opportunity and thank everyone who supported me during my doctoral stopover.

My thanks go to

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All my friends, especially Dirk and Tanja Kilb and Fabian Hefner, for the distraction in my leisure time making these years a pleasure,

My grandmother, for sharing and discussing values and for her support,

My brother, for always expecting the best results and for asking the important questions,

My parents, for all their love, for always supporting me and for being very honest and proud!

Zusammenfassung

Die Erstellung und Erbringung telemedizinischer Dienstleistungen, die sowohl effizient als auch nutzerzentriert sind, stellt eine große Herausforderung in diesem so vielversprechenden Feld der Telemedizin dar. Diese Dissertation präsentiert einen adäquaten Lösungs- und Umsetzungsvorschlag, indem sie einen systematischen Ansatz zur Modularisierung von Telemedizin-Dienstleistungen vorstellt: die Modularisierungsmethode SMART.

Einer gestaltungsorientierten Vorgehensweise folgend, wurde diese Methode in mehreren Iterationen entwickelt und evaluiert. Es konnte gezeigt werden, dass die drei leitenden Forschungsfragen dieser Dissertation, die die Anforderungen an eine solche Methode, deren Gestaltung sowie deren Evaluation untersuchen, erfolgreich beantwortet werden konnten. Die Methode eignet sich zur Modularisierung von telemedizinischen Dienstleistungen und ihre Anwendung erzielt die gewünschten Effekte, bspw. höhere Effizienz durch nachweisbar hohe Wiederverwendung von Dienstleistungsmodulen.

Die Dissertation liefert mehrere theoretische Beiträge. Neben der Gestaltung, Anwendung und Evaluierung der Modularisierungsmethode als einem Artefakt im Sinne der gestaltungsorientierten Forschung wird auch eine Modellierungstechnik vorgestellt, die sich für telemedizinische Dienstleistungen eignet. Außerdem wird eine Konzeptualisierung von Dienstleistungsmodulen vorgestellt, die insbesondere auch eine Abgrenzung zu Dienstleistungen und Dienstleistungsprozessen umfasst. Darüber hinaus werden Modularisierungsparameter und Metriken zur Messung von Modularisierungseffekten eingeführt. Dabei wird auch die Perspektive des Dienstleistungssystems beleuchtet, in dem Anbieter und andere Akteure die Telemedizin-Dienstleistungen gemeinsam schaffen.

Der praktische Beitrag dieser Arbeit basiert insbesondere auf der SMART Methode und ihrer Anwendung. Telemedizin-Anbieter werden durch die Erkenntnisse dieser Dissertation dazu befähigt, systematisch ihre Dienstleistungen zu modularisieren und diese somit effizient und nutzerzentriert im Dienstleistungssystem Telemedizin anzubieten. Dabei geht die Dissertation detailliert auf Dienstleistungen ein, bei denen das Zusammenspiel von IT-Dienstleistungen und personenorientierten Dienstleistungen entscheidend ist.

Die Dissertation geht außerdem auf die mögliche Weiterentwicklung der vorgestellten Artefakte ein und diskutiert zukünftige Forschungsaktivitäten, die die Entwicklung der Telemedizin, Modularisierungspotentiale in anderen Bereichen, das Gestalten von Dienstleistungssystemen sowie den Zusammenhang zwischen Digitalisierung und Dienstleistungsforschung adressieren. Auf diese Weise leistet diese Dissertation auch einen Beitrag für alle personenorientierten Bereiche, die sich digitalem Wandel und digitalen Transformationen stellen.

Stichworte: Dienstleistungsmodularisierung, Modularisierungsmethode, Telemedizin, Dienstleistungssystem, Dienstleistungsforschung

Abstract

The design and provision of telemedical services which are both, efficient and customer-centric, constitute a huge challenge in the promising field of telemedicine. This dissertation presents an adequate solution. It outlines a systematic approach for the modularization of telemedical services: the SMART method.

Following a design science research approach, this method was iteratively designed and evaluated. Thereby, the three overarching research questions could be answered successfully. They address the requirements elicitation, the design, and the evaluation of the method. The method is not only suitable for the modularization of telemedical services, its application also confirms the intended effects, e.g., higher efficiencies due to the reuse of service modules.

This dissertation provides several theoretical contributions. As a design science research artifact, it presents the SMART method, its design, application, and evaluation. Also, it outlines a modeling technique that is tailored to the needs of the field of telemedicine. Furthermore, a conceptualization of service modules is provided which allows for the delimitation to services and services processes. In addition to the introduction of modularization parameters and metrics for the measurement of modularization effects, a system perspective is considered. Thus, this dissertation sheds light on service system telemedicine and its participants.

The application of the SMART method represents the key practical contribution of this thesis. Based on this dissertation, service providers from the field of telemedicine are able to modularize their services and thus, they are enabled to design and provide their services in an efficient and user-centric fashion. While doing so, this dissertation explicitly addresses services that comprise a combination of person-oriented services and IT services.

Future research implications are outlined and comprise activities that address further developments of the designed artifacts, developments of the telemedicine sector, modularization potentials in other areas, service systems engineering as well as the interconnectedness of digitization and service research. Thereby, this dissertation also contributes to all person-oriented fields that face digital transformations.

Keywords: Service Modularization, Modularization Method, Telemedicine, Service System, Service Research

Table of Contents

Preface V

Acknowledgements VII

Zusammenfassung IX

Abstract XI

List of Tables XIX

List of Figures XX

List of Abbreviations XXI

1 Introduction and Motivation 1

2 Research Methodology 4

3 Theoretical Foundations 8

3.1 Services and Service Systems 8

3.2 Modularization 10

3.3 Methods 11

4 Telemedicine 13

5 Overview of the Main Dissertation Results 15

5.1 The SMART Method 15

5.2 BTPM Modeling Technique 15

5.3 Service Modularization and Digitization in the Health Sector 16

5.4 Status Quo of Telemedicine from a Service Perspective 17

6 Overview of Publications included in the Dissertation 18

7 Engineering Knowledge-Intense, Person-Oriented Services – A State of the Art Analysis 27

7.1 Introduction 27

7.2 What makes KIPO Services Different? 29

7.2.1 Definition of Services 29

7.2.2 Characteristics of KIPO Services 30

7.3 Analyzed Aspects 33

7.4 Analyzed Literature ... **35**
7.5 Results: Comparison of Existing SE Approaches ... **36**
7.6 Discussion ... **39**
7.7 Limitations and Conclusion ... **42**
7.8 References ... **42**
8 Towards a Typology for Telemedical Services ... **49**
8.1 Introduction ... **49**
8.2 Related Work ... **50**
8.3 Research Approach ... **53**
8.4 The TMS Typology ... **54**
8.5 Applying the Typology ... **57**
8.6 Discussion and Conclusion ... **58**
8.7 References ... **59**
9 Towards Modularization of Complex Services – A Systematic Literature Review on Modularization Methods ... **60**
9.1 Introduction ... **60**
9.2 Foundations ... **63**
9.2.1 Modularization ... 63
9.2.2 Methods ... 64
9.3 Research Method ... **65**
9.3.1 Analyzed Aspects ... 65
9.3.2 Systematic Literature Review ... 68
9.4 Results ... **70**
9.5 Discussion ... **73**
9.6 Limitations and Future Research ... **76**
9.7 Conclusion and Outlook ... **77**
9.8 References ... **79**
9.9 Appendix ... **87**

10 TM³ - A Modularization Method for Telemedical Services: Design and Evaluation 91

10.1 Introduction 91

10.2 Related Work 93

10.3 Research Design and Method Criteria 94

10.4 The Method and its Phases 95

10.4.1 Phase 1: Status Capturing 96
10.4.2 Phase 2: Decomposition 96
10.4.3 Phase 3: Matrix Generation 97
10.4.4 Phase 4: Interface Specification 99
10.4.5 Phase 5: Testing 99

10.5 Method Application 100

10.5.1 Status Capturing 100
10.5.2 Decomposition 100
10.5.3 Matrix Generation 102
10.5.4 Interface Specification 103
10.5.5 Testing 103

10.6 Criteria-based Evaluation 103

10.7 Limitations and Future Research 104

10.8 Conclusion and Expected Contribution 105

10.9 Acknowledgements 105

10.10 References 106

11 Blueprint-driven Telemedicine Process Modeling - The Interdisciplinary Development and Evaluation of a Modeling Technique for Telemedical Services 116

11.1 Introduction and Related Work 117

11.2 Domain Background 118

11.3 Requirements 119

11.4 Methodology 120

11.5 Research Setting 121

11.5.1 The Iterations ... 122
11.5.2 The Five-phase AR Cycles ... 123

11.6 Results ... 124

11.6.1 Cycle 1: BTPM and its Characteristics ... 124
11.6.2 Cycle 2: Learning Experiences ... 127

11.7 Proof-of-Concept ... 127

11.8 Evaluation ... 130

11.9 Limitations and Future Research ... 130

11.10 Contribution ... 131

11.11 References ... 132

12 Together They are Strong - The Quest for Service Modularization Parameters ... 135

12.1 Introduction ... 135

12.2 Background ... 137

12.2.1 Service Modularization ... 137
12.2.2 Modularization Principles ... 137
12.2.3 Complex Services and Domain Specifics ... 138
12.2.4 The Field of Telemedicine ... 138

12.3 Modularization Parameters ... 139

12.4 Research Setting ... 140

12.4.1 Research Design ... 141

12.5 Findings so Far and Preliminary Conclusion ... 145

12.6 Expected Contribution and Future Research ... 146

12.7 Acknowledgements ... 146

12.8 References ... 146

13 Service Modularization in Service Systems - Supporting Service Design, Customization, and Provisioning with the SMART Method ... 151

13.1 Introduction and Motivation ... 152

13.2 Related Work ... 153

13.2.1 Service Systems ... 153
13.2.2 Modularization ... 154
13.2.3 Services – Service Processes – Service Modules ... 156
13.2.4 Service Systems in Healthcare – Telemedicine and Telemonitoring ... 157
13.3 Research Methodology ... 158
13.4 The Method and its Phases ... 159
13.4.1 Phase 1: Status Capturing ... 160
13.4.2 Phase 2: Decomposition ... 160
13.4.3 Phase 3: Matrix Generation ... 161
13.4.4 Phase 4: Interface Specification and Testing ... 165
13.4.5 Phase 5: Effect Elicitation ... 166
13.5 Application in the Telemonitoring Sector ... 166
13.5.1 Phase 1: Status Capturing ... 167
13.5.2 Phase 2: Decomposition ... 167
13.5.3 Phase 3: Matrix Generation ... 169
13.5.4 Phase 4: Interface Specification and Testing ... 173
13.5.5 Phase 5: Effect Elicitation ... 174
13.6 Further Evaluation and Discussion ... 176
13.7 Limitations and Future Research ... 180
13.8 Contribution, Conclusion, and Managerial Implications ... 183
13.9 References ... 185
14 Theoretical Contribution ... 193
14.1 The Modularization Method ... 193
14.2 The BTPM Technique ... 194
14.3 Conceptualization of Service Modules ... 195
14.4 Modularization Parameters ... 195
14.5 Metrics for Service Modularization ... 196
14.6 Service Providers in Service System Telemedicine ... 196
15 Practical Contribution ... 197
16 Limitations ... 200

17 Implications for Future Research ... 202
17.1 Redevelopment of Artifacts ... 202
17.2 Modularization in other Contexts ... 203
17.3 Service Systems, Service Portfolios, and Architecture ... 203
17.4 Developments in the Field of Telemedicine ... 205
17.5 The Interplay of Digitization and Services ... 205
Complete List of References ... 207
Complete List of Publications ... 223

List of Tables

Table 1.1: Research Questions 2
Table 2.1: Design-Science Research Guidelines 4
Table 6.1: Publications Included in the Dissertation 18
Table 7.1: Comparison of the Analyzed Approaches 39
Table 8.1: Typology’s Application using Exemplary TMSs 58
Table 9.1: Search Results 69
Table 9.2: Relevant Articles Retrieved through Review Papers 70
Table 9.3: Results of the SLR - Assessment of MM dealing with Services using the Analysis Framework 72
Table 9.4: Overall Results of the SLR - Assessment using the Analysis Framework. 90
Table 11.1: List of Requirements 120
Table 11.2: List of Met Requirements 130
Table 13.1: Research Methodology following the DSRM Activities 159
Table 13.2: Modularization Parameters: Rules for the Pair-wise Assessment of Service Processes 164
Table 13.3: Overview of SMART Statistics for Module Strength = 1 174
Table 13.4: Overview of SMART Statistics for Module Strength = 2 175
Table 13.5: Overview of SMART Statistics for Module Strength = 3 175

List of Figures

Figure 1.1: Structure of the Dissertation 3
Figure 2.1: Information Systems Research Framework 5
Figure 2.2: DSRM Process Model 6
Figure 3.1: Services, Service Processes, Service Modules and Modular Services and their Interdependencies 9
Figure 8.1: Graphical Representation of the Telemedicine Typology 51
Figure 8.2: Dimensions of the Telemedicine Typology 54
Figure 10.1: Overview of TM³ with its According Phases, Activities and Resulting Artifacts 95
Figure 10.3: Three Dependency Matrices of chosen Modularity Parameters and their Accumulated Dependency Matrix 102
Figure 11.1: AR Cycle 122
Figure 11.2: Overview of BTPM and Characteristic Features 126
Figure 11.3: Activities of the Patient within the Telemonitoring Service, Including Interfaces to other Pools 129
Figure 12.1: Modularization Method and Phases 140
Figure 12.2: Overview of Evaluation Workshops 141
Figure 13.1: Services, Service Processes, Service Modules and Modular Services and their Interdependencies 156
Figure 13.2: Overview of SMART with its According Phases, Activities, and Resulting Artifacts 160
Figure 13.3: Exemplary Service Process Map Modeled with BTPM 168
Figure 13.4: Matrices for each Modularization Parameter and the Resulting Accumulated Matrix 170
Figure 13.5: Visualization of the Accumulated Matrix of an Exemplary Service and the Created Module 171
Figure 13.6: Service Module “Adaption” and its Service Processes 172
Figure 13.7: Service Module “Data Exchange” and its Service Processes 172
Figure 13.8: Service Module “Measurement” and its Service Processes 173
Figure 13.9: The Modularization Continuum and Module Strengths 178

List of Abbreviations

ACM	Association for Computing Machinery
AISLIB	Association of Information Systems Library
AR	Action Research
BPMN	Business Process Model and Notation
BSBM	Business Service Blueprinting Modeling
BTPM	Blueprint-driven Telemedicine Process Modeling
CEO	Chief Executive Officer
COPD	Chronic Obstructive Pulmonary Disease
DSR	Design Science Research
DSRM	Design Science Research Methodology
EPC	Event-driven Process Chains
FMEA	Failure Mode and Effects Analysis
HS	Holistic Service
ICT	Information and Communication Technology
IEEE	Institute of Electrical and Electronics Engineers
IS	Information Systems
IT	Information Technology
KIPO	Knowledge-Intense, Person-Oriented
ME	Method Engineering
MM	Modularization Method
NSD	New Service Development

PACS	Picture Archiving and Communication System
QFD	Quality Function Deployment
RQ	Research Question
SCORE	System Components, Operations, Results, Engagement
SE	Service Engineering
SMART	Service ModulARizaTion
SOA	Service Oriented Architecture
TM³	TeleMedicine Modularization Method
TMS	Telemedical Service
TRIZ	Theory of Inventive Problem Solving
UML	Unified Modeling Language
VHB	German Academic Association for Business Research (Verband der Hochschullehrer für Betriebswirtschaft e.V.)

1 Introduction and Motivation

Telemedicine is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed 2011). The global market for such telemedicine services (TMSs) is expected to grow from $9.8 billion in 2010 to $23 billion in 2015 (BCC Research 2011) and 43.5 billion in 2019 (BCC Research 2014). TMSs comprise a very heterogeneous market in terms of both, stakeholders and offered services.

TMS providers face the challenge to deliver their services in a fast-growing market in which not only pace and technical advancements constitute obstacles, but also an according flexibility to provide customer-centric, “tailored” services to a heterogeneous range of customers. When trying to cope with these challenges, considering the characteristics of TMSs is important: they always comprise a combination of person-oriented services and IT services. In such a complex environment, modularization is supposed to enable TMS providers to develop, (re-) configure and manage their service offerings within their overall service portfolio in an efficient manner while implementing customer centricity. As each patient requires various needs resulting from different life situations, state of disease, insurance coverage, etc., modularization offers the possibility to mass-customize individual offerings, allowing individually configured (“tailored”) service offerings and optimal treatment at reasonable cost (Peters and Menschner 2012), since all but only the modules the patient needs or has chosen are integrated. In this context, TMS providers strive to leverage modularization potentials such as reuse, faster development, module-wide innovation, and rapid reconfiguration (Böhmann and Krcmar 2006).

To assist TMS providers in this endeavor, this thesis presents a method that allows for a systematic step-by-step modularization of TMSs – the SMART method. Thereby, it adheres to design science research guidelines (Hevner, March et al. 2004; Gregor and Jones 2007). The main theoretical contribution of this thesis is a modularization method (MM) for TMSs that will enable telemedicine providers to modularize their services in order to offer customer-centric and tailored TMSs in an efficient manner. According to Gregor (2006), this is a theoretical contribution of the type of theory of design and action.

In order to do design and evaluate this method, the thesis is based on three overarching research questions. These research questions (RQs) follow the logical structure of the design science research setting in this thesis. They represent the requirements, design, and evaluation of the artifact. Each of these RQs consists of a subset of other RQs and all publications in this thesis contribute by answering one or more of them. An overview of the RQs is provided in Table 1.1.

Requirements	RQ1:	What are requirements for modularization at the TMS provider's side?
	a)	What are TMSs and what makes them specific?
	b)	Which challenges do TMS providers face?
Design	RQ2:	How can TMSs be modularized in a systematic way?
	a)	Are there existing MMs (also from other domains) which consider the elicited requirements at the service provider side?
	b)	Which phases and activities does a MM for TMSs involve?
Evaluation	RQ3:	Is the newly developed method suitable to enable the modularization of TMSs by TMS providers?
	a)	Is the MM applicable in practice?
	b)	What are the benefits of using this new MM?

Table 1.1: Research Questions
Source: own illustration

After the topic of this thesis and its motivation are presented in this first chapter, the research methodology follows (chapter 2). Then, theoretical foundations of this thesis are illustrated, i.e., foundations on services and service systems, on modularization, and on methods (chapter 3). Telemedicine is introduced as the field examined in this thesis (chapter 4), before the main dissertation results are presented (chapter 5). Afterwards, an overview of the publications included in this dissertation is given (chapter 6). This part constitutes the first part of the wrapper which embraces the seven publications (chapters 7-13). In the second part of the wrapper, theoretical contributions (chapter 14) as well as practical contributions (chapter 15) are outlined before limitations of this dissertation are addressed (chapter 16). In the last chapter of this thesis (chapter 17), implications for future research are presented. The overall structure of this thesis is depicted in Figure 1.1.

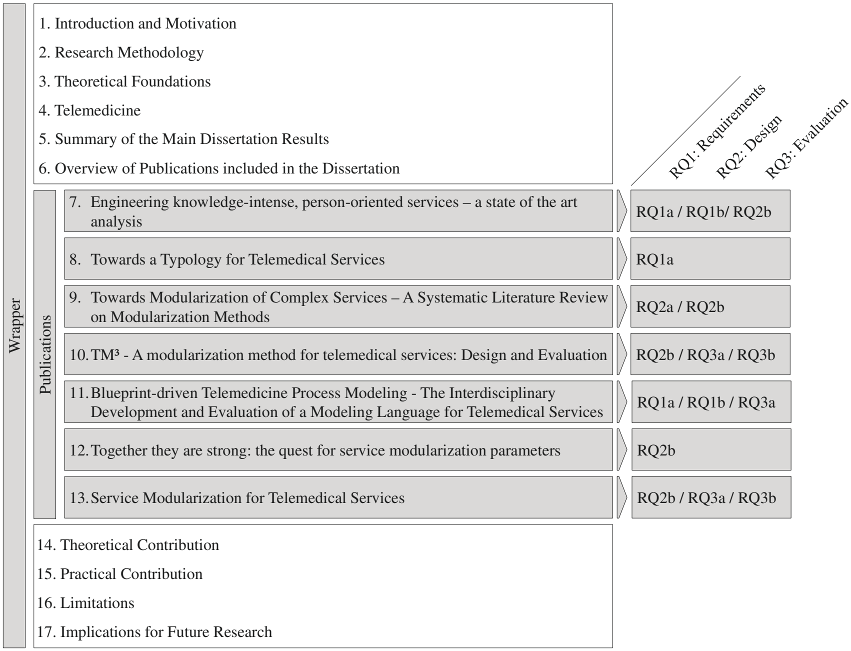

Figure 1.1: Structure of the Dissertation
Source: own illustration

2 Research Methodology

This thesis adheres to design science research guidelines (Hevner, March et al. 2004; Gregor and Jones 2007), which aim to develop solutions to organizational and business problems through design and evaluation of novel artifacts. These guidelines are presented in Table 2.1.

Guideline	Description
Guideline 1: Design and Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.
Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, design foundations, and or design methodologies.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.
Guideline 6: Design as a Search Process	The search of an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.

Table 2.1: Design-Science Research Guidelines
Source: Hevner, March et al. (2004)

To achieve this, design science research focuses on the creation of innovative and purposeful artifacts for a specified problem domain. Such artifacts include not only new constructs or prototypes, but also new methods for their development. The SMART method as core contribution of this thesis is exactly such a method. The according artifacts can be understood as theories for design and action (Gregor 2006).

Design science is performed in an iterative way; generation/test cycles are therefore carried out repeatedly before leading to a solution (Simon 1996; Hevner, March et al. 2004).

An important aspect of design science research is its positioning in the Information Systems Research Framework visualized in Figure 2.1.

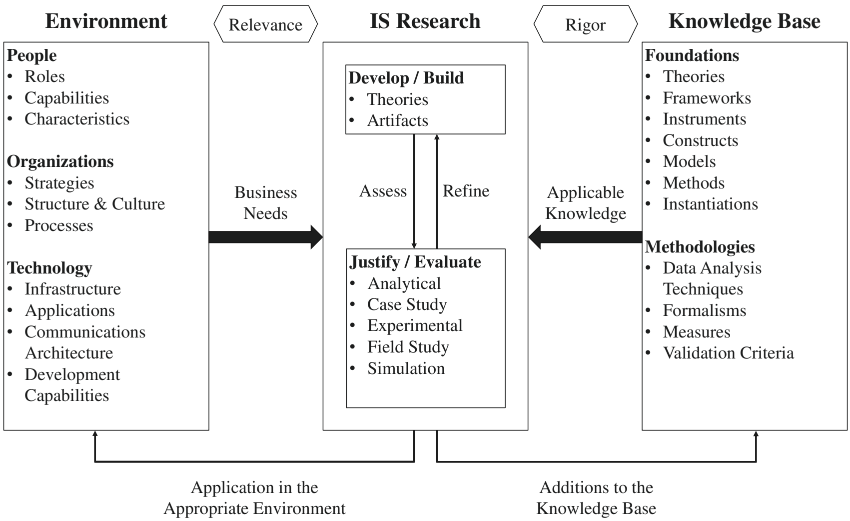

Figure 2.1: Information Systems Research Framework
Source: Hevner, March et al. (2004)

Performing build-and-evaluate cycles, design science research creates artifacts that should be relevant and rigorous. Thus, they need to be built and evaluated considering both the environment and its constituting people, as well as organizations and technologies; and the existing knowledge base comprising foundations and methodologies. This way, business needs and applicable knowledge are used for the design process which results in application of the artifacts in appropriate environments as well as additions to the knowledge base.

In this context, the different publications in this thesis need to be regarded as 1) one part of an overall design science project contributing to the SMART method, and 2) one single contribution, thereby following different kinds of research methods as well, e.g., systematic literature reviews or a combination of design science research and action research. As this section is intended to describe the overall research methodology, I refer to the corresponding research method sections of each individual publication for more detailed information, but want to outline the setting for the last publication here as it presents the SMART method and its design which is informed by all other publications.

Here, the design science research methodology by Peffers et al. (2007) is used following the guidelines defined by Hevner et al. (2004).

It consists of six activities to be conducted (Peffers, Tuunanen et al. 2007) as depicted in Figure 2.2:

1. Problem identification and motivation: The research problem and its importance are defined.
2. Objectives of a solution: The objectives of a solution need to be defined in order to guide the subsequent activities and to allow for the evaluation of the designed artifact.
3. Design and development: The actual solution is designed and developed.
4. Demonstration: The suitability of the designed solution to solve the targeted problem needs to be demonstrated.
5. Evaluation: The observations made in the demonstration step are analyzed regarding the suitability of the proposed solution. The evaluation results can be integrated in the next build-and-evaluate iteration of the artifact.
6. Communication: This comprises the publication of the result and its importance to relevant audiences from research and practice.

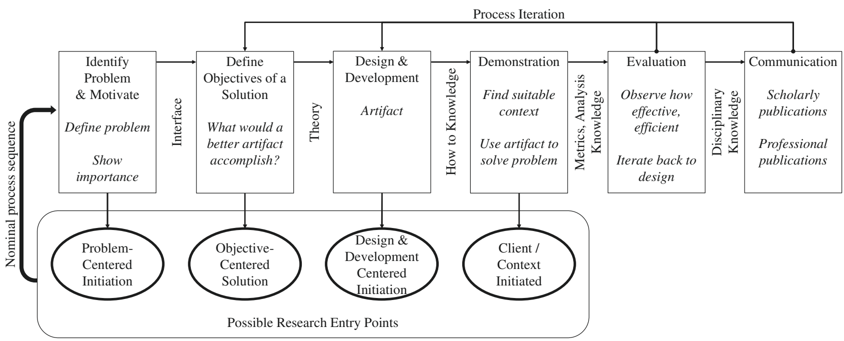

Figure 2.2: DSRM Process Model
Source: Peffers, Tuunanen et al. (2007)

The figure also shows several possible entry points which center around a problem, an objective, the design and development, or the client and context. In publication 7, the followed research process is problem-centered, meaning it is initiated by a problem definition. The problem definition has been derived from the need of service providers in the field to implement efficiency as well as user orientation during service provision. This was done in case studies that were conducted at the service provider site and inherit both, several interviews as well as documents and other materials from the provider. The according evaluation is conducted by means of a complementary evaluation method (Patton 2002) comprising criteria-based evaluation, evaluation by application, and evaluation by showing the artifacts' effects. The result is the SMART method, a design science research artifact that according to Gregor (2006) is a theoretical contribution of the type of design and action.

3 Theoretical Foundations

3.1 Services and Service Systems

A service itself is "(a set of) activities being part of interactions between the components of service systems" (Leimeister 2012). It is a complex phenomenon. Within service industries, more and more service come into existence that comprise a combination of both, IT and non-IT services, while the latter also integrate highly knowledge-intense, person-oriented (Menschner, Peters et al. 2011) and interactive parts as well. As an example for such services, the field of telemedicine is a paragon. These TMSs are further characterized by a large number of stakeholders (Georgi and Peters 2013), e.g., patients and their relatives, physicians, care personnel, service providers, technology manufacturers, or telecommunication companies.

All TMSs are provided in service systems. Maglio and Spohrer (2008) define service systems as "value-co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information (e.g., language, laws, measures, and methods)." Referring to them as ecosystems, Vargo and Lusch (2011) and Alter (2013) define service systems as "work systems producing a service". Given these various definitions, one can agree on the many-to-many service experiences (Chandler and Lusch 2015) service systems are based on.

These service experiences are made during the co-creation of services (Vargo and Lusch 2004; Vargo, Maglio et al. 2008). The path of co-creation is not simple or uni-faceted, but rather involves a "complex combination of activities and interactions between lead firms and network actors, characterized by both lead firm and network-based innovation" (Perks, Gruber et al. 2012) in which the service provider not only makes value propositions, but "can engage itself in customers' value fulfillment as well" (Grönroos 2008). When considering the magnitude of service system resources, their integration in the value co-creation process is critical. Here, the actors' resource integration should be "informed by both the value proposition and the service and social structures (with the dimensions of legitimation, domination, and signification) of the service system" (Edvardsson, Skålén et al. 2012).

TMSs are always part of these service systems. As IT and non-IT services are inherent to any TMS by definition, TMSs differ much in regards to their standardization and interface specification capabilities. That is why "innovative assembly of ICT as well as non-ICT resources” is needed (Srivastava and Shainesh 2015) in service systems. This call is answered in the publications of this dissertation.

In addition, I want to provide an overview of how I see the interdependency between four terms that are frequently used in the publications of this dissertation, namely: service, service process, service module, and modular service. This is visualized in Figure 3.1:

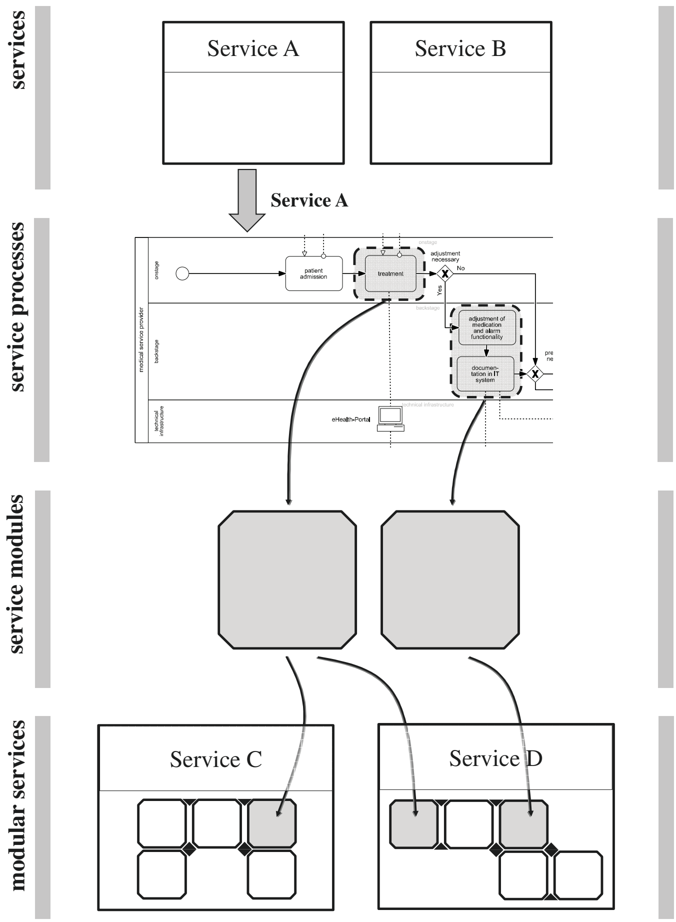

Figure 3.1: Services, Service Processes, Service Modules and Modular Services and their Interdependencies
Source: own illustration

All services can be decomposed into a set of service processes representing all activities for the conduction of the according service. Using systematic modularization, such a decomposed service can be used to create service modules that comprise service processes. For successful service modularization, these service modules are used to build modular services. It is exactly this terminology which underlies the logic of this dissertation in general and chapter 13 presenting the SMART method in particular.

3.2 Modularization

Modularization comprises the decomposition of one object into decoupled single components with specified interfaces that can be combined to create new single components (Böhmann and Krcmar 2006). First ideas go back to Parnas (1972), who postulated that decomposing systems into modules improves overall manageability, as not all (sub-) functions (of a module) need to be visible but can be hidden if the overall module function is clearly specified, i.e., information hiding.

Modularization rests upon the basic principles of cohesion and loose coupling (Balzert 1996). Cohesion describes the extent of intra-module dependencies. A high cohesion is a requirement for well-specified modules that can be reused and combined with other service modules. Loose coupling prescribes that there are only few inter-module dependencies between the elements of the different modules (Böhmann and Krcmar 2006). Thus, loose coupling relates to the independence of the modules. Modules serve a specific function (Schilling 2000) and are connected by interfaces which have to be specified appropriately (Ulrich 1995; Baldwin and Clark 1997).

The potentials of service modularization (Böhmann and Krcmar 2006) are manifold: (1) reuse – the repeated use of one specific module within different services; (2) faster development – the increase of overall development speed through higher manageability due to smaller objects of consideration (the modules) that have defined interfaces; (3) module-wide innovation – the possibility of concentrating innovation efforts within one strategically important module that is supposed to provide competitive advantages; (4) rapid reconfiguration – the efficient (re-) configuration of modules enabling a customer-centric service provision in a mass customization manner.

In the field of product development, applying modularization has a profound history that has been examined in management and organizational contexts for almost two decades (Baldwin and Clark 1997; Baldwin 2008). The building of a specific modularization theory has also been attempted (Schilling 2000).

Thus far, only few studies have dealt with service modularization (Voss and Hsuan 2009; Bask, Lipponen et al. 2010; de Blok, Luijkx et al. 2010; Tuunanen and Cassab 2011) in greater detail; the modularity of service process architectures has been examined (Frandsen 2012), modular design has been elicited as a viable strategy for coping with the complexity faced in service networks (Becker, Beverungen et al. 2013), and service modularity has been put into context with business model development (Rajahonka 2013) and customization (Rajahonka, Bask et al. 2013). While the concept and effects of service modularization have been elicited (Dörbecker and Böhmann 2013) and there have been attempts to consider service modularity and customization systematically (Bask, Lipponen et al. 2011), systematic modularization – as the act of identifying and forming modules – in the form of a repeatable method needs to be investigated further. This is exactly the gap which this thesis closes.

It is also crucial to understand that modularity or the extent of modularization (the measure of how much of the overall service is finally modular) might not be 100 percent for most services. The reason for this lies in the continuum between a fully integrated and a fully modularized service (Gershenson, Prasad et al. 2004), and thus modularity is always a relative measure. While first works have presented meaningful modularization measures for services (Dörbecker, Böhm et al. 2015), I believe that the thesis at hand, especially chapter 13, is the first scientific work that not only presents a method, the SMART method, as a powerful means for service modularization, but also measures its effectiveness with dedicated modularization measures such as the service module reuse rate.

3.3 Methods

According to Brinkkemper (1996), a method provides a detailed prescription of how to perform a collection of activities. The term method is closely related to method engineering (Brinkkemper 1996). Here, method refers to a particular procedure for attaining something (Odell 1996). A method is hence a process that is planned and systematic in terms of its mean and purpose (Braun, Wortmann et al. 2005). This understanding needs to be applied to modularization methods (MMs) as well. Characteristic features of methods include goal orientation (respectively the modularization of a TMS), a systematic approach (respectively the clear separation of activities in phases with dedicated resulting artifacts), and repeatability. The SMART method as core contribution of this thesis addresses these method features.

4 Telemedicine

All societies need healthcare services – truly an enormous market. Global expenditure on health care has reached $7.2 trillion (Deloitte 2015). In the last decade, great advancements have been realized, e.g., in the field of TMSs which constitutes the provision of medical services over geographical distances through the use of information and communication technology (DGTelemed 2011). TMSs have had enormous growth rates, e.g., the European market alone is expected to reach $5 billion by 2015 (European Commission 2014); globally, it is predicted to increase from $9.8 billion in 2010 to an expected $23 billion in 2015 (BCC Research 2011) and 43.5 billion in 2019 (BCC Research 2014). Although in many different forms (Gartner 2012), TMSs are relevant for all continents.

Thereby, offered TMSs are of heterogeneous nature, ranging from telemonitoring services (e.g., defibrillators that capture and transfer a patient's heart beat data in order to enable physicians to monitor the patient's heart functions remotely and to automatically trigger alarm functions) to teleconsultation services enabling experts to guide other physicians through the conduction of medical procedures, e.g., in telestroke units. The heterogeneity also applies to the TMS context. TMSs are used at various stages of the overall treatment process of patients, e.g., before the discharge of patients from hospitals in order to assist in improving a patient's understanding and curation (San Nicolas-Rocca, Schooley et al. 2014). They might be applied at very remote locations involving different concepts and levels of existing knowledge (Miscione 2007), or in developing countries facing very low ratios of health professionals to population, thus allowing TMSs to mitigate the shortage of medical personnel (Abera, Mengesha et al. 2014). Also, TMSs concern all age groups, which requires specific handling and different practice styles (McColl-Kennedy, Vargo et al. 2012), e.g., in service co-creation processes with the elderly (McLoughlin, Maniatopoulos et al. 2012).

TMSs always comprise a combination of IT services and non-IT, highly person-oriented services. IT services might involve the data transfer of a TMS device to a monitoring facility. Due to industry standards or technical input and output requirements, these parts are highly standardized. Non-IT parts might be knowledge-intensive and person-oriented (KIPO) service parts, e.g., an interaction between physician and patient that could be highly individual because of the patient's individual state and situation.

Such TMSs are beneficial in supporting a patient's quality of life (Berry and Bendapudi 2007) and, where implemented, can reduce the cost of delivering health care. Despite being considered medically and technically viable, few TMS innovations have been put to practice (Cho, Mathiassen et al. 2008; Essén 2009).

In Germany, recent developments encouraging the use and acceptance of TMSs are being triggered. And these do not only include constantly growing health expenditures (World Health Organization 2015) calling for the efficiencies promised by TMSs, but also new impulse on the legislative side. In the beginning of this year, the German Federal Ministry of Health (2015) presented a proposal for the so-called eHealth law, which intends, among other goals, to provide incentives for the fast launch and use of digital medical applications, to improve interoperability between medical IT systems, and to foster the reimbursement of TMSs. This proposal was welcomed by the German Medical Association at their annual assembly in May and guidelines for according execution in practice are part of an ongoing discussion already (118th German Medical Assembly 2015).

Although broad acceptance among German physicians could be observed for TMSs and telematic infrastructures in general (Institut für Demoskopie Allensbach 2010), the issue requires an open discussion on an involvement in the digitization in terms of service system telemedicine including all its participants. This is critical for a much wider use and acceptance of TMSs. Telemedicine-dedicated device and software markets – estimated at $843 million in 2012 – are anticipated to reach $2.9 billion by 2019, while mobile health markets related to telemedicine at currently $1.4 billion are anticipated to reach $1.5 trillion by 2019 due to the use of 7 billion smart phones plus half that many connected tablet devices (Wintergreen Research Inc. 2013). In this context, tools for prioritizing integrated mHealth strategies for universal health coverage are developed and refined already (Mehl and Labrique 2014).

These promises also incur new challenges, including the combination of increased quality and a more efficient provision of such services. In order to conquer this challenge and succeed in the endeavor of providing efficient healthcare services and TMSs in particular, I consider four key areas: value co-creation and customer orientation; new information technologies (IT) enabling completely new services while still supporting traditional services; a service system perspective considering all stakeholders; and the design of services and service processes in a systematic manner. The thesis at hand follows exactly this plan.

5 Overview of the Main Dissertation Results

5.1 The SMART Method

The modularization method SMART constitutes the most important result of this dissertation. It is presented in the last publication of this thesis. The method supports the design, efficient customization, and service provisioning of TMSs. It is developed and evaluated following the design science research methodology (DSRM) and contains five phases. Within the method's evaluation, its usefulness could be confirmed, which is supported by the presentation of according metrics that demonstrate its effects. I hereby present a systematic and repeatable approach which contributes to service modularization for TMSs in particular and for all services comprising a combination of person-oriented and IT services in general. It is based on the extensive analysis of existing modularization methods which is presented in chapter 9. The method is capable of modularizing and reengineering non-modular services, while enabling the engineering of modular services from scratch. Depending on the resulting artifacts of the first two phases of the method, either a process map of the actual status for existing services or a process map of the desired status for to-be-created services are used as input for the consecutive SMART phases. In terms of design science research and resulting artifacts, the SMART method is a paragon for the successful design and evaluation of a method. Thus, it represents a theoretical contribution of design and action (Gregor 2006).

As the method can be applied to all services in a portfolio, it fosters holistic service modularization in multi-stakeholder environments such as telemedicine. I am convinced that the SMART method can be useful in the operationalization of digital transformations in all fields that are based on person-oriented services.

5.2 BTPM Modeling Technique

The BTPM modeling technique is an integral part of the SMART method. Still, it is one of the main dissertation results on its own. This technique allows for the modeling of service processes. As it is designed and evaluated for TMSs, it fulfills the requirements of such a complex environment. Although it is applicable to less complex settings, I want to point out particularities of the TMS field and how BTPM addresses them by combining elements from the well-known BPMN as well as service blueprinting. It is suitable for services that are developed and provisioned in multi-stakeholder environments. This is accomplished by using pools for every stakeholder who are separated by lines of interaction. There is no limitation of pools, all stakeholders can be modeled. It respects person-oriented and IT services. Three lanes are used in every pool for this purpose, i.e., for every stakeholder. The frontstage lane contains interactions with other stakeholders. It is separated from the backstage lane by the line of visibility as in the backstage part, all service processes invisible to other stakeholders are modeled. The lane for technical infrastructure comprises all service processes that are part of IT systems or devices. This also responds to new sensor-driven services and allows for the representation of "actions" which are located at a specific stakeholder, but might be processed automatically, e.g., a telemonitoring device from a patient might not require a conscious action by the patient, but still causes the transfer of data from the patient to a monitoring center. This feature is relevant and transferable to many other digitized services.

5.3 Service Modularization and Digitization in the Health Sector

The thesis provides knowledge that is relevant in terms of service modularization. In the context of modularization, it presents and builds on principles of modularization and modularization attempts from other fields. It also discusses the required changes for applying the concept of modularization to TMSs.

As outlined in chapter 3, the thesis also illustrates the granularity level in which modules should be seen in service scenarios, i.e., services comprise service modules which themselves are based on sets of service processes. This clarity is important, especially since the term module is used in a plethora of fields; often with conceptualizations that are incompatible with the service perspective presented in this thesis.

User centricity and co-creation of value as prevalent in service-dominant logic (Vargo and Lusch 2004; Vargo and Lusch 2008) as well as the consideration of telemedicine as a service system (Maglio, Srinivasan et al. 2006; Edvardsson, Skålén et al. 2012) are integral to this thesis. The SMART method and the BTPM technique incorporate these conceptualizations.

Furthermore, the thesis provides insights into the interplay of person-oriented and IT services and illustrates how combinations of such services need to be designed. This kind of combination is evident in all digital transformations of sectors that have been providing person-oriented services. Thus, the relevance of the SMART method and the insights presented in this thesis are supposed to increase with the ongoing digitization development, especially in the health sector.

5.4 Status Quo of Telemedicine from a Service Perspective

The thesis provides up-to-date knowledge from the field of telemedicine. Its according section presents an overview of the field in its current status. The TMS market and its importance on a global, European, and German scale is presented based on recent reports and information. This is accompanied by the typology of TMSs presented in chapter 8. It gives insights into the heterogeneity of TMSs and allows for describing and classifying TMSs. Also, it enables a representation of the TMS domain that fosters understandability and systematic differentiation. The typology thereby congregates relevant TMS dimensions that are usually discussed separately and are dealt with differently in the various application fields and research domains. Thus, a basis of shared information and jointly used language and terminology for the very heterogeneous field of TMSs is created which also facilitates interdisciplinary TMS developments and innovations. It can be considered as a useful navigation aid and entry point for practitioners and scientists that are new to the field of TMSs. Throughout the thesis, telemedicine is considered from a service perspective. In times of digitization, this is invaluable for developing and studying future offerings.

6 Overview of Publications included in the Dissertation

This thesis comprises seven publications, which answer the three overarching research questions introduced above. I want to point out that I tried to present a focused set of publications in this thesis. Still, there is a substantial set of publications which accompanied these publications (please see the "Complete List of Publications" at the end of this thesis).

In this section, I give a short summary of each publication and explain which research question(s) they address. Table 6.1 presents the seven publications and their chapters in the thesis.

No.	*Publication*	Chapter
1	*Menschner, P.; Peters, C. & Leimeister, J. M. (2011): Engineering Knowledge-Intense, Person-Oriented Services – A State of the Art Analysis. In: Proceedings of the 19th European Conference on Information Systems (ECIS), Helsinki, Finland. Published. VHB JOURQUAL B*	7
2	*Peters, C. & Menschner, P. (2012): Towards a Typology for Telemedical Services. In: Ancilliary Proceedings of the 20th European Conference on Information Systems (ECIS), Barcelona, Spain. Published. VHB JOURQUAL B*	8
3	*Peters, C.; Menschner, P.; Leimeister, J.M. (2015): Towards Modularization of Complex Services - A Systematic Literature Review on Modularization Methods. In: Journal of Business and Information Systems Engineering (BISE). Submitted, under review (2nd round). VHB JOURQUAL B*	9
4	*Peters, C. & Leimeister, J. M. (2013): TM³ - A Modularization Method for Telemedical Services: Design and Evaluation. In: Proceedings of the 21st European Conference on Information Systems (ECIS), Utrecht, Netherlands. Published. VHB JOURQUAL B*	10
5	*Peters, C.; Elm, C.; Söllner, M; Leimeister, J.M. (2014): Blueprint-driven Telemedicine Process Modeling - The Interdisciplinary Development and Evaluation of a Modeling Technique for Telemedical Services. In: Pre-Workshop of the Special Interest Group Services (SIGSVC) at the International Conference on Information Systems (ICIS), Auckland, New Zealand. Accepted for publication.*	11
6	*Peters, C. (2014): Together They are Strong - The Quest for Service Modularization Parameters. In: Proceedings of the 22^{nd} European Conference on Information Systems (ECIS), Tel Aviv, Israel. VHB JOURQUAL B*	12
7	*Peters, C.; Leimeister, J.M. (2015): Service Modularization in Service Systems - Supporting Service Design, Customization, and Provisioning with the SMART Method. In: Journal of Service Research. Submitted. VHB JOURQUAL A*	13

Table 6.1: Publications Included in the Dissertation

Source: own illustration

Publication 1: *Menschner, P.; Peters, C. & Leimeister, J. M. (2011): Engineering Knowledge-Intense, Person-Oriented Services – A State of the Art Analysis. In: Proceedings of the 19th European Conference on Information Systems (ECIS), Helsinki, Finland.*

Publication 1 provides a state-of-the-art analysis of service engineering approaches for knowledge-intense person-oriented (KIPO) services, focusing on the IT-enabled provision of such services. Key attributes distinguishing KIPO services from other services are derived before being integrated in a framework with regard to their applicability regarding KIPO service development and used for a systematic literature review. Such services are of high economic relevance, yet they are laggards in terms of IT potential realization. As the most value-creating activities in service provision are bound to persons or personal knowledge, KIPO service design is complicated.

The paper shows that shortcomings of existent approaches include an insufficient level of detail, i.e., no concrete actions or methods for deployment are described, a lack of practical corroboration as well as insufficient IT support and automation for its application. Further, current approaches are not sufficiently equipped to handle the interplay between people-bound activities and technical components.

Publication 1 contributes to RQ1a "What are TMSs and what makes them specific?" as it examines KIPO services, in particular IT-enabled KIPO services. Such IT-enabled KIPO services comprise TMSs as well; traditional medical service provision would be represented by KIPO services. The paper focuses on IT-enabled KIPO services, TMSs fall exactly in this category. It also points out the particularities of different service types and configurations. Also, it contributes to overcoming the challenges of RQ1b "Which challenges do TMS providers face?", e.g., the interplay between people-bound activities and technical components. As methods dealing with the efficient provision of services are examined, first method-related design insights and means of method engineering can already be gained here for answering RQ2b "Which phases and activities does an MM for TMSs involve?".

Publication 2: *Peters, C. & Menschner, P. (2012): Towards a Typology for Telemedical Services. In: Ancilliary Proceedings of the 20th European Conference on Information Systems (ECIS), Barcelona, Spain.*

Publication 2 presents a typology for describing and classifying TMSs. This typology is based on 13 well-described dimensions, each represented by a set of attributes. The paper enables a representation of the TMS domain that fosters understandability and systematic differentiation of TMSs in this interdisciplinary domain. It shows that the few existing telemedicine typologies fall short of this purpose. Thus, publication 2 adjusts and extends these typologies in order to present a new typology that suits the aforementioned purpose. In this paper, the typology's applicability in real-world scenarios is demonstrated.

Publication 2 contributes to RQ1a "What are TMSs and what makes them specific?" The presented typology can be used as navigation aid and entry point for practitioners and scientists who are new to the field of TMSs. From the perspective of its classificatory goal, the typology enables the detection and development of meta or reference classes of different TMSs, which allows the identification of best practices and success stories, thus providing a basis for comparison or benchmarking and increasing manageability of the heterogeneous TMS environment. The typology also addresses the needs of TMS experts who search for structured differentiation of their objects of investigation.

The typology congregates relevant TMS dimensions which are usually discussed separately and dealt with differently in the various application fields and research domains. Thus, a basis of shared information and jointly used language and terminology for the very heterogeneous field of TMSs that also intends to facilitate interdisciplinary TMS developments and innovations is created.

Publication 3: *Peters, C.; Menschner, P.; Leimeister, J.M. (2015): Towards Modularization of Complex Services - A Systematic Literature Review on Modularization Methods. In: Journal of Business and Information Systems Engineering (BISE).*

Publication 3 presents a systematic literature review and state-of-the-art analysis of modularization methods and checks their suitability for complex services. It considers methods and approaches from various domains. An analysis framework guided by seven key questions is first developed and then used for the assessment of the existing methods. Forty-six modularization methods could be identified – eight of which deal with services. Following a concept-centric approach, these eight methods are discussed and a summary of their assessments based on the analysis framework is provided.

It was found that most MMs do not incorporate a service perspective at all, and even if this was the case, the person-oriented part of complex services would still not be taken into account in the majority of methods and approaches. Overall, four MMs could be found that explicitly deal with IT services (Böhmann and Krcmar 2005; Böhmann, Langer et al. 2008; Sarkar, Ramachandran et al. 2009; Bavota, De Lucia et al. 2010): one that deals with logistic services (Corsten and Gössinger 2007) and three (Burr 2002; Böttcher, Becker et al. 2011; Peters and Leimeister 2013) that integrate IT and non-IT services.

They serve as starting points for the design of MMs for complex services. Thereby, publication 3 contributes to RQ2a "Are there existing MMs (also from other domains) which consider the elicited requirements at the service provider side?" and gives insights for RQ2b "Which phases and activities does an MM for TMSs involve?" by synthesizing literature and accumulating existing, interdisciplinary knowledge of MMs (from a more general research perspective).

Publication 3 reveals a lack of MMs that also integrate person-oriented services, which is crucial for complex services such as TMSs, as these are the services that originated in the traditional medical service provision performed by physicians or nurses. Often, these are important parts of the overall service offerings representing the most trust-building and value-creating ones. By synthesizing the literature and by accumulating the existing knowledge of MMs, the paper is not only valuable for many fields integrating person-oriented services or IT and non-IT service configurations, as well as for service modularization in general, but it also lays a foundation for all research activities dealing with MMs for complex services, especially the design of a modularization method for complex services. As these MMs are posited to enable providers to develop and (re-) configure complex services more efficiently, the paper also reinforces service and customer orientation in complex service environments and thus makes a practical contribution.

Publication 4: *Peters, C. & Leimeister, J. M. (2013): TM³ - A Modularization Method for Telemedical Services: Design and Evaluation. In: Proceedings of the 21st European Conference on Information Systems (ECIS), Utrecht, Netherlands.*

Publication 4 presents the TeleMedicine Modularization Method TM³ that enables telemedicine providers to modularize their services in order to offer customer-centric and tailored TMSs. Modularization inheriting potential benefits such as reuse, faster development, module-wide innovation, and rapid reconfiguration is supposed to become crucial for successful service delivery in the heterogeneous, fast-growing, and highly specific telemedicine market. This complex environment is characterized by the challenge of integrating IT as well as non-IT and highly person-oriented service parts. Based on a case study-informed set of criteria, this design science paper introduces the five-phase TM³. Here, the phases of (1) status capturing, (2) decomposition and (3) matrix generation, (4) interface specification, and (5) testing as well as its according activities and artifacts are presented. The method is then evaluated using a) application in use and b) a criteria-based evaluation. The paper contributes with the design and evaluation of a novel MM suitable for TMSs. By presenting TM³, publication 4 also extends the body of knowledge in regards to method engineering and supports practitioners in providing tailored service offerings to a steadily increasing number of telemedicine stakeholders.

As the paper shows by means of the design, application, and two-fold evaluation of TM³, it not only extends the body of knowledge in regards to method engineering and supports practitioners in providing individually tailored service offerings to their steadily growing customer base; it also shows the method's suitability and resulting improvements and benefits at the provider's site.

Publication 4 thereby contributes to RQ2b "Which phases and activities does an MM for TMSs involve?" as it presents exactly these phases, their corresponding activities, and resulting artifacts. Also, RQ3a "Is the MM applicable in practice?" can be answered positively by the two-fold evaluation and first benefits as demanded in RQ3b "What are the benefits of using this new MM?" for the TMS providers are outlined.

Publication 5: Peters, C.; Elm, C.; Söllner, M; Leimeister, J.M. (2014): Blueprint-driven Telemedicine Process Modeling - The Interdisciplinary Development and Evaluation of a Modeling Technique for Telemedical Services. In: Pre-Workshop of the Special Interest Group Services (SIGSVC) at the International Conference on Information Systems (ICIS), Auckland, New Zealand.

Publication 5 presents the Blueprint-driven Telemedicine Process Modeling (BTPM) technique, a modeling technique for telemedicine processes and services based on BPMN and service blueprinting.

The paper illustrates how an action research (AR) setting guided the workshop-informed, iterative design and evaluation of BTPM in an interdisciplinary setting. It also outlines how the dual imperative of AR (McKay and Marshall 2001) was followed by using two cycles, a problem-solving cycle and a research cycle. Thereby, the two overarching questions "How must a modeling technique for TMSs look like that fulfils elicited requirements (aiming at the solution technology)?" and "How can a modeling technique for TMSs be developed in an interdisciplinary AR setting (aiming at providing insights regarding the process of AR)?" are answered. During this process, three iterations are used which are all integrated into workshop settings with telemedicine experts, followed by a proof-of-concept which models an existing TMS using BTPM.

This BTPM technique inherits the well-known BPMN concept of pools and lanes which allows for modular stakeholder extensions, i.e., by adding new pools for new stakeholders. Also, it integrates blueprinting-specific elements, e.g., the line of interaction or the line of visibility, in order to represent both, value-creating face-to-face momenta as well as front and backstage activities. Furthermore, BTPM explicitly considers telemedical devices and distinguishes between stakeholders by using color coding.

Publication 5 contributes to RQ2b "Which phases and activities does a MM for TMSs involve?" as it represents the BTPM technique used for the second phase of TM³ (publication 4) and the SMART method (publication 7). This technique is adequate for telemedicine as it respects the particularities of this service system and explicitly assists all stakeholders, especially TMS providers, to model their service experience scenarios in an easy manner. BTPM also responds to the challenges of RQ1b "Which challenges do TMS providers face?" and provides further insights for RQ1a "What are TMSs and what makes them specific?" during its application. For the second phase of TM³ and the SMART method, the paper presents a proof-of-concept and thus a preliminary result for the evaluative parts RQ3a "Is the MM applicable in practice?" and RQ3b "What are the benefits of using this new MM?" are dealing with.

Publication 6: Peters, C. (2014): Together They are Strong - The Quest for Service Modularization Parameters. In: Proceedings of the 22nd European Conference on Information Systems (ECIS), Tel Aviv, Israel.

Publication 6 deals with service modularization of complex services and examines modularization parameters in particular. As interdependencies between modules reflect the basic principles of modularization, i.e., cohesion and loose coupling, it is them which need to be elicited. These interdependencies are based on attributes of the underlying service processes that make up the to-be-modularized service. Also, these attributes represent candidates for modularization parameters.

The paper presents a research setting that is based on a three-stage workshop series. It comprises dedicated expert workshops for modularization parameters which involve participants with roles such as founder and CEO, chief developer, process analyst, and requirements engineer as well as service process expert. Preceding these workshops, a preliminary workshop sharpened the understanding of modularization, and a service for the modularization was chosen and modeled with BTPM in another workshop.

Publication 6 suggests that the right choice of modularization parameters is based on existing parameters which should serve as the starting set for all modularization attempts for complex services and a further step in which extra or obsolete parameters are included or excluded according to the setting. The paper presents such a set of modularization parameters and thereby contributes to service modularization research by providing the ingredients (modularization parameters) for the recipe (the overall modularization method) for systematic service modularization of complex services. It also contributes to RQ2b "Which phases and activities does a MM for TMSs involve?" and is an integral part of the SMART method presented in publication 7.

Publication 7: Peters, C.; Leimeister, J.M. (2015): Service Modularization in Service Systems - Supporting Service Design, Customization, and Provisioning with the SMART Method. In: Journal of Service Research.

Publication 7 presents SMART, a method for the modularization of TMSs that supports the design, efficient customization, and service provisioning of TMSs. It can be regarded as the core of this thesis.

Following the design science research methodology (DSRM) for information systems research by Peffers, Tuunanen et al. (2007), the paper guides through the design and evaluation of the SMART method using the DSRM activities, namely 1) problem identification and motivation, 2) objective definition for a solution, 3) design and development, 4) demonstration, 5) evaluation, and 6) communication. Within the paper, the method's application to the field of telemonitoring is presented, demonstrating its applicability and feasibility, as well as the usefulness of the approach.

For SMART, findings from already presented publications and existing research are synthesized, e.g., in the fields of service modularization (integrating publications 3, 4, and 6), service modeling (publication 5), service systems (publications 1, 2, and 5), service interaction design (publications 4 and 5), and service engineering (publications 1 and 4), resulting in an applicable, feasible, and repeatable method for the modularization of TMSs. The application of SMART leads to 1) increased transparency and awareness of the stakeholder's interactions visualized in service process maps, 2) efficiency gains by means of the creation of reusable modules, and 3) the provision of the basis for any service portfolio in person-oriented fields capable of integrating and redeveloping digitized services.

Thereby, publication 7 contributes to RQ2b "Which phases and activities does a MM for TMSs involve?" as it presents the five-phase SMART method itself, to RQ3a "Is the MM applicable in practice?" as it demonstrates the case study setting in which it could be applied successfully, and to RQ3b "What are the benefits of using this new MM?" as it presents precise effects that could be achieved by the application of the SMART method. While applying SMART to 20 services representing 235 service processes, a service module reuse rate of 23% on average and service modularization rates from 45 to 93% could be realized. Also, the paper contributes to service modularization for all services integrating person-oriented and IT services and thus to service modularization and digital transformations in multi-stakeholder environments such as the health sector.

7 Engineering Knowledge-Intense, Person-Oriented Services – A State of the Art Analysis

Menschner, Philipp; Peters, Christoph; Leimeister, Jan Marco

Abstract:

This paper provides a state-of-the-art analysis of service engineering (SE) approaches for knowledge-intense person-oriented (KIPO) services, focussing on IT-enabled provision of such services. Key attributes are derived that distinguish KIPOs from other services. These attributes are integrated in a framework with regard to their applicability on KIPOs development and used for a systematic literature review. KIPOs are of high economic relevance, yet they are laggards in terms of realization of IT potentials. As the most value-creating activities in service provision are bound to persons or personal knowledge, KIPOs design is complicated. The analysis reveals several gaps in SE research. In particular, identified shortcomings of existent approaches are an insufficient level of detail, i.e. no concrete actions or methods for deployment are described, a lack of practical corroboration as well as insufficient IT support. Further, current approaches are not sufficiently equipped to handle the interplay between people-bound activities and technical components. This paper contributes to IS research by clearly identifying these gaps in SE methods. It further provides researchers with ideas for future research activities and guides practitioners in selecting methods that serve as candidates to be integrated into KIPOs development in order to leverage IT potentials more systematically and efficiently.

Keywords: service science, service engineering, knowledge-intense services, person-oriented services, literature review.

7.1 Introduction

Services dominate western economies, accounting for about 70% of employment and gross value added. Moreover, services are the only part of western economies to have expanded in terms of employment in recent years, as manufacturing, mining and agriculture continue to contract (Maglio and Spohrer 2008). Due to increased competition in many service markets, differentiation through innovative service offerings is developing into a key unique selling point (Maglio and Spohrer 2008). Much of service innovation today is about the adoption and effective implementation of IT

(Zysman 2006). The potentials of the IT-usage in business are well-known. Amongst others, IT allows standardization and support of processes, automation or integration (Davenport 1993). The use of IT also bears vast potential for services. On the one hand, IT enables new forms of cooperation and communication in service systems (Rai and Sambamurthy 2006), on the other hand it enables automation, standardization and new concepts for customer integration (Fitzsimmons and Fitzsimmons 2005). In other words, automation by IT is a result of increased industrialization of the established service economy (Fitzsimmons and Fitzsimmons 2005). Furthermore, entire services today are increasingly delivered using IT (Rust and Kannan 2002).

The innovative application of IT varies among service industries though (Sheehan 2006). KIPO in particular, predominately existent in health care or education, are still lagging behind on intelligent use of IT. Typical KIPOs are for instance nutritional or health counseling. They are highly individualized, knowledge-demanding and generally delivered face-to-face. Enabling IT potentials for such services raises problems existing design methods do not address (Patrício, Fisk et al. 2008). This is partly due to the fact that KIPOs face certain specific specialties, e.g. regulatory issues or retentions upheld by service providers and consumers, which leads to the prevalent notion that KIPOs are not suitable for systematic service engineering (Menschner, Hartmann et al. 2010). In the case of health counseling, e.g., such specialties include that customers are sick and reluctant, relinquish privacy or are at risk (Berry and Bendapudi 2007). Yet, several new technologies have been developed and introduced, which might lead to IT-enabled service innovations also in these sectors (Menschner, Prinz et al. 2011). Despite this fact, only little of these innovations have been put into practice (Cho, Mathiassen et al. 2008; Essén 2009).

Essential to the successful design of services is that they are underlined by a reasonable service process and design. Beginning in the 1990s, the research discipline of SE emerged especially in Germany (Ganz 2006). It traces back to concepts of new service development and service design, which evolved in the Anglo-American region in the 1980s. Those concepts mainly relate to the research field of services marketing (Bullinger, Fähnrich et al. 2003; Zeithaml and Bitner 2003). SE, in contrast, focuses on adopting concepts which are successfully implemented in product and software engineering to the field of services. It is defined as the systematic design and development of services by deploying engineering methods and practices, and by using tools of the engineering design field (Bullinger, Fähnrich et al. 2003). Although in the beginning most of the contributions to service engineering came from engineering research (Fähnrich and Meiren 2007), there is an increase of contributions from IS-related research (Rai and Sambamurthy 2006; Spohrer, Maglio et al. 2007; Buhl, Heinrich et al. 2008). This is due to the fact that the rise of new information and communication technologies changes services in two ways: first, the use of IT can make a contribution by adding faster and more structured development processes (Leimeister, Huber et al. 2009; Rubleske and Kaarst-Brown 2009), secondly new services arise from using these technologies. So far, most of recent service engineering literature deals with development of IT services, e-services, or product-service bundles (Böhmann and Krcmar 2005; Knebel, Leimeister et al. 2007; Becker, Beverungen et al. 2008; Orman 2008). A variety of models for SE have been developed, although a common critique is that most of them still lack appropriate method and tool support that would allow a better penetration of concepts in practice (Zhou and Tan 2008). Hence, SE is still an emerging discipline (Bullinger, Fähnrich et al. 2003; Chesbrough and Spohrer 2006).

Regarding KIPOs, the increase in technologies over the last few years additionally offers enormous potential for improving services and creating new services. If the same increase in productivity, quality and growth wants to be achieved with KIPOs as has been experienced during the industrial revolution around manufacturing products, intelligent IT support and structured development methods and routines become crucial enablers for industrializing KIPOs. The vision is thus that KIPOs will be IT-enabled, which incorporates automation of certain routine and manual functions, but also IT complementing the effective use of human insight, intelligence and knowledge (Zysman 2006).

The objective of this paper is to assess and evaluate existing service engineering and design methods with regard to their applicability for the development of KIPOs. The paper is structured as follows: first, we derive a set of key attributes that distinguish KIPOs from other services and identify challenges for SE. These attributes are then integrated in a framework for analyzing SE literature. This analysis is discussed and future research opportunities are outlined.

7.2 What makes KIPO Services Different?

7.2.1 Definition of Services

The concept of service has been defined in different business fields with varying definitions. Service definitions in literature can be classified by three types of definitions: negative definitions, enumerative definitions and constitutive definitions (Zeithaml and Bitner 2003). The negative definitions position services by dissociation from real assets or goods, while enumerative definitions use listings of examples for a specification of services. Both classes of definitions are rather unsuitable for research (Buhl, Heinrich et al. 2008). The third category, constitutive definitions, formulates fundamental characteristics of services.

In information systems (IS), the term service can be regarded from two perspectives: from a business view and a technical view (Buhl, Heinrich et al. 2008). Services in a business sense are characterized by intangibility, immateriality, simultaneity of production and consumption (uno-actu-principle), as well as the integration of the consumer as external factor in the process of creation. Service from a technical perspective is a software realized artifact that offers some functionality. Similar findings can be found in (Chesbrough and Spohrer 2006; Rai and Sambamurthy 2006). For the case of the business-oriented services, information science can make contributions by supporting service provision by intelligent usage of information and communication technology. The focus of this paper is the IT-based realization and provision of services from a business view. Other works introduce the concept of service systems (Spohrer, Maglio et al. 2007). Service systems are value-creation networks composed of people, technology, and organizations (Maglio, Srinivasan et al. 2006).

7.2.2 Characteristics of KIPO Services

Knowledge-intense services are defined as follows: during production or process the generation or the use of novel knowledge accounts for a large proportion of the service (Hauknes 1999). These services are predominantly found in the industries communication, financials, research and consulting, health care, or education. Other authors use the expression “information-intense” with a quite similar definition: information actions amount for the largest proportion of value created by the service system (Apte and Mason 1995). Examples are vocational education, consulting, or emergency and surgical healthcare (Glushko 2009). KIPOs are additionally characterized by a high degree of customer interaction and are bound to persons or personal knowledge (Menschner, Hartmann et al. 2010). To define KIPOs, we adopt the concept of service systems. These systems combine and integrate different service design contexts (Maglio, Srinivasan et al. 2006; Spohrer, Maglio et al. 2007). Based on those works, Glushko (2009) introduces seven contexts for service design (“person-to-person”, “technology enhanced person-to-person”, “self-service”, “multi-channel”, “services on multiple devices or platforms”, “backstage intense or computational services” and “location-based and context-aware services”) which he applies on information-intensive services. Following this approach, we define KIPOs as follows: A KIPO is a knowledge-intense service system, which incorporates one or more person-to-person-encounters as fundamental and integral part of the service.

We argue that certain distinct characteristics of KIPOs mandate a customized service engineering approach. These are: individual history of customers, emotional tie, high degree of implicit knowledge and people-boundness (Menschner, Hartmann et al. 2010).

Every customer has an individual history: A fundamental key attribute is the high degree of individualization in KIPOs, caused by the huge amount of information necessary for service provision. Every customer has his or her individual biography, medical background, lifestyle etc. As KIPOs need to be designed to fulfil the specific needs of each customer, this results in a challenge for service providers. Every time they are facing a customer, they have to adapt themselves to the individual situation of the person in front. If the customer is not willing or capable to interact with the service provider, no service production will be possible. Due to this, the practical and emotional knowledge (empathy) of the service provider is essential to get access to the customer and to understand his needs. For example, knowing medical and personal history helps a nutrition counsellor to get a better understanding of the life situation of a patient and is indispensable for prescribing adequate treatments. This interaction and detailed knowledge of the patients’ situation is also prevailing responsible for the service quality perceived by the patient. This poses an enormous challenge to the development of KIPOs, as establishing an adequate information basis is very time-consuming and additionally relies on information directly communicated by the customer. Recent works try to overcome this deficit by establishing electronic data capture by customers or patients themselves (Knebel, Leimeister et al. 2007; Menschner, Prinz et al. 2011), yet this is not possible for all kinds of information. With regard to KIPOs, we conclude that a specific information basis for each customer is a fundamental key characteristic, which has to be considered during the development of such services.

Emotional tie and stress: A direct consequence from the need of acquaintance is that delivering KIPOs can be emotionally daunting. The service provider needs to fully understand a person’s history, life-style and emotional being, in order to be able to provide the service accordingly. This can be stressful as, e.g. in home care or life counselling, customers are sometimes incurably sick, have encountered strokes of fate, or sometimes just possess a difficult personality (Berry and Bendapudi 2007). Yet building up an emotional relationship is often inevitable for service provision. For SE, this encompasses certain challenges with regards to resource or personnel allocation. On the one hand, service providers need to be emotionally stable, on the other hand, once an emotional tie is established between an employee and a customer, the customer cannot easily be served by another employee. Thus, flexibility issues arise that have to be coped with. A SE method hence needs to be able to handle such individual person-oriented settings.

High degree of implicit knowledge: KIPOs rely on a high degree of implicit knowledge that is accumulated and used during service provision. As an example, the working staff within the home care sector needs to evaluate and react on the patients' needs and health status. There are different forms of implicit knowledge. It can derive from personal experiences with a certain customer, including emotional insights, a customer's individual history or impressions obtained during interactions. Other forms are experiences on how to read or interpret certain persons, how to interact with them or talk to them (Menschner, Hartmann et al. 2010). Usually there is no documentation of this knowledge, yet it is essential for efficient and effective service provision. Further, documentation of implicit knowledge faces some limitations. On the one hand, it is very time-consuming and therefore often economically unreasonable. On the other hand, implicit knowledge is sometimes tacit, e.g. of emotional type or a sort of personal experience, which is difficult to document and thus challenging to transfer from one person to another. This complicates standardization and automation of such services. A further consequence of insufficient documentation is that it is hard to implement quality management and assurance measures.

Service delivery is people-bound: KIPOs are performed at people and the dominant factor for perceived service quality is the person providing the service. Thus, it can be concluded that KIPOs contain at least some partial processes that must remain as they are: person-to-person encounters that can hardly be standardized or automated. Therefore, a service engineering method needs to be able to identify such "must-have" personal encounters. It further has to be able to cope with two different settings: such that must remain personally delivered and such that can be standardized and automated. Thus, it needs to develop criteria on how to distinguish between those two.

Although automation is difficult, IT can be used to either assist the person in charge of service provision, or to enhance the interactions between customer and provider

(Fitzsimmons and Fitzsimmons 2005). A service engineering method has to consider to which extent technology should be used and for which process steps. Yet, the use of IT generates even more challenges. As (Glushko and Tabas 2009) point out, different interaction channels have an impact on customer perception and service quality. Service engineering methods have to cope with the fact that services are complemented or replaced by automated services. Also, the extent of customer integration into the service provisioning processes has to be examined. Only then, the optimal trade-off between customer integration and IT usage can be determined which is the key to an increase in perceived service quality.

7.3 Analyzed Aspects

Based on the key characteristics elaborated above and their impact on service engineering, we have developed an analysis framework. We have derived challenges and translated them into applicable questions. This framework has been used to review existing literature on their suitability for KIPO SE.

As SE involves the systematic development of services using models, methods and tools, it is important to define these terms. According to Brinkkemper (1996), a method is an approach that describes the conduction of an entire development process or project. It provides a detailed prescription of how to perform a collection of activities. A technique can be defined as a part of a method that gives concrete and tangible instructions for how to conduct the work of an activity. Brinkkemper (1996) defines a technique as "a procedure, possibly with a prescribed notation, to perform a development activity." Thus, a method provides a systematic approach of how to use different techniques. A tool is an automatic way to support a part of the development process.

Thus, in order to be a SE method, an analyzed approach needs to cover the entire development process and the steps have to be described in detail. Based on this, the following aspects require further analysis:

Life-cycle coverage: Are all phases of the engineering process included in the method or just selected phases such as analysis or idea generation?

Granularity of approach: Are there defined techniques and guidance for the engineering of services? Are the steps described in detail?

As the focus of this paper is IT-enabled KIPOs, requirements also derive from the integration of certain design elements, the application of IT, and integration of customers into service provision, which is also partially enabled through IT. Yet, a closer analysis shows that KIPO service settings contain processes that should be continued to be delivered personally, as they are the most value creating activities (Essén 2009). Furthermore, IT can make a contribution by supporting these processes with IT systems, e.g. by providing information or templates that make the provision more efficient. Additionally, there are typical service candidates for automation, e.g. services that contain sub-processes or activities that are partly standardized for several clients or do add value. These could be automated and delivered by IT systems to enable scalability. Therefore, the following aspects are in need of consideration:

Does the approach consider the information and knowledge intensity of the studied KIPOs?

Does the approach support the development and design of person-oriented service processes?

Does the approach support the integration of IT, resp. modeling of IT and software components?

Does the approach provide decision support on automation and customer integration? Does the approach allow the identification of must-have person-to-person encounters and potentials for automation through IT?

Does the approach support the interaction of technical components and people-bound process steps?

Additionally, integration of new technology leads to completely new and unknown services. As the development of such innovations is computing within a user's changing environment, it is important to determine user needs at a very early stage of development (Iachello, Truong et al. 2006). User needs are to be reflected in more specific requirements which in case of fulfillment satisfy the user's needs. Recent studies underline the potential of involving users, specifically in the process of mobile service innovation (van de Kar and den Hengst 2009). Involving users as innovators can result in more innovative services that have greater user value (Magnusson 2003). Additionally, as user requirements are often "sticky" information, significant costs are involved in eliciting these requirements in non-participatory design settings (Oliveira and von Hippel 2009). Hence, participatory design and prototyping approaches have proven to be valuable to the development of mobile or ubiquitous computing services (Resatsch, Sandner et al. 2008) and are also paramount for high acceptance of IT-enabled KIPOs. This leads to the last aspect:

Participatory development: Is customer integration provided for the entire engineering process of services? Are there concepts, findings or methods for systematic customer integration in the approach?

The following sections present the choice of the examined body of literature as well as the results these sources revealed in terms of the analyzed aspects.

7.4 Analyzed Literature

As mentioned above, we were mainly interested in identifying articles that contribute to the body of knowledge of SE, i.e. articles providing methods or approaches that guide the systematic development of services. We started with a systematic literature review which was performed on the online databases EBSCOhost, ACM and AISLIB. Thus, we cover a broad range of high-quality, peer-reviewed publications. The search comprised the key words "service engineering", "service design", "(new) service development", "service innovation" and their corresponding abbreviations. This was due to the fact that especially the term "service engineering" is rather uncommon in international literature, and a sole usage of this term would exclude relevant works. The search has been limited to the fields "title", "keywords" and "abstract". The review time period was from 2000 to 2010. For the time prior, we meta-reviewed several literature reviews and included suitable approaches (Johne and Storey 1998; Fähnrich and Meiren 2007; Zhou and Tan 2008). The initial search returned over 700 articles. Accounting for duplicate results and after a preliminary scan of the article abstracts, the number of articles to be included was substantially reduced. Reasons for excluding articles were, among others, a different understanding of the term service, e.g. a solely technical view (e.g. web-services, SOA), as well as articles that did not focus on engineering aspects, i.e. they did not provide prescriptions, guiding or processes for systematic development of services. Moreover, several cross-referenced articles and books not found in those databases were included. This set of existing literature was further extended by a comprehensive review of relevant academic conferences (e.g. ECIS, ICIS, RESER) that we expected would have published articles on service engineering. For the conferences we applied the same selection processes. Finally, 26 relevant journal and conference articles, as well as books and book chapters, were included in the review.

For our analysis, we decided not to include some conventional approaches as service blueprint, Quality Function Deployment (QFD), Failure Mode and Effects Analysis (FMEA) etc. Reasons are: (1) several reviewed articles build open these methods, (2) they have already have heavily been reviewed (e.g. (Zhou and Tan 2008)), (3) their limitations for developing IT-enabled services are known (Patrício, Fisk et al. 2008).

7.5 Results: Comparison of Existing SE Approaches

In this section a detailed overview of the analyzed aspects is outlined. In order to assess the approaches, the construction of a table deemed appropriate. Therefore, all approaches are assigned to a respective row. All seven analyzed aspects have dedicated columns. Thus, each approach is assessed by following the aspects from left to right in the table's rows. For the aspects life-cycle coverage and granularity of the approach, trivalent scales (0, +, ++) are used with the following semantics: 0 stands for no life-cycle perspective at all, while + marks approaches which integrate a life-cycle perspective, but do not cover it in a comprehensive manner. Finally, ++ represents approaches which cover the whole life-cycle. Therefore, we define Bullinger and Schreiner (2006) as our reference life-cycle model that dictates the completeness criterion, as their model is a reference model based on other approaches. Considering the granularity of the approach, 0 is used for approaches that only present very light-weight approaches and are limited to the presentation of meta-levels and major process steps. + represents approaches who clearly describe their main process steps, but in contrast to ++ do not elaborate on actionable advice regarding the according process steps. For all other analyzed aspects, the heterogeneity and unpredictability of potential assessments suggested a mere textual evaluation which allows an adequately flexible reflection.

The analysis of the 26 SE approaches as reflected in Table 7.1 was conducted independently by two coders. The second coder restricted the analysis to a random control sample. The results of the coding process of the control sample were consistent with the results of the original coder. In the following, we describe our observations that resulted from the analysis of the approaches.

The analyzed articles can be allocated to different groups. The first group comprises approaches that can generally be classified as frameworks and process models.

Identified shortcomings of these approaches are an insufficient level of detail, i.e. no concrete actions or methods to be deployed are described, a lack of practical corroboration as well as insufficient IT support (Patrício, Fisk et al. 2008). The second group encompasses approaches that focus mainly on sub-categories of service engineering, e.g. user experience or service quality. Only a few articles present comprehensive approaches. Some works compare different approaches on a specific service and contribute to service engineering theory, yet they do not present novel methods or guidance. Additionally, we identified a range of works that analyze the impact and challenges that arise through technology infusion into the service encounter. Yet, these approaches, e.g. (Simons and Bouwman 2005), focus mainly on multi-channel service delivery and mainly focus on the service encounter, neglecting back-office processes.

	Life-cycle Coverage	**Granularity of approach**	**Information- or knowledge-based perspective**	**Design of personal encounter**	**Design of technical components**	**Identification of personal encounters and IT potentials**	**Integration of technical and personal components**	**Participatory Development**	**Comments**
(Alam and Perry 2002)	++	0	no	no	no	no	no	yes, customer feedback for all stages identified	proposal of 2 new NSD processes
(Bitner, Ostrom et al. 2008)	+	++	no	yes	no	no	no	partially, focus on employees	extension of service blueprint
(Booz, Allen et al. 1982)	++	+	no	yes	no	no	no	yes	
(Bullinger and Schreiner 2006)	++	0	no	no	no	no	no	partially	reference model
(Chai, Zhang et al. 2005)	0	++	no	no, focuses on problem elimination	no	no	partially, as this can be modelled via the function diagram	no	uses principles for problem solving
(Chuang 2007)	+	++	no	yes	no	no	no	yes	based on service blueprint and FMEA

	Life-cycle Coverage	Granularity of approach	Information- or knowledge-based perspective	Design of personal encounter	Design of technical components	Identification of personal encounters and IT potentials	Integration of technical and personal components	Participatory Development	Comments
(Edvardsson and Olsson 1996)	++	+	no	yes	no	no	no	yes, customer focus	
(Fließ and Kleinaltenkamp 2004)	0	++	no	yes	no	no	no	no	extends service blueprint
(Froehle and Roth 2007)	yes	0	partially - intellectual resources are included	no	no	no	no	not explicitly, covered by several identified constructs	combines resource and process based approaches
(Goldstein, Johnston et al. 2002)	0	+	no	yes	no	no	no	no	focus on service concept
(Jing-Hua, Lei et al. 2009)	++	+	no	yes, but focus on quality	no	no	no	yes	based on Gap-Model and QFD
(Kindström and Kowalkowski 2009)	+	0	no	no	no	no	no	only stating that customer input is essential	focus on managerial implications
(Kingman-Brundage and Shostack 1991)	++	+	no	yes	no	no	no	yes	focus on developer teams
(Matthing, Sandén et al. 2004)	0	+	no	no	no	no	no	yes, focus of the study is to highlight the importance of customer integration	focus on idea generation
(Meiren and Burger 2008)	++	+	no	yes	no	no	no	Only in testing	focus on testing services
(Meyer, Böttcher et al. 2008)	++	0	no	no	partially	no	yes	yes	integrate software and service engineering
(Opitz 2008)	++	+	no	no	partially	no	yes	yes	

	Life-cycle Coverage	Granularity of approach	Information- or knowledge-based perspective	Design of personal encounter	Design of technical components	Identification of personal encounters and IT potentials	Integration of technical and personal components	Participatory Development	Comments
(Patrício, Fisk et al. 2008)	+	++	no	yes	yes	no	Yes	partially	focus on multi-channel encounters, based on service blueprint
(Qi and Chuan Tan 2009)	++	0	partially	no	partiall y	no	no	no	incorporating a knowledge dimension
(Ramaswamy 1996)	++	+	no	yes	no	no	no	yes	includes service management
(Scheuing and Johnson 1989)	++	+	no	no	no	possibly in specific test phases		no	very detailed phases
(Simons and Bouwman 2005)	+	+	no	yes	yes	no	yes	yes	addressing multi-channel, compares several approaches to QFD
(Smith, Fischbacher et al. 2007)	++	++	no	yes	no	no	no	Employees only	based on QFD, Service Blueprint and Stage Gate Model, rather testing methods than providing new methods
(Stevens and Dimitriadis 2005)	++	+	no	yes	no	no	partially	yes	incorporates learning process
(Torsi, Nasr et al. 2009)	0	0	no	yes	yes	no	yes	yes	only preliminary work
(Yang and Hsiao 2009)	++	+	no	no	no	no	partially	yes	based on TRIZ

Table 7.1: Comparison of the Analyzed Approaches
Source: own illustration

7.6 Discussion

The importance of SE for successful development of services is being increasingly recognized. The number of publications that deal with the issue of SE has increased in recent years, but to the best of the authors' knowledge, a comprehensive analysis of the coverage and specific characteristics has not been conducted yet, particularly, the evaluation of the approaches' fit regarding requirements resulting from the specifics of designing IT-enabled KIPOs. Their design incorporates both, the design of people-bound activities and IT components as well as their interrelation. With regard to KIPOs, no methods could be found that are capable of treating such complex services as a whole. That is a lack in current literature, as none of the analyzed methods provides engineering tools that can serve as a bridge between automation and social aspects. Systematic approaches to develop KIPOs that cover all aspects and characteristics could not be found.

In this paper, we developed a framework and applied it to a significant sample of SE approaches, in order to describe and differentiate these approaches in more detail. One benefit of our framework is that it supports selection of different approaches for organisations trying to leverage IT potentials for KIPOs. A second benefit is that our results are suitable to provide starting-points on how to address identified gaps and shortcomings. For example, a variety of approaches for SE have been proposed that provide no actionable details. Most of them also lack appropriate method and tool support that would allow a better penetration of concepts in practice. To fulfil this, these methods need to be specified and elaborated in more detail. Other methods are already mature, yet they only cover distinct aspects of engineering KIPOs. Thus, we conjecture that currently there is a lack of methods that meet the requirement of a comprehensive SE approach for developing IT-enabled KIPOs, which was the starting point of our research. A comprehensive method should further provide guidelines on how to identify those process steps that need to remain personally delivered, and other process steps that can subsequently be supported or even automated by IT. There is currently no method or approach that systematically addresses this issue.

To overcome the lack of methods to systematically develop economically reasonable and user-friendly IT-enabled KIPO services and processes, we provide suggestions of how our results can inform the design of an improved SE method. Analyzing the deficits of the analyzed approaches, the concepts of method engineering (Brinkkemper 1996) could be used to outline how a consolidated method may look like. Concepts of method engineering are amongst others method integration or best of breed approaches to combine different fragments or steps of existing methods. Some of the analyzed approaches already follow this approach, e.g. by combination of service blueprint with FMEA (Chuang 2007), or by integrating QFD with Gap-Analysis (Jing-Hua, Lei et al. 2009). Other works successfully extend existing approaches by integrating other views and techniques, e.g. by extending service blueprinting (Patrício, Fisk et al. 2008) or the TRIZ method (Chai, Zhang et al. 2005). Those articles present good starting points for further considerations of method integrations. Further, several commonalities of analyzed methods could be identified. Despite most approaches are following a different life-cycle, complementary aspects, e.g. common starting points or similar phases, can be identified. Some works try to integrate and consolidate these differing life-cycles, yet those works still lack appropriate method support. Future research could try to assess existing methods on their suitability for certain life-cycle phases and provide a matching. This could serve as a basis for selecting the appropriate methods within each phase. A challenge thereby lies, however, in formulating and detailing the interrelation and interfaces of the existing methods.

One of the main challenges in engineering IT-enabled KIPOs is in the duality of people-bound activities and IT components, as engineering approaches so far could not be successfully applied to individual and personal services. First starting points on how this conflict could be addressed can be derived from works trying to design multi-channel service encounters (Simons and Bouwman 2005; Patrício, Fisk et al. 2008). These works could potentially be extended to analyze the whole service process, as in their current states they are only addressing the service encounter. Other interesting starting points for dissolving this duality are the approaches of (Chai, Zhang et al. 2005), who apply the TRIZ method to overcome conflicting design issues. Yet, they do not explicitly address technology infusion.

For integrating an information and knowledge dimension, only the approaches of (Froehle and Roth 2007) and (Qi and Chuan Tan 2009) present starting points. Customer integration is provided by most of the approaches. This supports the fact that customer integration has been recognized as being essential to successfully develop services, although hardly any work could be found that analyzes the degree of customer involvement in service provision.

Once a first idea of a service concept is identified, it might also seem meaningful to integrate methods from other disciplines into the field of service engineering. Especially, as increasing parts of KIPOs will be delivered using electronic means, the integration of methods from software engineering or, especially when mobile or ubiquitous elements are considered, from participatory design approaches such as prototyping will be inevitable to ensure customer acceptance. Future research needs to demonstrate how a comprehensive method that suits the needs of KIPOs can be developed and show the utility and applicability of such a method in practice.

7.7 Limitations and Conclusion

As any literature review, this paper faces limitations that are due to the literature selection process. By integrating relevant works from cross-references and earlier reviews related to SE or NSD, as well as by the choice of the key words, we tried to reduce the risk of missing out on relevant works. Also, other streams of research might be suitable to address some of the key issues identified for SE of IT-enabled KIPOs. These include, e.g. software development and prototyping approaches targeted for developing pure IT-services. Hence, more detailed and thorough analyses are required.

According to Webster and Watson (2002), a contribution of a literature review is to identify critical knowledge gaps in existing research and making a chart for future research. Thus, the results we presented in this paper are a first step towards filling the research gaps as have been proposed in recent research appraisals in the field of service science, calling for development of suitable methods. Our results support the presumptions that SE is still a young discipline, and further work has to be done on the elaboration and particularization of existing methods. As a lot of approaches are still too general and abstract to be widely employed and accepted in practice, practical corroboration could be ensured by making the approaches more accessible through case studies, design patterns or more detailed prescription of actions. To meet the challenges for the case of IT-enabled KIPOs, methods are needed that support those services as a whole. The main gap we identified is a lack of methods that are capable of handling the interaction between people-bound activities and automation by means of IT. We have further pointed out initial considerations for integrating and combining existing approaches by means of method engineering to develop a comprehensive SE method for KIPOs through future research.

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8 Towards a Typology for Telemedical Services

Peters, Christoph; Menschner, Philipp

Abstract:

This research-in-progress paper presents a typology for describing and classifying telemedical services (TMSs). As TMSs are highly heterogeneous and complex, our objective is to provide an overview of TMSs and to reduce the complexity of handling the highly distinctive TMSs. Our typology is based on 13 well-described dimensions (e.g. purpose), each represented by a set of attributes (e.g. cure, palliation, prevention or rehabilitation). Based on this, we want to enable a representation of a highly aggregated overview of the TMS domain that fosters understandability and systematic differentiation of TMSs in this interdisciplinary domain. We show that the few existing telemedicine typologies fall short of this purpose. Thus, we adjust and extend these typologies in order to present a new typology that suits the current demands. In this paper, we already show the typology's applicability in real world scenarios. We thereby contribute by fostering manageability of this complex field for all participants of TMSs. This can help with the identification of both well-established structural patterns and best practices of existing TMSs, setting a basis for benchmarking opportunities. Further it allows identification of interesting and promising white spots for future research and service innovations in the telemedicine sector.

Keywords: telemedicine, typology, service system, eHealth.

8.1 Introduction

TMSs are defined as the provision of medical services over geographic distances through the use of information and communication technology (ICT) (DGTelemed 2011). As the demographic shift in many industrialized countries has led to increased health care spending and a higher demand for services, threatening existing public health and welfare systems, TMSs have the potential to overcome many of the prevailing difficulties. Compared to health care spending in general, the proportion of TMSs is still relatively small. Yet, the global telemedicine market is expected to grow from $9.8 billion in 2010 to $23 billion in 2015 (BCC Research 2011), representing a fast growing market. The TMS sector is characterized by its heterogeneous stakeholders such as patients and their relatives, physicians and clinical personnel, (IT) service providers and professionals and hospitals as well as health insurance companies. These stakeholders can be regarded as participants of a service system (Maglio, Srinivasan et al. 2006). For many of these participants, TMSs is an opportunity to reduce costs (hospitals and health insurance companies), increase treatment quality (physicians), explore new markets (TMS providers) or feel healthier and intensively cared for (patients and their relatives). The heterogeneity of TMSs also applies to the range of applications, treatments or technologies used. Thus, the TMS sector is a very interdisciplinary field where many service system participants are facing challenges by accessing new domains, e.g. physicians needing to extend their IT skills or IT service providers needing to understand medical procedures as well as the traditional medical service provision in order to find new solutions where IT enables new and innovative TMSs.

This paper's contribution is to provide a comprehensive typology that allows structuring and describing TMSs. With the typology, we articulate a cohesive view of relevant dimensions that are usually discussed separately and are dealt differently in the various application fields and domains. We hence try to create a basis of shared information and jointly used language and terminology for the very heterogeneous field of TMSs. The typology can be used to detect and develop meta or reference classes of different TMSs, allowing the identification of best practices, success stories and thus providing a basis for comparison or benchmarking. It further could facilitate service design and service innovation processes within eHealth. The paper is structured as follows: In the following section we present related work and provide a detailed outline of existing typologies, followed by a description of our research approach and our understanding and goal of a typology. We then present the core contribution of this paper, a new telemedicine typology for which we describe its thirteen dimensions and respective attribute sets. For the assessment of the typology, we show its suitability by using example services. We close with a discussion and conclusion.

8.2 Related Work

We conducted a systematic literature search on the databases Science Direct, IEEE, Web of Knowledge, PubMed, ACM Digital Library and SpringerLink. As we were interested in identifying articles which attempt to draw a picture of the telemedical environment by presenting telemedicine typologies, the search comprised of the key words "telemedicine" and "typology" and their corresponding German expressions. The search has been limited to the fields "title", "keywords" and "abstract". The time period was January 2000 to August 2011. The search returned only 15 articles. A further screening of the articles revealed that only three of them present a typology for TMSs.

The typology by Dardelet (2001) categorizes TMSs in three main parts: telesurveillance, teleaction and teleexpertise. Telesurveillance relates to all TMSs in which data of the patient's health is remotely provided. This happens in a permanent or regular interaction setting and mostly applies to immobile people, e.g. elderly people. Thereby, it subsumes many services being performed in the post-hospital phase at the patient's home. Teleaction services are those which are based on synchronous communication, e.g. telesurgery, while teleexpertise is referred to settings that involve one expert or a group of experts on at least one side of the service provision party. An example might be the teleconsultation for telemedical stroke units. The term "telesurveillance" used by Dardelet corresponds to the term "telemonitoring" which is used in the vast majority of telemedical studies and is therefore used in the remainder of this paper.

The typology by Schultz and Salomo (2005) distinguishes the relationship between service provider and service consumer. Within the typology, services are characterized being doc-2-doc (relationship between two physicians) or doc-2-patient (relationship between physician and patient). The latter are coined primary (actually performing the treatment process) or secondary (supporting the treatment process) TMSs. Doc-2-doc services are supposed to be either teleeducation or teleconsultation services, e.g. in the field of teleradiology. Primary doc-2-patient TMSs are dealing with teletherapy, e.g. telesurgery, while secondary doc-2-patient TMSs are dealing with telediagnosis and telemonitoring. Telemonitoring services are often applied in fields such as cardiology or diabetic diseases in which data collection is comparably easy due to a high amount of digitized data.

Relationship	Doc2Doc		Doc2Patient		
	Teleeducation	Teleconsultation	Telemonitoring	Telediagnosis	Teletherapy

Figure 8.1: Graphical Representation of the Telemedicine Typology
Source: (Schultz and Salomo 2005)

The typology by Dierks (1999) names nine categories of telemedical services, namely:

Telediagnosis / Teleconsultation / Teleconference: takes place when one physician at the patient's place is assisted by a remote colleague being an expert and giving advice or indications for the relevant treatment. If more than two physicians are involved, the term teleconference is used.

Telemonitoring: remote observation and / or control of patient data over telecommunication means.

Teletherapy: Similar to telediagnosis or teleconsultation, but with an active participation of the remote physician in the treatment process.

Electronic patient records: The time-independent access to patient data at a remote storage center.

Electronic patient card: The patient owns a chip card which enables him / her to carry all personal health data in their wallet.

Electronic prescription: Electronic data that facilitates the processes between patient, physician and pharmacist to receive subscribed prescriptions.

Medical practice networks: Networks connecting medical practices with each other or hospitals.

Telearchival / archival storage: Digital repositories of stored data, e.g. PACS.

Consistent telecommunication system: secure and efficient data exchange based on consistent communication standards.

This typology aims to provide a complete set of all categories TMSs can be part of. Some of them are not mutually exclusive at all, but instead can be categorized by huge overlaps. Within the typology, distinctions can be made regarding the service providers and service consumers, e.g. all involved telemedicine stakeholders, as well as the used media, e.g. telecommunication means, and the service's object, e.g. remote diagnosis or monitoring (Dierks 1999). Although the presented typologies integrate valuable considerations, they obviously fall short on providing a decent description and classification scheme for the heterogeneous field of TMSs, yet they present good starting points.

8.3 Research Approach

Typologies are “conceptual, multidimensional classification schemes or sets of configurations that have been derived without a formally collected and quantitatively analyzed data set. [They identify] configurations or types exclusively on the basis of conceptual or theoretical distinctions” and resultant typologies are of an “a priori nature and generated mentally and verbally, not by any replicable empirical basis” (Bailey 1994). These characteristics make typologies distinctively different from other classifications such as taxonomies which are explicitly based on empirical data (Bailey 1994).

The goals of the presented typology can be described as descriptive and classificatory (Elman 2005). We thereby outline the characteristic features of TMSs on the one hand and provide classification opportunities on the other hand. The descriptive function of the typology is represented by 13 well-described dimensions, each represented by a set of attributes. While the dimensions claim to comprise the overall TMS environment and define a complete TMS typology, the attributes do not claim to be exhaustive. This is an important characteristic of our typology since it allows smaller adaption due to technical advancements, etc. Also, it might even inform new TMS configurations. Whereas the descriptive function of our typology is important and presents the TMS environment at a glance, the main contribution lies in its classificatory goals. Through the classification, the typology helps to structure the TMS environment, which is characterized by the heterogeneity of both TMSs and its service system participants, as well as by the diversity of the involved application fields and domains. We test our typology’s applicability by using exemplary TMSs. It is planned to extend this applicability testing by using numerous TMSs from various origins in consecutive research activities. Thereby, we provide benchmarking opportunities and allow for the derivation of meta or reference classes for TMSs. The derivation of meta classes would increase manageability, because the heterogeneity of the TMS environment could be separated into homogeneous classes that share common features.

The dimensions’ derivation was based on conceptual or theoretical distinctions as per definition. We considered the existent knowledge base and the results of our literature search as a valuable starting point for the derivation. We include references for all dimensions that are derived based on the according sources. The remaining dimensions are derived conceptually and from our own experience which is based on interviews with different participants of the service system telemedicine, own development of TMSs and the conduction of several case studies within the TMS environment.

8.4 The TMS Typology

This section presents our newly developed telemedicine typology which aims to overcome the shortcomings of the existing ones. The set of dimensions is depicted in Figure 8.2. For each dimension, we present a set of attributes which is, as discussed earlier, not a final set and explicitly allows the combination of attributes and the co-existence of more than one attribute per dimension within a TMS.

Purpose	Application field	Involved participants	Paying entity	Business model
Information type	Technology type	Frequency	Synchrony	Criticality
Location	(Device) mobility	Process orientation		

Figure 8.2: Dimensions of the Telemedicine Typology
Source: own illustration

Purpose: TMSs can follow different purposes such as cure, palliation, prevention or rehabilitation. Curative treatments aim to heal patients suffering from a disease or bad medical condition. Palliative treatments try to only reduce the negative consequences of diseases. Preventive treatments intend to avoid the outbreak of specific diseases whereas rehabilitative treatments aim to restore the physical conditions of patients.

Application field: This can be any sort of medical field such as cardiology, radiology, surgery, psychiatry, etc. Thereby, the before-mentioned combination of attributes within one dimension is important. There are TMSs that address several fields of application at the same time, e.g. devices measuring different vital parameters at a glance and require different skill sets, e.g. manual aptitude in surgery in contrast to emotional intelligence for psychiatric treatments.

Involved Participants: TMSs are characterized by its heterogeneous stakeholders such as patients and their relatives, physicians and clinical personnel, (IT) service providers and professionals, hospitals and health insurance companies (Peters, Drees et al. 2011). The relationships between all stakeholders concerned in the telemedicine sector are numerous and the overall telemedical environment can be regarded as a service system which is defined as "a value-creation network composed of people, technology, and organizations" (Maglio, Srinivasan et al. 2006) that need shared information for system-wide interaction (Spohrer, Maglio et al. 2007). Service systems explicitly consider all people such as the patient's relatives or other care personnel that are involved during the TMSs. It is one important aspect of all TMSs, especially in contrast to traditional medical service provision, to increase this shared information. For some treatment relationships already accepted terms exist (see Figure 8.1).

Paying entity: Within TMSs, the target user (patient / physician) might not be the paying entity (for doc-2-patient / doc-2-doc settings). Instead, health insurance companies are often responsible for the financial funding of offered patient-TMSs. This is the case in the primary health market. In contrast, the secondary health market is characterized by private funding. A special case is the provision of TMSs that have an initial funding from research funding institutions for a clearly defined pilot phase.

Business model: The aspect of the business model of TMSs relates to the decision of the TMS payment structure. Often the costs for telemonitoring TMSs at the patient's home can be characterized through initial device costs at the beginning of the overall treatment process and concurrent costs throughout the treatment phase which are due to the maintainance of the IT infrastructure and the costs for medical personnel controlling the data and initiating interactions, etc. The design of the payment structure is an important decision for the service provider and might differ considerably depending on the decision whether to sell or rent the device.

Information type: As all service systems, the TMSs use or create information, which in the context of service systems "can be expressed as informational entities that are used, created, captured, transmitted, stored, retrieved, manipulated, updated, displayed, and/or deleted by processes and activities" (Alter 2011). Typical types could be: voice or video (doc-2-doc consultation), electronic data sets (e.g. vital data and used sensors), observed emotions (psychiatric consulting hour) or self-reported documents (nutrition monitoring). The type of information has an influence on its accuracy and unambiguousness.

Technology type: TMSs integrate ICT per definition. The technologies include, but are not limited to: any kind of hardware and software configurations, tools used by service system participants, sensors or automated agents. The interplay of technology-enabled and person-oriented service activities is highly relevant for TMSs as "[telemedical] service systems are decomposed into successively smaller subsystems, some of which are totally automated" (Alter 2011).

Frequency: The treatment's frequency can be either discrete or continuous and might vary from once in a lifetime, e.g. for discrete alarm functionalities, to a 24/7 continuous telemonitoring setting.

Synchrony: The delivery of a telemedicine service can be synchronically, which indicates that the communicating participants have to invest in coordination activities so that the communication / interacting can be guaranteed. Asynchronous service delivery means that the communication process does not require the presence of the participants at the same time. Most telemonitoring services can hence be considered as the latter.

Criticality: Criticality describes a responsiveness requirement. It addresses the variance for availability and reaction demands, e.g. between the control of weight development for obesity patients versus life-critical TMSs in stroke unit networks.

Location: The place of the service consumption is the direct environment of the TMS location setting. It might range from the location of the medical service provider, e.g. hospitals, to the direct environment of the patient, i.e. his or her home or workplace, to extremely challenging settings such as airline flights or very remote areas. The location of the service offering is an important aspect in terms of operation and maintenance or problem handling scenarios.

(Device) mobility: Many TMSs are enabled through the use of devices which vary in terms of portability. Consequently, TMSs and their application differ widely in terms of their mobility. While telemedical defibrillators are implemented, other devices have to be worn. Others are at least portable – either restricted for specific areas such as the patient's home or completely location-independent - and TMSs might be stationary as well (e.g. doc-2-doc TMSs in hospitals).

Process orientation: TMSs consist of service activities and processes. When activities have a clear sequence and individual steps that are performed using defined methods, they constitute a process (Alter 2011). In contrast to clearly defined automated agent processes, activities might vary depending on environmental influences, e.g. through the moods of participants in person-oriented service provision. Process awareness as well as the sequence and order of ICT-enabled and non-ICT-enabled parts of TMSs need to be considered in this dimension. Levels of process orientation might be: no process orientation, implicit process awareness and knowledge of participants, explicit service structures, modular process design characterized by clearly defined process units and interfaces.

8.5 Applying the Typology

The following table applies the typology using four example TMSs.

	TMS 1	**TMS 2**	**TMS 3**	**TMS 4**
Short description of service	24/7 monitoring of defibrillator status including alarm functionality	IT-based physical activity intervention service with personal support capturing movement data via mobile app	Specialized stroke unit provides 24/7 teleconsultation support for several hospitals	Corporate health management for nutrition documentation and control
Dimension				
Purpose	Curative	Preventive	Curative	Preventive
Application field	Cardiology	Health promotion, fitness	Neurology	Dietetics
Involved participants	Patients, physicians, (IT) service providers	Patients, trainer, (IT) service providers	Patients, physicians, clinic personnel, (IT) service providers, hospitals	Patients, service providers
Paying entity	Statutory health insurance	Private persons, employee's company	Statutory health insurance, ministries, one NPO, one private company	Employee's company
Business model	Initial device / implementation payment plus regular monitoring payments	Continuous payments	Payments per session	Continuous payments
Information type	Sensor-captured electronic data	User-generated electronic data	Video, sensor-captured electronic data	User-generated and sensor-captured electronic data
Technology type	Sensors, data station, fixed line connection	Mobile phone, wireless connection	Camera, medical equipment, fixed line connection	Sensors, mobile phone, wireless connection
Frequency	Continuous	Discrete	Discrete	Discrete
Synchrony	Asynchronous	Asynchronous	Synchronous	Asynchronous
Criticality	Immediate action required	Not existent	Immediate action required	Not existent
Location	At home	Everywhere	Hospital	Everywhere
(Device) mobility	Implemented (monit. only within data station boundaries)	Portable	Static	Portable

	TMS 1	TMS 2	TMS 3	TMS 4
Process orientation	Strong (automated monitoring and escalation process)	Weak (person-oriented activities, process-driven training plans)	None (one consulting activity on demand)	Strong (regular input of nutrition data, follow-up process)

Table 8.1: Typology's Application using Exemplary TMSs
Source: own illustration

8.6 Discussion and Conclusion

Being research-in-progress, this paper faces some limitations. Although the descriptive character of our typology could be shown through the application of four example TMSs, more TMSs are needed to confirm our typology's classificatory claim. We will continue to describe and classify TMSs according to our typology, and, by the time of the conference, we hope to be able to present first meta classes and best-practice TMSs. Further, this paper misses a detailed evaluation of the presented typology. This will also be achieved during the continuous data collection and application of the typology.

We contribute by the provision of a comprehensive typology that consists of 13 dimensions and allows structuring and describing TMSs. For each dimension, we outline a set of attributes. Through its descriptive character, the typology can be used as navigation aid and entry point for practitioners and scientists that are new to the field of TMSs. From the perspective of its classificatory goal, the typology enables the detection and development of meta or reference classes of different TMSs which allows the identification of best practices, success stories and thus providing a basis for comparison or benchmarking and increase manageability of the heterogeneous TMS environment. Thereby, we address the needs of TMS experts who search for structured differentiation of their objects of investigation. With the typology, we articulate a cohesive view of relevant dimensions that are usually discussed separately and are dealt differently in the various application fields and domains. We hence try to create a basis of shared information and jointly used language and terminology for the very heterogeneous field of TMSs. Thus, we also contribute by facilitating interdisciplinary TMS developments and service innovation. Future research needs to show that our typology meets the intended goals to derive meta and reference classes for TMSs, to help with the identification of white spots and to support benchmarking and business opportunities.

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9 Towards Modularization of Complex Services – A Systematic Literature Review on Modularization Methods

Peters, Christoph; Menschner, Philipp; Leimeister, Jan Marco

Abstract:

This paper presents a systematic literature review and state-of-the-art analysis of modularization methods and checks their suitability for complex services. We develop an analysis framework guided by seven key questions and assess existing methods. Our results indicate that no modularization method for complex services is in existence as of yet. We could, however, identify forty-six modularization methods - eight of which deal with services. In a detailed discussion, we follow a concept-centric approach and summarize the methods' assessments based on the analysis framework. We nurture this by referencing the most relevant methods, serving as starting points for the design of modularization methods for complex services. This paper contributes to IS research by synthesizing literature and accumulating existing, interdisciplinary knowledge of modularization methods. We further provide researchers with ideas for future research activities and guide practitioners in selecting methods that serve as candidates to be integrated into modular efforts for complex services.

Keywords: Systematic literature review, State-of-the-art analysis, Modularization method, Complex services

9.1 Introduction

Service has grown into an important field of research in information systems (Rai and Sambamurthy 2006) as information technology (IT) revolutionizes the way services are delivered. The essential drivers in service innovation today are about adopting and effectively implementing IT within service offerings (Spohrer and Kwan 2009). On the one hand, IT enables new forms of cooperation and communication in services (Rai and Sambamurthy 2006); on the other hand, IT enables automation, standardization, and new concepts for customer integration (Fitzsimmons and Fitzsimmons 2005).

Services, however, are multifaceted phenomena. The scope of this paper are complex services. We refer to such services as follows: They are characterized by a combination of IT services and non-IT, highly person-oriented, and often knowledge-intensive services (Menschner, Peters et al. 2011). Their provision includes many stakeholders acting in service systems. Maglio and Spohrer (2008) define these service systems as "value-co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information (e.g., language, laws, measures, and methods)," while Alter (2013) states "a service system is a work system that produces services" and any processes or activities within services rely on resources (2012). Complex services hence must incorporate all types of resources. For development and provision of these services, handling this complexity constitutes an enormous challenge. To illustrate this, the field of telemedicine can serve as an example and we will use it throughout the paper. Telemedicine is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed 2011). Telemedical services (TMSs) comprise IT and non-IT services. IT services might be the data transfer of a TMS device to a monitoring facility. Due to industry standards or technical input-output requirements, these parts are highly standardized. Non-IT services might be knowledge-intense and person-oriented (KIPO) services, e.g., an interaction between physician and patient that could be highly individual because of the patient's individual state and situation. TMSs comprise a heterogeneous market, ranging from telemonitoring services (e.g., defibrillators that capture and transfer the patients' heart beat data in order to enable physicians to monitor the patients' heart functions remotely and to trigger alarm functions automatically) to teleconsultation services that enable experts to guide other physicians through the conduction of medical procedures, e.g., in telestroke units. As the IT and non-IT services inherent to any telemedicine service by definition differ so much in regards to their standardization and interface specification capabilities, TMSs can be regarded as complex services.

The market for telemedicine worldwide is continuously growing, from $9.8 billion in 2010 to an expected $23 billion in 2015 (BCC Research 2011). In the European market, it is expected to reach $5 billion in 2015 (European Commission 2014). For providers of TMSs who want not only to benefit from this expected growth but also to leverage their own market potentials in a competitive market, this prospect calls for flexibility in this fast-changing market.

Hence, it can be concluded that there is a need to better understand how innovations in complex services can be systematically introduced and developed. While there is already a solid knowledge base on service engineering, e.g., by Luczak (Luczak 2004) and Bullinger (Bullinger and Schreiner 2006), novel work should seek to "enhance the possibilities for modularization, standardization, contextualization and reconfiguration of service components and resources, as well as for modeling and simulation of the behavior of service systems and their key actors” (Böhmann, Leimeister et al. 2014).

A well-known concept for achieving the desired flexibility while being efficient is modularization. It offers various potentials: reuse of existing components or modules, faster development of new offerings, innovation as well as rapid configuration of individual offerings (Böhmann and Krcmar 2006). Further, modularization has to be conducted in a systematic manner, i.e., through the use of modularization methods (MM). However, applying MM to complex services raises questions that current literature can only answer rudimentarily.

Hence, the aim of this paper is to answer the following research questions:

- What are criteria that modularization methods for complex services need to address?
- What modularization methods do exist in literature and to which extent do they meet these criteria?
- What are the implications for modularization methods that deal with complex services?

To answer these questions, we developed an analysis framework. We have derived challenges and translated them into applicable questions. The framework then was used to review existing literature regarding their suitability for modularization of complex services.

The rest of this paper is structured as follows. First, foundations are laid by defining and describing two core concepts of this paper: modularization and methods. Second, the analysis framework we developed as well as the literature review are presented. The framework is guided by seven questions that are relevant for the modularization of complex services. Third, these questions and the corresponding answers provided in the discussion section are the main contribution of this paper. The results, i.e., the assessment of MM, are then discussed in terms of their applicability and usefulness in the context of complex services. Last, limitations and potential future research activities are outlined.

9.2 Foundations

This chapter aims at introducing the two core concepts, modularization and methods, for the literature review.

9.2.1 Modularization

Modularization is a well-established concept, which has been successfully applied in production contexts for many years (Ulrich 1995). IT has been applied for over 100 years in industry-related fields such as the automotive industry, aircraft construction, consumer electronics, and in the manufacturing of personal computers (Burr 2004). Other popular fields are nuclear power plant construction (Maru and Kawahata 2002), engineering, architecture, space station design, photovoltaic systems, robotics, and software development. Moreover, modularization has been applied extensively in the reorganization of factory structures (Burr 2002). However, the principle of modularization applied to the field of services is still in its infancy.

Modularization comprises the decomposition of one object into decoupled single components with specified interfaces which can be combined to create new single components (Böhmann and Krcmar 2006). First ideas go back to Parnas (1972), who postulated that decomposing systems into modules improves overall manageability, as not all (sub-)functions (of a module) need to be visible but can be hidden if the overall module function is clearly specified. Modularization has been examined for management and organizational contexts for almost two decades (Baldwin and Clark 1997; Baldwin 2008) and the building of a specific modularization theory has previously been attempted (Schilling 2000). In the context of services, the decomposition of an overall service creates modules that are built by services processes. These services can be consumed separately, but the combination of the modules enables the creation of new service offerings.

Modularization rests upon the basic principles of cohesion and loose coupling (Balzert 1996). Cohesion describes the extent of intra-module dependencies. A high cohesion is a requirement for well-specified modules that can be reused and combined with other service modules. Loose coupling (Böhmann and Krcmar 2006) means that there are only few inter-module dependencies between the elements of the different modules. Thus, loose coupling directs to the independence of the modules or partial services. Modules are connected by interfaces which also have to be specified appropriately.

The potentials of service modularization (Böhmann and Krcmar 2006) are manifold: (1) reuse - the repeated use of one specific module within different services; (2) faster development - the increase of overall development speed through higher manageability due to smaller objects of consideration (the modules) that have defined interfaces; (3) module-wide innovation - the possibility to concentrate innovation efforts within one strategically important module that is supposed to provide competitive advantages; (4) rapid reconfiguration - the efficient (re-)configuration of modules enables a customer-centric service provision in a mass customization manner.

As mentioned above, applying modularization has a long history in many fields, especially in production contexts. Thus far, only few studies have dealt with service modularization in particular (Voss and Hsuan 2009; Bask, Lipponen et al. 2010; de Blok, Luijkx et al. 2010; Tuunanen and Cassab 2011); in greater detail, the modularity of service process architectures has been examined (Frandsen 2012), and service modularity has been put into context with business model development (Rajahonka 2013) and customization (Rajahonka, Bask et al. 2013). While the concept and effects of service modularization have been elicited (Dörbecker and Böhmann 2013) and there are attempts to consider service modularity and customization systematically (Bask, Lipponen et al. 2011), systematic modularization - as the act of identifying and forming modules - in the form of MM still needs to be investigated further. When having a closer look at the overall service portfolios offered by providers of complex services, it becomes obvious that MM provide enormous potential. Modularization has the potential to foster service aggregation even across different stakeholders. Additionally, complex services are characterized by a high degree of heterogeneity because of their person-oriented fashion. Modularization can offer the possibility to mass customize individual offerings, e.g., by allowing optimal treatment at reasonable cost in telemedicine (Peters and Menschner 2012), where each patient's need is slightly different as a result of different life situations, state of disease, insurance coverage, etc.

9.2.2 Methods

According to Brinkkemper (1996), a method is an approach that describes the conduction of an entire development process or project. It provides a detailed prescription of how to perform a collection of activities. March and Smith (1995) view methods as a central artifact within information systems research, next to theoretical constructs, models, and instantiations. The authors further state that methods have a component-based structure. These components can be called techniques. A technique can be defined as a part of a method that gives concrete and tangible instructions on how to conduct the work of an activity. Brinkkemper (1996) defines a technique as “a procedure, possibly with a prescribed notation, to perform a development activity.” Thus, a method provides a systematic approach of how to use different techniques, and a tool is an automatic way to support a part of the development process.

The term method is closely related to method engineering (ME) (Brinkkemper 1996). Brinkkemper defines method “as an approach to perform a systems development project, based on a specific way of thinking, consisting of directions and rules, structured in a systematic way in development activities with corresponding development rules” (1996). Further, method refers to a particular procedure for attaining something (Odell 1996). ME conceives methods as a set of disparate fragments. These method fragments need to be stored in a repository that are standardized and then used to compose a new method based on the project situation. These developed methods must be adapted and tailored to the specific context in which they are used (Henderson-Sellers and Ralyté 2010).

However, ME assumes pre-established, formal methodologies that are used to derive method fragments. For the case of complex services, this proves to be difficult, since such a formal approach is impractical when addressing social and personal aspects. A method is hence a process that is planned and systematic in terms of its meaning and purpose (Braun, Wortmann et al. 2005). This understanding needs also to be applied for modularization efforts. Characteristic features of modularization methods are goal-orientation, a systematic approach (rules on how to act and precise tasks for achieving goals), principles (design-guidelines, strategies, templates, and reference models), and repeatability.

9.3 Research Method

9.3.1 Analyzed Aspects

In this chapter, the analysis framework is introduced in detail. The seven questions are motivated by the literature we found and constitute our analysis framework as outlined below:

Which service system components are addressed by the approach (Service System Perspective)? In this section, we are going to tie in with the service-definitions we introduced in chapter 9.1. According to (Alter 2013), “service providers are participants in service systems. In addition, customers often are participants in service systems because they often perform some of the work within the service system." Complex services hence consist of IT and non-IT services (human tasks) and are always constituted through person-oriented services. According service systems include the people necessary to perform these processes. As for TMSs, this leads to a service system in which people, e.g. physicians, patients, and their relatives, and / or machines, e.g., telemedical devices, use information (e.g., patient heart data), technology, and other resources to deliver telemedical services. Customers are active participants and also the beneficiary of the service, e.g., within TMSs active participation of the patient - the beneficiary - is necessary, e.g., by reporting a state of health, wearing specific devices, etc. (Essén 2009) That is why MM for complex services need to cover all of these service constituents. This is reflected in the service perspective dimension which can be attributed to: "no service perspective (no)"; "an exclusive IT service perspective (IT)"; "an exclusive non-IT service perspective (S)"; a combination of these two "(IT+S)" or "a holistic service perspective (HS)"; however, the latter would be the one which suits the requirements of a modularization method for complex services because it also integrates person-oriented services. Considering that many MM (also from other more or less related fields) are included, this dimension is of highest significance for deriving implications for the design of MM for complex services.

Are all phases of modularization covered by the approach (Life cycle coverage)?: When underlying the above-mentioned definition of modularization, typical phases of modularization (Lai and Gershenson 2008) can be found taking a modularization life-cycle perspective, i.e., (1) capturing the actual offering, (2) decomposition, (3) modularization, (4) interface specification, and (5) testing / evaluation. This aspect is important, as it distinguishes end-to-end methods from techniques that focus on sub-problems only. This analysis further can provide candidates that might be integrated in order to derive end-to-end MM (Brinkkemper 1996). For creating the most value possible, we try not only to answer this yes / no question, but to also capture the phases in the analyzed methods, as well as to mention all captured phases per MM.

How detailed are the phases described (Granularity)? A method is a process that is planned and systematic in terms of its mean and purpose (Braun, Wortmann et al. 2005). Characteristic features of methods are goal-orientation, a systematic approach, and repeatability. This implies that methods need to provide a detailed prescription of how to perform a collection of activities, and give concrete and tangible instructions for how to conduct the work of an activity (Brinkkemper 1996; Odell 1996). As methods often have a component-based structure, these components can be called techniques. According to Brinkkemper's definition of technique, this leads to a product-oriented and process-oriented view. The product-oriented view focuses on the output of applying the technique, which, for example, can be a conceptual model. In the process-oriented view, a technique describes the necessary activities in order to produce the outcome of the technique. Further, repeatability can be assured by deriving principles, design-guidelines, templates, or reference models to support the engineer. The phases of a method or technique can be measured according to their granularity: detailed phases with comprehensive techniques / examples (++), clearly described phases, partly with examples (+), phases with brief description (0), and phases only mentioned (without description) (-).

Is the method supported by a repository such as a service repository or module system (Service Architecture View)? This tells us something about the service orientation in the field and the awareness of well-defined interfaces known from IT services and Service Oriented Architecture (SOA) implementations (Peters and Leimeister 2013). The leading question is: Does a so-called service repository exist (yes) which comprises all modules of the provider(s) that then can be orchestrated or not (no)? If existing, such a repository is a key driver for the engineering of new services, as they can be based (at least partly) on existing modules. The importance of this aspect can be illustrated by the TMS example: TMSs comprise IT services such as data transfer, device management, or software updates. Due to industry standards or technical input-output requirements, these parts are highly standardized. Having a repository supporting the method would ease complying with these standards and the reusing of different components.

Does the method allow for the redesign / optimization of existing complex services (Aim)? As goal-orientation is a characteristic feature of a method (Braun, Wortmann et al. 2005), this dimension reflects how, by whom, as well as for whom the approaches are designed. Typically, there are very different providers that enter the market: very matured, big organizations such as - in the case of telemedicine - telecommunication providers with a well-established service architecture on the one side, and new companies just founded that plan to deliver complex services exclusively to this market, on the other side. The method's aim can be: "creating (C)" modules not as yet existing, e.g., creating new, innovative module-based offerings, or "modifying (M)" existing offerings (through decomposition, etc.), e.g., by shifting from a non-modular design to a modular one, or both (both). In the context of complex services, this can be considered a top feature, as it facilitates the improvement of service configurations despite challenges specific to complex services such as the integration of person-oriented modules which are not easily standardized.

Application Scope: Services, especially complex services, are often positioned in interdisciplinary fields (Buhl, Heinrich et al. 2008). For the case of TMSs, this would inter alia imply medicine, computer science, or telecommunications. In order to integrate the different perspectives, the scope of the MM applicability is the present object of consideration. Is the method designed and applicable for “a dedicated case (C)” (e.g., in the production process of industrial products), “a specific domain (D)” (e.g., in the automotive sector), or “in general (G)”, i.e., for all products and services in all domains? This aspect is important, as it provides indications as to which extent a method could be transferable to other domains. Some MM are such specific for their respective case that their value for other cases or domains is hardly provided.

Continuity: The markets of complex services are fast-changing ones that create many new service offerings or configurations in short development cycles. It is therefore important to focus on the repeatability of the analyzed method in the progress of the changing service portfolio of providers. The dimension answers the question: Is the method supposed to be applied once (O) (i.e., an architecture of modules is created that is not supposed to be changed), event-driven (E) (e.g., after new product launches), or in regular temporal loops (R) (e.g., every year)? Most complex services, such as TMSs, are fast-changing environments, which implies very short innovation loops (Berry and Bendapudi 2007). This holds especially true for the IT services and their underlying infrastructure. MM for complex services thus must be able to handle technological change on a repeated basis.

9.3.2 Systematic Literature Review

In order to derive a broad coverage of literature on MM, we performed a systematic literature review on the online databases of: AIS Library, IEEE Xplore Digital Library, ACM Digital Library, EBSCOhost Google Scholar, and SpringerLink. Further, we included the Senior Scholars' Basket of Journals (Members of the Senior Scholars Consortium 2011). As we are dealing with services, we additionally considered all A-D ranked service journals of the VHB JOURQUAL ranking 2.1 (VHB 2012). As proposed by Webster and Watson (2002), this set of searched databases and journals was further extended by a comprehensive review of relevant academic top-ranked conferences, i.e., all AIS conferences and all affiliated AIS conferences. Thus, we hoped to increase the probability of including latest research activities that are characterized by shorter review cycles than most journals.

Our search comprised the key words "modularization method" and "modularisation method"; "modularization approach" and "modularisation approach"; as well as their German equivalents "Modularisierungsmethode" and "Modularisierungsansatz." We did not include service specifics in the literature search process, as we wanted to establish a broad literature base for the analysis. Service specifics were included into the analysis framework which is explained above. The search was limited to the fields: "title," "keywords," and "abstract" where possible; an outlet such as Google Scholar only leaves the option to perform full text searches. The review time period was from the beginning of the outlets' releases until January 2015. This initial search returned 1342 publications. After a preliminary scan of the article abstracts, we excluded all publications that did not deal with modularization in a systematic manner. Next, we excluded all papers that only mentioned MM without further description or explanation. Accounting for duplicate results, the number of articles to be included was reduced to 44.

For all outlets that delivered search hits, the initial results and the results after applying our filter are visualized in Table 9.1.

	EBSCOhost	**IEEE Xplore Digital Library**	**AIS Digital Library**	**Google Scholar**	**Springer Link**
modulari[z/s]ation method	1 (8)	0 (19)	1 (2)	17 (383)	5 (80)
Modularisierungs-methode	0	0	0	5 (14)	0 (3)
modulari[z/s]ation approach	2 (25)	2 (10)	1 (3)	3 (499)	4 (137)
Modularisierungs-ansatz	0	0	0 (2)	2 (128)	1 (29)

Table 9.1: Search Results
(initial findings in brackets)
Source: own illustration

As suggested by Webster and Watson (2002), we also "went backward" by reviewing the citations for the articles. By analyzing these resulting works in detail, we could identify eight review articles (Straube and Ouyeder 2001; Holmqvist and Persson 2003; Hölttä and Salonen 2003; Hui 2004; Padamat 2004; Pirrung 2004; Mons, Tapie et al. 2010; Daniilidis, Ensslin et al. 2011) that mentioned and discussed several methods. By working through these review papers, we again found (after applying the same filter, i.e., excluding all papers that only mentioned MM without further description or explanation) additional works depicted in the following table:

Review Paper	**Additionally found publications**
(Daniilidis, Ensslin et al. 2011)	(Pimmler and Eppinger 1994; Ericsson and Erixon 1999; Stone, Wood et al. 2000; Martin and Ishii 2002)
(Holmqvist and Persson 2003)	(Kahmeyer, Schneider et al. 1994; Pahl and Beitz 1996; Erixon 1998; Huang and Kusiak 1998)
(Straube and Ouyeder 2001)	(Kusiak and Chow 1987; Pimmler and Eppinger 1994; Lanner and Malmqvist 1996; Erixon 1998; Göpfert 1998; Schuh, Millarg et al. 1998; Eversheim and Neuhausen 2001; Burr 2002; Matt 2002; Schmidt 2002; Koppenhagen 2004; Schuh, Merchiers et al. 2004; Böhmann and Krcmar 2005; Corsten and Gössinger 2007; Blees, Jonas et al. 2008; Lai and Gershenson 2008)
(Pirrung 2004)	(Kahmeyer, Schneider et al. 1994; Pahl and Beitz 1996; Erixon 1998; Huang and Kusiak 1998; Yassine 2004)
(Hui 2004)	(Suh 1990; Kahmeyer, Schneider et al. 1994; Pimmler and Eppinger 1994; Pahl and Beitz 1996; Erixon 1998; Huang and Kusiak 1998)
(Padamat 2004)	(Erixon 1998; Stone, Wood et al. 2000; Hölttä and Salonen 2003)
(Hölttä and Salonen 2003)	(Pimmler and Eppinger 1994; Ericsson and Erixon 2000; Stone, Wood et al. 2000)
(Mons, Tapie et al. 2010)	(Steward 1981)

Table 9.2: Relevant Articles Retrieved through Review Papers
Source: own illustration

Overall, there were 46 MM that we could retrieve and which are categorized in our analysis framework.

9.4 Results

In this section, the results of our systematic literature review are presented. The assessment of the literature using our analysis framework was conducted independently by two coders. The second coder restricted the analysis to a random control sample. The results of the coding process of the control sample were consistent with the results of the original coder. In the following, we describe our observations that resulted from the analysis of the eight approaches. Table 9.3 displays the eight approaches identified that integrate a service perspective (please refer to Table 9.4 in the Appendix for the full results of our assessment).

Reference	Service System Perspective	Life Cycle Coverage	Granularity	Service Architecture View	Aim	Application Scope	Continuity	Description
(Peters and Leimeister 2013)	IT+S	1-5	+	yes	M	D	O	Five-phase method for complex services that starts with an existing but un-modularized service offering
(Böttcher, Becker et al. 2011)	IT+S	1-4	+	yes	M	G	O	Meta model for the modularization of services to enable customer specific service offerings
(Burr 2002)	IT+S	1-4	+	yes	M	C	O	Presents a comprehensive method which is applicable to IT and non-IT services
(Böhmann 2004) and (Böhmann and Krcmar 2005)	IT	1-5	+	yes	both	C	O	Restricted to the modularization of IT services
(Böhmann, Langer et al. 2008)	IT	1-4	+	yes	M	C	E	Sums up and slightly further develops findings of [(Böhmann and Krcmar 2005)]
(Sarkar, Ramachandran et al. 2009)	IT	1-4	0	no	M	D	O	Modularization approach applied to a large-scale banking application
(Bavota, De Lucia et al. 2010)	IT	1-3	+	no	M	C	O	Generates a meaningful re-modularization of software systems
(Corsten and Gössinger 2007)	S	1-4	+	no	M	D	O	Created for the modularization of logistic services, relies on the analysis of process dependencies

Reference	Service System Perspective	Life Cycle Coverage	Granularity	Service Architecture View	Aim	Application Scope	Continuity	Description

Legend:

Service System Perspective: "an exclusive IT service perspective (IT)"; "an exclusive non-IT service perspective (S)"; a combination of these two "(IT+S)"

Life Cycle Coverage: (1) capturing the actual offering; (2) decomposition; (3) modularization; (4) interface specification; (5) testing / evaluation

Granularity: (++) detailed phases with comprehensive techniques / examples; (+) clearly described phases, partly with examples; (0) phases with brief description; (-) phases only mentioned (without description)

Service Architecture View: Does a so-called service repository exist (yes) which comprises all modules of the provider(s) that then can be orchestrated or not (no)?

Aim: "creating (C)" modules not as yet existing; "modifying (M)" existing offerings (through decomposition, etc.); both (both)

Application Scope: "a dedicated case (C)"; "a specific domain (D)"; "in general (G)"

Continuity: Is the method supposed to be applied once (O); event-driven (E); in regular temporal loops (R)

Table 9.3: Results of the SLR - Assessment of MM dealing with Services using the Analysis Framework
Source: own illustration

In order to assess the question of how existing MM address the specifics of complex services, we first analyzed if and how all components of a service system are integrated into the approaches (Service System Perspective). Most literature does not integrate all components of a service system. The most promising starting points here are provided in the publications that (at least) deal with services. We identified eight approaches that go beyond modularization of products that can serve as starting points for MM for complex services.

Concerning the question whether all phases are covered within the method (Life cycle coverage), a particular pattern can be identified. Most approaches focus on the first phases of modularization. There are results that cover all phases (e.g., (Böhmann and Krcmar 2005; Koga and Aoyama 2007)), but this is not valid for all publications found. The ones that cannot be regarded "complete" in this respect mostly ignore interface specifications and (most commonly) an explicit testing and evaluation phase.

Regarding the level of detail in the description of the phases (Granularity), a variety of approaches for modularization has been proposed that provide no actionable details. Most of the approaches also lack appropriate method and tool support that would allow a better penetration of concepts in practice.

This also links to a further dimension of our review, whether the proposed methods are supported by a repository such as a service repository or module system (Service Architecture View). This important aspect can be regarded as the major shortcoming of all existing methods, as none is explicitly supported by a service repository.

Concerning the objective of the methods being developed for the creation or the reconfiguration of services (Aim), more approaches focus on the redesign of existing modules than the new creation of modules.

Finally, we assessed the methods on their generalizability and transferability to complex services (Application Scope and Continuity). Most of the analyzed methods were intentionally designed to be domain-specific, yet most were dedicated to a specific case. No MM could be identified that claims to be applicable in general. Concerning the latter works we identified and analyzed, our results show that the application and development of MM are still mainly limited to the development of material products respectively the creation of modular product architectures. Regarding the application scope, domain-specified MM are unusual, e.g., specific MM used in the construction of nuclear plants (Maru and Kawahata 2002) or in the construction of rail vehicles (Schmidt 2002).

9.5 Discussion

The chapter discusses the results shown in Table 9.3 and articulated in the section above. Our discussion is concept-centric and thereby follows the structure of our analysis framework.

In terms of the service system perspective, Burr (2002) has developed a modularization method for different types of services, e.g., IT services or financial services. His method comprises four steps, from decomposition of an overall functionality in partial functionalities, to division into partial services, to normalizing and specification of interfaces. The goal is to create modular service architectures, imitating the well-established concept of product architectures. This approach makes Burr's modularization method a good candidate for inspiring the design of TMS-MM, as it can serve as a framework for a TMS provider to structure their overall TMS portfolio. There is thus the possibility of forming service modules comprising specific IT-related functions, e.g., health monitoring functions, telediagnosis-related functions, or teleconsultation-related functions.

However, as Burr et al. (2002) focus mainly on technical services, the person-oriented dimension is covered insufficiently within the method; it would thus need to be extended in order to be able to modularize complex services explicitly. Similarly, this holds true for the method of Corsten and Gössinger (2007). They present a modularization method for logistic services based on the analysis of process dependencies. The measurement of the strengths of the connections between the processes is summarized in a process dependency matrix. This approach provides its most useful contribution to the design of MM for complex services with its dependency matrix. Its matrix might address the special challenge of different kinds of interfaces, ranging from those which are easy to standardize (e.g., IT services that use technical standards and well-defined interfaces) to interfaces being responsible for the interplay between person-oriented services and other services.

Other works considering not only products focus on modularization, especially in the context of IT services. Böhmann and Krcmar (2005) have created a systematic approach for the development of modular service architectures in the context of IT. Their approach was subsequently further developed and formalized to the SCORE-method by Böhmann et al. (Böhmann 2004; 2008). This method makes use of the economic potential of the modularization of services. The modular service architecture uses four types of modules: system performance modules, process performance modules, special modules, and integration modules. From a complex service perspective, the determination of performance characteristics and service levels especially, but also the application of the well-elaborated modularization matrix, seem promising. Yet, despite their method potentially being adapted to the technical parts of complex services, the method in its current state is not capable of handling patient-to-doctor relationships and integrating them into an overall modularization of complex services, because the many person-to-person interactions in such settings of complex services would always lead to a so-called integration module.

When it comes to life cycle coverage, the approaches that explicitly integrate interface specification and evaluation phases are of utmost importance for modularizing complex services, as defining interfaces between human tasks such as medical examinations and non-human tasks such as IT-services are complex and put great challenges on the design of complex services. Hence, solutions for defining and specifying such interfaces need to be provided. Further, as developing complex services is challenging within a user's changing environment (i.e., patients having little to no experience with such services), testing and evaluating are crucial for service success (Menschner, Peters et al. 2011).

As we presented, there are many approaches lacking appropriate method and tool support that would allow a better penetration of concepts in practice. To fulfill this, these methods need to be specified and elaborated upon in more detail. Other methods are already mature, yet they cover only distinct aspects of modularizing complex services, e.g., the product or IT components. A comprehensive approach for modularizing complex services comprising guidelines and detailed actions and tasks could not be found. The service architecture view is not integrated in the majority of approaches. Such repository could facilitate the construction of complex service modules, as it improves reusability and synergistic effects between modules. As to the aim of modularization approaches, most do not consider the new creation of modules, but allow for a redesign of existing modules. This seems to be adequate as within complex services, a major goal is to improve service configurations. Creating completely new modules from scratch seems rather difficult due to challenges such as the integration of person-oriented modules, as well as the need for continuity.

Mainly, MM are applied for the development of industrial products, without being specially created to consider the characteristics of specific types of industrial products. Moreover, no MM have been detected that are especially developed to create new and innovative modular-built products, although a few methods explicitly call for this option. Many typical phases of the modularization process are explicitly stated in most detected MM, but a slight majority of MM do not comprise the step of evaluating the results of the modularization process. Regarding the aspects of continuity, most MM are not designed to be reapplied if particular events occur or if a specific time has passed since its previous application. But if the process of applying MM includes the analysis of particular events or customer requirements, the re-application of the MM can be derived if particular events occur or customer requirements change. As stated previously, no MM exists that match the particularities of complex services.

To sum up, one of the main challenges in modularizing complex services is in the duality of not only people-bound activities and IT components but also their interrelation; our results confirm that MM thus far have not been successfully applied to map the individual and personal services within modularization architectures. Another big obstacle is interface design specification between modules. Despite being resolved within product modularization and even IT services, complex services put enormous challenges on interface specifications. For the field of TMSs, this can be exemplified on the steady research stream and activities aiming at standardization of interfaces (Duennebeil, Sunyaev et al. 2013). Due to human tasks and involvement, to the best of our knowledge, no method is capable of this. However, we identified several works offering promising starting points. While Burr (2002) might be valuable when it comes to interfaces between different kinds of service types, the works of Böhmann and colleagues (Böhmann and Krcmar 2005; Böhmann, Langer et al. 2008) might be beneficial for the consideration of the IT services of complex services interfaces. These work as well, and the method by Corsten and Gössinger (2007) might be studied more extensively in regards to the applicability of their presented dependency matrices. For the combination of such methods, modularization engineering principles should be taken into account.

From the analysis of all the other found and examined approaches which are outlined in Table 9.4 in the appendix, we can conclude that especially for the many interdisciplinary attempts of modularization, it is highly recommended to check for the existing approaches whether they might provide insights for the domain of study.

9.6 Limitations and Future Research

As in any literature review, this paper faces limitations due to the literature selection process. By not only integrating several online databases (the Senior Scholars' Basket of Journals, dedicated service journals, AIS, as well as affiliated AIS conferences) but also by following Webster and Watson (2002) suggestion to "go backward" and taking citations of gained review articles into account, we tried to reduce the risk of missing out on relevant works. Still, there is the possibility that we have omitted important works that did not match our search criteria. Another limitation might be that we could not avoid Google Scholar to search the full texts while we were able to restrict other databases to only search in titles and abstracts, etc. This explains both, the high number of overall results in Google Scholar, but also the low percentage of relevant results.

As for future research, this literature review on MM for complex services should be the basis for the design and evaluation of MM in the domains dealing with such services. Here, tool-support and further automation of such methods need to be addressed. The concept of systematic modularization for other fields is worthwhile for future research as well. In times of increased digitization, there is an increased need for all methods and techniques that manage services which comprise a combination of IT and non-IT services. As modularization often takes place in very interdisciplinary settings, concepts are necessary which can be easily communicated and understood. Thus, the (visual) representation of to-be-modularized services and according modularization methods by comprehensive modeling techniques is an important area of research. Furthermore, modularization attempts within the upcoming research activities of engineering service systems is of utmost importance. Here, the engineering and management of modular service architectures integrating many stakeholders of service systems comes into play. This is accompanied by challenges in regards to newly to-be-defined roles in the service systems, e.g. service providers becoming service orchestrators of value co-creating service networks. Here, the question arises how modularization benefits can be realized within the overall system. These service system perspectives and according concepts might also bring a necessity for new jobs or competencies to perform existing jobs. For all digital environments and digital services, new forms of digital work and blended work scenarios are possible. When planning them as modular services, concepts for these forms of digital work needs to be designed and evaluated. This is much in line with architecture thinking as in SOA. When implementing such concepts in fields of complex services, the singular focus on IT services needs to be extended in order to address also person-oriented service offerings.

9.7 Conclusion and Outlook

We conducted a systematic literature review of MM in order to derive implications for a modularization method for complex services.

Thereby we tried to answer the following three research questions:

- What are criteria that modularization methods for complex services need to address?
- What modularization methods do exist in literature and to which extent do they meet these criteria?
- What are the implications for modularization methods that deal with complex services?

We therefore created an analysis framework that consists of the relevant criteria and which helped us assess the suitability of our search results within this context. We found that most MM do not incorporate a service perspective at all, and even if this were the case, the person-oriented part of complex services would still not be taken into account.

According to Webster and Watson (2002), a contribution of a literature review is to identify critical knowledge gaps in existing research and establishing a chart for future research. Thus, the results presented in this paper can serve as a first step toward filling the research gaps proposed in recent research appraisals in the field of service science calling for development of suitable methods. Many identified modularization methods are still too general and abstract to be widely employed and accepted in practice. To meet the challenges for the case of a modularization method for complex services, methods are needed that support these services as a whole.

As we gained these results and presented existing MM, we also assessed them in regards to the criteria using our analysis framework. The main gap we identified is a lack of methods capable of handling IT and non-IT, especially person-oriented services. Overall, four MM could be found that explicitly deal with IT services (Böhmann and Krcmar 2005; Böhmann, Langer et al. 2008; Sarkar, Ramachandran et al. 2009; Bavota, De Lucia et al. 2010): one that deals with logistic services (Corsten and Gössinger 2007) and three (Burr 2002; Böttcher, Becker et al. 2011; Peters and Leimeister 2013) that integrate IT and non-IT services.

Regarding implications for a modularization method for complex services, it can be concluded that there is still a lack of MM that also integrate person-oriented services, which is crucial for complex services such as TMSs, as these are the services that originated in the traditional medical service provision performed by physicians or nurses. Often, these are important parts of the overall service offering that represent the most trust-building and value-creating ones. We have further pointed out the way in which some of the identified MM can be used to serve as valuable parts to be integrated and combined by means of ME to develop a comprehensive modularization method for complex services through future research, e.g., the paper by Böhmann et al. (2008) is suitable to provide insights into all IT-relevant parts of MM for complex services. It is a long way ahead, but the findings might also be the foundation for an integrated service architecture.

Thus, the paper at hand contributes to theory by synthesizing the literature and by accumulating the existing knowledge of MM. This is hoped to be valuable not only for many fields integrating person-oriented services or IT/non-IT service configurations, as well as for service modularization in general, but also by laying a foundation for all research activities dealing with MM for complex services, especially the design of a modularization method for complex services. As these MM are posited to enable providers to develop and (re-)configure complex services more efficiently, we also reinforce service and customer orientation in complex service environments and thus make a practical contribution.

9.8 References

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9.9 Appendix

The results of our systematic literature review are presented and assessed according to our analysis framework in Table 9.4 below.

Reference	Service System Perspective	Life Cycle Coverage	Granularity	Service Architecture View	Aim	Application Scope	Continuity	Description
(Granström and Hagman 2012)	no	1-5	++	no	M	D	O	Applied to modularize electronic defense systems
(Ericsson and Erixon 1999)	no	1-5	++	no	M	C	O	Five-step approach for the creation of modular product architectures considering customer requirements
(Göpfert 1998)	no	1-5	+	no	both	C	O	Supports modularization in the product development process
(Lai and Gershenson 2008)	no	1-5	+	no	M	C	O	Approach which additionally considers the similarity of assembly processes
(Koga and Aoyama 2007)	no	1-5	+	no	M	C	O	Design of product family architectures considering the maximization of the product variety and the minimization of family costs

Reference	Service System Perspective	Life Cycle Coverage	Granularity	Service Architecture View	Aim	Application Scope	Continuity	Description
(Blees, Jonas et al. 2008)	no	1-5	0	no	both	C	O	Designed for the creation of modular product families
(Eversheim and Neuhausen 2001)	no	1-5	0	no	M	C	O	Systematic modularization of the fabric organization to increase flexibility and adaptability
(Koga, Niwa et al. 2009)	no	1-5	0	no	M	C	O	Systematic modularization of engine rooms
(Kusiak and Chow 1987)	no	1-5	0	no	M	C	O	Algorithms for the modularization of industrial products to overcome group technology problem
(Schmidt 2002)	no	1-4	++	no	M	D	O	Created for the process of the construction of railway vehicles
(Blees 2011)	no	1-4	++	no	M	C	O	Comprehensive approach for the creation of modular product families
(Yassine 2004)	no	1-4	+	no	M	C	O	Matrix-based tool for modularization process
(Günthner, Wilke et al. 2006)	no	1-4	+	no	M	C	O	Structured and function-oriented modularization process for material flow systems
(Huang and Kusiak 1998)	no	1-4	+	no	M	C	O	Unifies different models and solutions to systematically modularize electrical and mechanical products
(Pimmler and Eppinger 1994)	no	1-4	+	no	M	C	O	General three-step process for the modularization of industrial products
(Arts, Chmarra et al. 2008)	no	1-4	+	no	M	C	O	Systematic modularization of large-complex products to increase their adaptability characteristics
(van Beek, Erden et al. 2010)	no	1-4	+	no	M	C	O	Modularization scheme for the modular design of mechatronic systems
(Jiang, Zhao et al. 2007)	no	1-4	-	no	M	C	O	Approach based on axiomatic design for the process of creating modular product families
(Pahl and Beitz 1996)	no	1-3	++	no	both	C	O	Six-step approach which supports the entire product development process

Reference	Service System Perspective	Life Cycle Coverage	Granularity	Service Architecture View	Aim	Application Scope	Continuity	Description
(Martin and Ishii 2002)	no	1,3,4	++	no	M	C	E	Systematic Modularization depending on the requirements to change product components and on the coupling strengths of the product components
(Wong and Bhattacharyya 2002)	no	1-3	+	no	M	G	O	Presents the Task-Structure approach for the modularization of knowledge intensive processes
(Stone, Wood et al. 2000)	no	1,3,4	+	no	M	C	O	Heuristic approach for the identification of modules for modular product architectures
(Hölttä and Salonen 2003)	no	1-3	0	no	M	C	O	Five-step algorithm is presented for the modularization of industrial products
(Lanner and Malmqvist 1996)	no	1-3	0	no	M	C	O	Unifies two further approaches to create a matrix approach used for the design of product architectures, considering technical and economic aspects
(Hata, Kato et al. 2001)	no	1-3	-	no	M	C	O	Presents a process of modularization which supports life cycle management
(Matt 2002)	no	1,3,4	-	no	M	C	O	Supports the modularization of production systems to respond to current requirements for modern factories
(Fukushige, Tonoike et al. 2009)	no	1,3,5	-	no	M	C	O	Supports the design of modular product architectures considering life-cycle requirements
(Maru and Kawahata 2002)	no	1,3	-	no	M	D	O	Already applied for the process of nuclear power plant construction
(Zhuo, San and Seng 2008)	no	3	-	no	C	G	O	Approach to modularize product family architecture (PFA)
(Krohs 2010)	no	2	-	no	M	D	O	Modularization method for decomposing biological networks

Reference	Service System Perspective	Life Cycle Coverage	Granularity	Service Architecture View	Aim	Application Scope	Continuity	Description
(Kong, Yang, Zhang, Li and Lian 2010)	no	3, 5	0	no	M	D	O	Reformation method based on modularization
(Wang, Yang, Le and Zhao 2013)	no	3	-	no	M	D	O	Automotive modularization design
(Ji, Chen, Qi and Song 2013)	no	3	0	no	C	G	O	Effectiveness-driven modular design method
(Wende, Thieme and Zschaler 2010)	no	3, (4)	-	no	M	D	O	Modularization approach covering both syntax and semantics
(Xu and Jiao 2013)	no	3, (5)	0	no	M	D	O	Design process modularization approach to establish the design process architecture and an integrated modeling and simulation method based on Petri nets (PNs)
(Abeyruwan et al. 2014)	no	3	-	no	C	D	O	BioAssay Ontology (BAO); description of a methodology for ontology modularization using a layered architecture
(Steinbauer, Fraser, Mühlenfeld and Wotawa 2004)	IT	3	0	no	C	C	E	Design approach for mobile robots
(Anding, Köhler and Hess 2003)	no	3	0	yes	C	D	O	Conceptual framework for a product platform; modularization approach separating content, semantic and layout

Legend:

Service System Perspective: "an exclusive IT service perspective (IT)"; "an exclusive non-IT service perspective (S)"; a combination of these two "(IT+S)"

Life Cycle Coverage: (1) capturing the actual offering; (2) decomposition; (3) modularization; (4) interface specification; (5) testing / evaluation

Granularity: (++) detailed phases with comprehensive techniques / examples; (+) clearly described phases, partly with examples; (0) phases with brief description; (-) phases only mentioned (without description)

Service Architecture View: Does a so-called service repository exist (yes) which comprises all modules of the provider(s) that then can be orchestrated or not (no)?

Aim: "creating (C)" modules not as yet existing; "modifying (M)" existing offerings (through decomposition, etc.); both (both)

Application Scope: "a dedicated case (C)"; "a specific domain (D)"; "in general (G)"

Continuity: Is the method supposed to be applied once (O); event-driven (E); in regular temporal loops (R)

Table 9.4: Overall Results of the SLR - Assessment using the Analysis Framework

Source: own illustration

10 TM³ - A Modularization Method for Telemedical Services: Design and Evaluation

Peters, Christoph; Leimeister, Jan Marco

Abstract:

The paper presents a method (TeleMedicine Modularization Method: TM³) that enables telemedicine providers to modularize their services in order to offer customer-centric and tailored telemedicine services (TMSs). Modularization which inherits potential benefits such as reuse, faster development, module-wide innovation and rapid reconfiguration is supposed to become crucial for successful service delivery in the heterogeneous, fast growing and highly specific telemedicine market. This complex environment is characterized by the challenge of integrating IT as well as non-IT and highly person-oriented service parts. Based on a case study informed set of criteria, this design science paper introduces the five-phase TM³. Here, the phases of (1) status capturing , (2) decomposition and (3) matrix generation, (4) interface specification and (5) testing as well as its according activities and artifacts are presented. The method is then evaluated using a) application in use and b) a criteria-based evaluation. The paper contributes to theory with the design and evaluation of a novel modularization method (MM) which is suitable for TMSs. By presenting TM³, we also extend the body of knowledge in regards to method engineering and support practitioners in providing tailored service offerings to a steadily increasing number of telemedicine stakeholders.

Keywords: modularization, method, telemedicine, services.

10.1 Introduction

Telemedicine is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed 2011). The global market for such TMSs is expected to grow from $9.8 billion in 2010 to $23 billion in 2015 (BCC Research 2011). TMSs comprise a very heterogeneous market ranging from TMSs, e.g. defibrillators that capture and transfer the patients' heart beat data in order to enable physicians to monitor the patients' heart functions remotely and to trigger alarm functions automatically, to teleconsultation services which enable experts to guide other physicians through the conduction of medical procedures, e.g. in telestroke units (Peters and Menschner 2012).

TMS providers face the challenge to deliver their services in a fast growing market in which not only the pace and technical advancements represent challenges. It is also about the flexibility to provide customer-centric, "tailored" services to a heterogeneous range of customers. When trying to cope with these challenges, it is of importance to consider the characteristics of TMSs: they include IT parts as well as non-IT parts, even highly person-oriented parts, per definition. In such a complex environment, modularization is supposed to enable TMS providers to manage and (re-) configure their service offerings within their overall service portfolio. As each patient's need is slightly different, resulting from different life situations, state of disease, insurance coverage, etc. (Menschner, Prinz et al. 2011), modularization offers the possibility to mass customize individual offerings, allowing individually configured ("tailored") service offerings and optimal treatment at reasonable cost, because all but only the patient-relevant modules are integrated.

Modularity is "a special form of design" that rests upon the basic principles of cohesion and loose coupling (Sanchez and Mahoney 1996). Cohesion describes the extent of intra-module dependencies. A high cohesion is a requirement for well-specified modules that can be reused and combined with other service modules. Loose coupling means that there are only few inter-module dependencies between the elements of the different modules. So, loose coupling directs to the independence of the modules. Modules are connected by interfaces which have to be specified appropriately, too. In a TMS context, this means that coming from a process-perspective, several processes can be combined to one module while then all together make up one service offering.

The concept of modularization has been successfully applied for years in production contexts, e.g. the automotive sector or modular architectures of product portfolios (Ulrich 1995). In this paper, we deal with the modularization of services which we define as "(a set of) activities being part of interactions between the components of service systems" (Leimeister 2012). Common potentials of service modularization (Schermann, Böhmann et al. 2012) are manifold: reuse – the repeated use of one specific module within different services; faster development – the increase of overall development speed through higher manageability due to smaller objects of consideration (the modules) that have defined interfaces; module-wide innovation – the possibility to concentrate innovation efforts within one strategically important module that is supposed to provide competitive advantages; rapid reconfiguration – the efficient (re-) configuration of modules enables a customer-centric service provision in a mass customization manner. As current research lacks in providing guidance on the systematic modularization of services and to assist TMS providers in leveraging these potentials, a method is developed that allows for exactly such a systematic step-by-step modularization. According to Brinkkemper (1996), a method provides a detailed prescription of how to perform a collection of activities. The term method is closely related to method engineering (Brinkkemper 1996). Here, method refers to a particular procedure for attaining something (Odell 1996). A method is hence a process that is planned and systematic in terms of its mean and purpose (Braun, Wortmann et al. 2005). This understanding needs also be applied for modularization methods (MMs). Characteristic features of methods are goal-orientation (here the modularization of a TMSs), a systematic approach (here the clear separation of activities in five phases with dedicated resulting artifacts) and repeatability.

10.2 Related Work

The principle of modularization has been applied for 100 years in industry-related fields such as the automotive industry, aircraft construction, consumer electronics, and in the manufacturing of personal computers (Burr 2004). Although many authors have dealt with service modularization already (Voss and Hsuan 2009; Bask, Lipponen et al. 2010; de Blok, Luijkx et al. 2010; Tuunanen and Cassab 2011) and the concept and effects of service modularization have been elicited (Dörbecker and Böhmann 2013), it can be seen that the systematic modularization in form of MMs is very rarely applied to the field of services.

Still, we could identify a set of MM dealing with services. Looking from a service system perspective, two of them deal with IT as well as non-IT (S) services (Burr 2002; Böttcher, Becker et al. 2011). Other works focus on modularization especially in the context of IT services. Böhmann and Krcmar (2005) have created a systematic approach for the development of modular service architectures in the context of IT. Their approach was subsequently further developed and formalized to the so-called SCORE-method by Böhmann, Langer and Schermann (2009). Sarkar et al.'s (2009) modularization approach applied to a large-scale banking application. A meaningful re-modularization of software systems was generated by Bavota et al. (2010). Corsten and Gössinger (2007) created a method for the modularization of logistic services that relies on the analysis of process dependencies. When considering phase coverage and taking the 5-phases of TM³ as the benchmark, it can be stated that many MM miss to have a dedicated testing phase. In terms of method granularity most MM clearly describe its phases and according activities.

Regarding MM for TMSs, it can be concluded that there is still a lack of any MM that also integrate person-oriented services, which is crucial for TMSs as these are the services originated in the traditional medical service provision performed by physicians or nurses. Often, these are important parts of the overall TMS offering representing the most trust-building and value-creating ones. It is up to this paper to also address these TMS-specific needs in an adequate manner.

10.3 Research Design and Method Criteria

The research in this paper is guided by the questions how TMSs can be modularized in a systematic way and whether the newly developed method is suitable to enable the modularization of TMSs. The research activities in this paper can be characterized as design science research and follow the typical structure of "building" and "evaluating" an artifact (Hevner, March et al. 2004). This kind of research was chosen and deemed appropriate because "at its core, design science is directed toward understanding and improving the search among potential components in order to construct an artifact that is intended to solve a problem" (Baskerville 2008). The artifact of this paper is the TM³.

In order to create a MM for TMSs that suits current demands and needs at the provider's side, two case studies were conducted comprising four interviews and the intensive study of product documentations and provider brochures. The interviews were conducted at leading German TMS providers in 2012 and comprised interview partners from both, top management and employees. These case studies revealed the following main challenges for TMS providers that we try to break down into criteria that assess TM³'s suitability. They are also used for the criteria-based evaluation of TM³ in section 10.6.

Multi-stakeholder perspective: The method needs to able to clearly integrate several stakeholders as this is characteristic for the TMS environment.

Expansion of the TMS market: The forecasted growth for TMSs is realized via a broader orientation along the value chain and by new customers, e.g. within the secondary health market. The arising requirements are supposed to be customer integration capabilities and the methods possible extension to completely new TMS stakeholders.

More patients with different needs: The demographic change was mentioned many times throughout the case study. This will not only increase the number of future TMS customers, but also their heterogeneity and diverse needs. That calls for the handling of customizable solutions that can be easily extended, esp. when it comes to multi-disease patients.

Cost pressure and high competition: The TMS market might rise, but still this requires a new level of flexibility in order to be successful in such a competitive setting. The methods needs to reflect this in providing information about how to form basic (standard) modules which are used in most TMSs and realize economies of scale to large extents as well as it needs to provide insights on which service parts stand for typical optional / add-on modules.

10.4 The Method and its Phases

The TM³ enables telemedicine providers to modularize their services in order to offer customer-centric and tailored TMSs. It consists of five phases: (1) status capturing, (2) decomposition and (3) matrix generation, (4) interface specification and (5) testing. For all of these phases, the main activities as well as the resulting artifacts are illustrated in Figure 10.1 and explained in the subsequent sections.

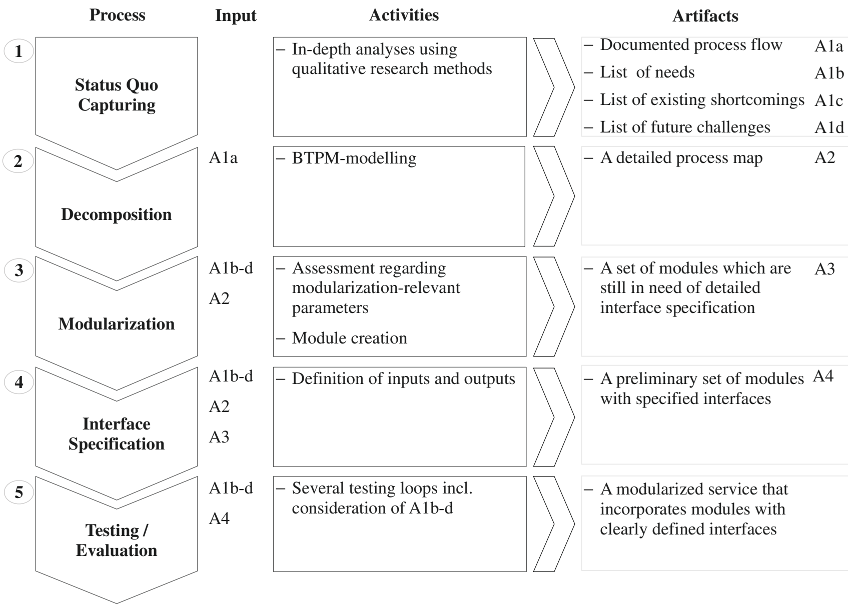


Figure 10.1: Overview of TM³ with its According Phases, Activities and Resulting Artifacts
Source: own illustration

10.4.1 Phase 1: Status Capturing

The method's start is all about getting a detailed picture of the object of modularization, i.e. the TMS that is about to be modularized. This is in line with Dubberly et al. (2008) who state that any design or engineering process starts with observations and investigation of the initial situation. We therefore perform in-depth analyses which are based on common qualitative research methods such as case studies, interviews, observations, questionnaires, document analyses, etc. (Miles and Huberman 1994) and which focus on the process flow of the service. Also, already-known weaknesses and challenges as well as specific needs for each stakeholder can be captured here.

As resulting artifacts, phase 1 delivers a documented process (flow) in either written or spoken form which also considers the process' stakeholders (A1a) and a set of lists that provide details on needs (A1b), existing shortcomings in the current processes (A1c) and challenges that can be anticipated by the stakeholders already (A1d).

10.4.2 Phase 2: Decomposition

Here, artifact 1a, the documented process flow, is used to decompose the service to a granularity stage which consists of processes only. This is formalized and visualized using the Blueprint-driven Telemedical Process Modeling (BTPM) language which was especially developed for TMSs and is already applied in several TMS settings (Peters and Leimeister 2013). Inspired by Business Service Blueprinting Modeling (BSBM) (Meis, Menschner et al. 2010), it is based on Business Process Model and Notation (BPMN) elements, but also integrates the service blueprinting idea that allows to model the TMS stakeholders' interactions transparently. Thus, it can be applied easily as BPMN is commonly known and is enriched by service elements which explicitly consider the person-oriented parts of the service as important. The BPMN-typical pools are used for the according stakeholders and with the help of the lanes, the front- and backstage activities can be represented for the according stakeholder's pool. Thereby, the relevant lines of the service blueprinting approach (Shostack 1984), e.g. the line of interaction (between the pools) and the line of visibility (between the lanes of a pool), can be represented. Also, BTPM integrates a specific device-lane at the patient's side in order to clearly locate the event here, but to emphasize that no patient-triggered action happened (think of an implanted defibrillator that sends the patient's vital data for monitoring purposes 24/7 automatically). All these features will be of high importance in the next two phases as they enable an adeqaute and comprehensive representation of

TMSs from a process perspective and give insights about potential TMS module candidates and (re-) configurations and their interfaces.

Phase 2 delivers one artifact which is a detailed process map of the service (A2). It is modeled with BTPM.

10.4.3 Phase 3: Matrix Generation

The phase of matrix generation builds on the artifacts A1b-d and A2 and decides on where modularization makes sense (resulting in the extent of modularization) and which processes are combined for module formation (resulting in the modules and their boundaries). It is crucial to understand that modularity or the extent of modularization, i.e. the measure on how much of the overall service is finally modular, might not be 100% for most services. The reason for this lies in the fact that there is continuum between a fully integrated and a fully modularized service (Gershenson, Prasad et al. 2004), thus modularity is always a relative measure.

Modularization efforts always need to be dependent on its costs and benefits. While modularization reduces the module-internal complexity, it also increases dependencies between processes which cause higher needs for communication and coordination as well as resource constraints and costs accordingly (Schantin 2004). This trade-off needs to be taken into account. It is also reflected in the choice of the service provider in making modules be part of basic or mandatory modules of a service offering guaranteeing the main functionalities, or whether the module is defined as optional add-on.

From a granularity perspective, modules can be considered an aggregation of one or more processes (granularity level of the second phase after decomposition). As this method focuses on the modularization of one service, a service has the lowest granularity level within the scope of this paper while processes have the highest granularity level considered.

Taking the process map of phase 2, this allows a step-by-step or process-by-process assessment of modularization-relevant parameters. The parameters for TM³ are derived from (Schantin 2004; Peters and Menschner 2012) and are as follows:

- Geographical specificity:
  There are processes that require a certain surrounding and others taking place in different locations. Non-virtual processes that are closer (in a geographical sense) might be important to consider here. The pools and especially lanes of the process map provide indicators here.
- Device-specificity:
  Some processes are coupled to a certain device. If so, modularization which is performed in awareness of device specificity tries to avoid frequent media breaks.
- Time-critical path dependencies:
  All processes within paths that run in parallel and are merged later on need to be checked whether they inherit critical time constraints which have crucial effects on the after-merge processes.
- Know-how specificity:
  There are processes which require a high knowledge and know-how which is closely related to the person's educational background performing it. An example for a process with a high know-how specificity is a surgery.
- IT-support / (semi-) automation:
  Here, a check for potential IT-support and (semi-) automation is performed. This is important when it comes to cost reduction purposes. All parts which are not value-creating, but can be considered commodity highly qualify here. The BTPM line of visibility is an indicator for potential qualifiers.
- Personal encounter / customer integration:
  In TMSs, many services integrate person-to-person parts; many of these personal encounters make up a high fraction of value-creating moments. Stakeholders, especially customers, can be integrated in the service provision. According to (Glushko 2009), there are different levels of integration; the highest one being a self-service setting.

Based on this assessment dependency matrices can be drawn which inform the building of modules and their size. As described above a module is characterized by a high cohesion, i.e. strong intra-module ties, and loose coupling, i.e. low inter-module dependencies. Taking the example of geographical specificity and assuming that it would be the sole modularization parameter, this would mean that processes that take place at the same location qualify to be included in the same module. Of course (as geographical specificity is only one of many parameters), the other parameters have to be considered as well. Depending on the method's application context, a weighted consideration of the different parameters makes sense.

As artifact, phase 3 delivers a proposed set of modules (A3) which are still in need of detailed interface specification.

10.4.4 Phase 4: Interface Specification

The proposed set of modules (A3), a set of lists that provide details on needs (A1b), existing shortcomings in the current processes (A1c) and challenges that can be anticipated already by the stakeholders (A1d) as well as the BTPM-modeled process map (A2) serve as inputs for this phase. The main goal of this phase is the interface specification of modules which themselves then show a black box character, i.e. they have defined inputs and outputs, but their internal functionalities and activities do not need to be evident to outsiders.

A main challenge here is the different level of interface specification clarity for different service modules. While modules that are "only" technical can have standardized and widely accepted formats for interfaces, e.g. in the form of protocols, the efforts for the precise specification of interfaces for person-oriented service modules are supposed to be higher. Precise in this case correlates with measurability of inputs and outputs.

A preliminary set of modules with specified interfaces (A4) is the artifact of the fourth phase.

10.4.5 Phase 5: Testing

The final phase of the method runs testing loops for the service with the preliminary set of modules with specified interfaces (A4). It thereby checks (a) whether the modularized service works properly and (b) whether it works efficiently, i.e. better (faster, cheaper), than without modularization.

In this phase the artifacts from phase 1 are also considered when the method is evaluated regarding its potential to address the needs (A1b) and existing shortcomings (A1c) as well as to master the anticipated future challenges (A1d). Phases 3-5 might be iterated as long as no satisfactory results are attained. If this is the case, the results of phase 5 are used as additional and considerable inputs for phases 4 and 5.

The artifact of phase 5 and the overall TM³ outcome is a modularized service that incorporates modules with clearly defined interfaces

10.5 Method Application

The method was successfully applied. We use a TMSs in the field of telemedical blood pressure management and now show the method's applicability phase by phase.

10.5.1 Status Capturing

The status of the service is captured using interviews and observations at the TMS provider's side. In this case, the service provider gets the monitoring devices from an outside manufacturer and is in direct contact with the patient as the service consumer. The service payment is settled by the health insurance company. The overall service can be separated into seven major steps, namely: patient education / clarification, provision of device, data measurement and transmission, data analysis and adjustment decision, patient contact and adjustment, end of treatment and the final billing of the service.

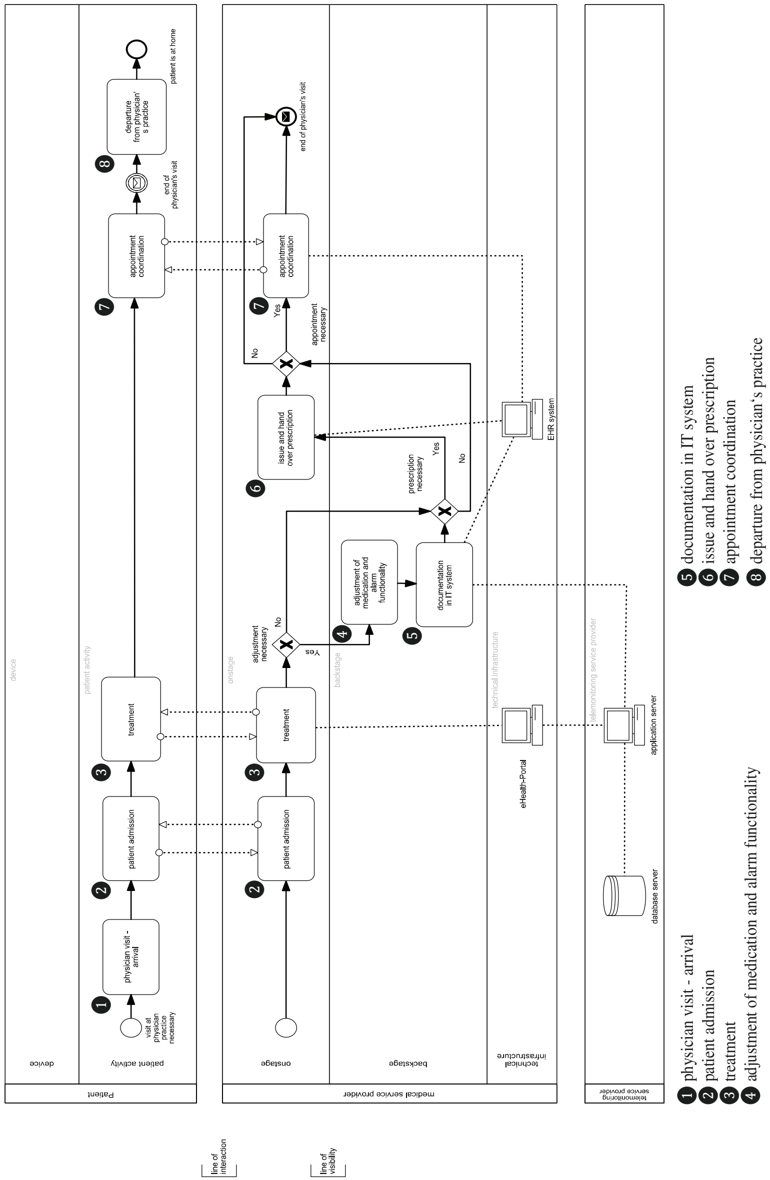
10.5.2 Decomposition

The process flow is then formalized and visualized using BTPM. Thus, the whole service is decomposed into its processes. This results in a process map that cannot be shown on such a page. That's why only an exemplary part of it, the patient contact and adjustment, is visualized in Figure 10.2.

There are three pools with stakeholders and lanes within them accordingly, e.g. a patient activity lane and a device lane in the patient's pool as well as an onstage lane, a backstage lane and a technical infrastructure lane in the pool of the medical service provider. It can be seen that the line of interaction and the line of visibility at the left side of the process map and the color-coding, e.g. for the medical service provider: physician activities are coded grey and nurse activities in dark green.

Figure 10.2: Process Map of the Service-Part "Patient contact and adjustment" Modeled with BTPM

Source: own illustration



10.5.3 Matrix Generation

Performing a process-by-process analysis along the process map we decided to show the methods applicability by choosing and assessing a set of modularization-relevant parameters. For ease of explanation, only three parameters were chosen, namely geographic specificity, know-how-specificity and personal encounter. This is visualized in the dependency matrices in Figure 10.3 which always compare two processes (P1 – P8, please see the example outlined in section 10.5.2) and fill the according cell, e.g. P3 and P5 in the personal encounter dependency matrix, with the assessed value, e.g. change from person-to-person to person-to-IT encounter or vice versa. These parameters are assessed regarding their dependency. That is why “0” is chosen for same location / qualification / encounter as it represents no / lowest dependency.

Geographical specificity

	P1	P2	P3	P4	P5	P6	P7	P8
P1	0	3	3	3	3	3	3	0
P2	3	0	0	0	0	0	0	3
P3	3	0	0	0	0	0	0	3
P4	3	0	0	0	0	0	0	3
P5	3	0	0	0	0	0	0	3
P6	3	0	0	0	0	0	0	3
P7	3	0	0	0	0	0	0	3
P8	0	3	3	3	3	3	3	0

Legend
- 0 same location
- 1 other floor
- 2 other building
- 3 other suburb
- 4 other city

Know-how specificity

	P1	P2	P3	P4	P5	P6	P7	P8
P1	0	3	5	3	3	5	3	0
P2	3	0	3	0	0	3	0	3
P3	5	3	0	3	3	0	3	5
P4	3	0	3	0	0	3	3	3
P5	3	0	3	0	0	3	0	3
P6	5	3	0	3	3	0	3	5
P7	3	0	3	3	0	3	0	3
P8	0	3	5	3	3	5	3	0

Legend
- 0 same qualification
- 1 slight difference
- 3 medium difference
- 5 big difference

Personal encounter

	P1	P2	P3	P4	P5	P6	P7	P8
P1	0	1	1	1	1	1	1	0
P2	1	0	0	2	2	0	0	1
P3	1	0	0	2	2	0	0	1
P4	1	2	2	0	0	2	2	1
P5	1	2	2	0	0	2	2	1
P6	1	0	0	2	2	0	0	1
P7	1	0	0	2	2	0	0	1
P8	0	1	1	1	1	1	1	0

Legend
- 0 same encounter
- 1 change from no to personal encounter
- 2 change from person to IT or vice versa
- 3 change from p2p to fully automated

Accumulated dependency matrix

	P1	P2	P3	P4	P5	P6	P7	P8
P1	0	7	9	7	7	9	7	0
P2	7	0	3	2	2	3	0	7
P3	9	3	0	5	5	0	3	9
P4	7	2	5	0	0	5	5	7
P5	7	2	5	0	0	5	2	7
P6	9	3	0	5	5	0	3	9
P7	7	0	3	5	2	3	0	7
P8	0	7	9	7	7	9	7	0

Figure 10.3: Three Dependency Matrices of chosen Modularity Parameters and their Accumulated Dependency Matrix
Source: own illustration

The accumulated dependency matrix adds up all three matrices and represents the overall dependency between the processes 1-8 from our example “patient contact and adjustment”. Because of the addition of matrices, low numbers in the cells of the accumulated matrix highly qualify two processes for a joint module as they represent the sum over all three dependency matrices. Here, the accumulated dependency matrix suggests forming modules out of P2 and P7, P3 and P6, P4 and P5 as well as P1 and P8. This set of modules is still in need for specified interfaces. We do not weight the parameters here.

10.5.4 Interface Specification

When thinking of the interfaces, one has to look at the processes in detail. Regarding our module candidates, it is about: the check-up and the prescription by the physician (P3 and P6), the IT-wise documentation of the medication adjustment and the update of the patient's health record by the physician's assistance in the back-office (P4 and P5) and the patient's arrival at and departure from the physician's practice (P1 and P8). For the first module, the in- and outputs are clearly defined. The input is the patient and an empty prescription form, the output is a patient after check-up and a filled prescription form. Here, the black box character of a module can be shown perfectly. For all other processes, it is absolutely not important how the patient's check-up was exactly performed – the physician is considered to perform it adequately.

10.5.5 Testing

When testing the modularized service, the last identified module candidate cannot be proven correct / working. The patient's arrival at and departure from the location of the medical service provider is not to be included in one module in a reasonable manner. The reason for this incorrectly suggested module in this case is the non-consideration (for example purposes) of the parameter time-critical path dependencies within the accumulated dependency matrix. As an overall summary, the method clearly shows that it enables TMS providers to modularize their services. In our demonstrated part, the modularization extent of the original service setting is 50% (4 out of 8 processes modularized). Avoiding media breaks and having joint inputs and outputs the service after the method's application is a) working and b) supposed to work better than before.

10.6 Criteria-based Evaluation

The newly designed TM³ is not only evaluated by application in use as section 10.5 has shown. The suitability of the method is also proven by taking the criteria presented in section 10.3 for another evaluation cycle. This is in line with (Hevner 2007).

Multi-stakeholder perspective: The consideration of new stakeholders is part of TM³ through their integration within the in-depth analysis of phase 1; also the process map built in phase 2 fully integrates them as BTPM can be modularly extended for each and every new stakeholder.

Expansion of the TMS market: TM³ realizes customer integrated again through the in-depth analysis of phase 1, but also by the considerations regarding the dedicated modularization parameter “personal encounter / customer integration” of phase 3 and by the interface specifications of phase 4 which builds on the BTPM-specific line of interaction of phase 2. The method’s possible extension to new TMS stakeholders is outlined already.

More patients with different needs: This is the core of TM³ - making TMS providers ready to deliver customer-centric, tailored service offerings. With the help of the dependency matrices of phase 3 and the interface specifications of phase 4, modularization takes place that is designed for this purpose.

Cost pressure and high competition: Cost pressure and high competition call for the realization of economies of scale and intelligent and innovative solutions. Both characteristics are achieved with the application of TM³. On the one hand this method gives clear indicators for basic (standard) modules (assuming the analysis of more than one service by the TMS provider). As a result, efficient reuse of modules is realized. On the other hand module-wide innovation and fast development cycles foster new services that provide competitive advantages.

10.7 Limitations and Future Research

The TM³ is suitable to support TMS providers in their modularization efforts and goals by providing a systematic, five-phase cooking plan. Still, it has some limitations that need to be considered as they also provide valuable starting points for future research activities in the field of TMS modularization and MM for services. The method’s focus is still one single TMS the provider is about to modularize. When thinking of following agendas, the modularization of whole service portfolios is supposed to strengthen the shown modularization benefits. This is especially true for the reuse of modules over a TMS provider’s portfolio. In this context, one can also think of creating completely modularized service architectures with Service Oriented Architecture (SOA)-like and TMS-specific service repositories that integrate not only IT services, but also non-IT, person-oriented services. In this context, potential transferability, especially to other smart interactive services (Wünderlich, Wangenheim et al. 2012), opens up an interesting area of future research. In this context, the role of TM³ for information system development as well as for new product and new service development needs to be assessed and its potential use as part of service engineering methods require further consideration (Menschner, Peters et al. 2011).

Also, only phase 2 is explicitly tool-supported as the BTPM process maps are created using a web-based modeling tool. Here, other phases might be adequately supported in the future as well. Another limitation arises through the space constraints of the paper, e.g. it was not possible to illustrate the whole process map of our exemplary service. We are convinced that the phenomenon known as modularity trap (Ernst 2005), i.e. that such systematically established modular systems limit radical innovations, is not prevalent in MM for TMSs (because of their specific, non-IT-exclusive nature) and in TM³, but this needs to be observed in consecutive research.

10.8 Conclusion and Expected Contribution

This paper presents the design and two-phase evaluation of TM³, a method which helps telemedicine providers to modularize their existing service offerings. Thus, they are able to increase their responsiveness in the fast-changing environment of TMSs and respect and respond to the heterogeneity of their users and customers through individually "tailored" service offerings. The method is described with all its five phases, their according activities and resulting artifacts which then serve as inputs for following phases. The artifact's evaluation is conducted in a twofold manner: by application in use and criteria-based. As we could show through the design, application and evaluation of TM³, we not only extend the body of knowledge in regards to method engineering and support practitioners in providing individually tailored service offerings to their steadily growing customer base; we also show the method's suitability and resulting improvements and benefits at the provider's side. Our next steps are the application of TM³ in further TMSs and its iterative refinement which we want to support with additional evaluation loops.

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11 Blueprint-driven Telemedicine Process Modeling - The Interdisciplinary Development and Evaluation of a Modeling Technique for Telemedical Services

Peters, Christoph; Elm, Christian; Söllner, Matthias; Leimeister, Jan Marco

Abstract:

Service process modeling faces domain-specific challenges. Telemedicine, understood as a service system, requires adequate representation for multi-stakeholder service scenarios, technical infrastructures as well as customer interaction levels. This is due to both its world nature, i.e. telemedicine integrates solely technical parts, as well as explicitly person-oriented parts.

This design science paper uses action research in order to develop the Blueprint-driven Telemedicine Process Modeling (BTPM) technique, a modeling technique for telemedical processes and services that are based on BPMN and service blueprinting.

We present how the action research setting guided us through the workshop - informed, iterative design and evaluation of BTPM. It inherits the well-known BPMN-concept of pools and lanes which allows for modular stakeholder-extensions, i.e. adding new pools for new stakeholders. Also, it integrates blueprinting-specific elements, e.g. the line of interaction or the line of visibility, in order to represent both, value-creating face-to-face momenta as well as on-stage and backstage activities. Furthermore, BTPM explicitly considers telemedical devices and distinguishes between stakeholders using color coding. In addition, we show how BTPM meets the telemedicine-specific requirements which have been elicited in case studies performed earlier and have been redefined in the workshops. We also provide a proof-of-concept using a telemonitoring service.

Thereby, we contribute to practice by presenting a modeling technique that is adequate for telemedicine as it respects the particularities of this service system. It explicitly assists providers to model their service experience scenarios. The theoretical contribution lies in the iterative design and evaluation of the artifact, the BTPM, and the interdisciplinary research setting for the domain-specific technique development.

Keywords: complex services, service modeling, modeling technique, telemedicine, action research, design science, service blueprint

11.1 Introduction and Related Work

The TMS environment consists of many stakeholders that have different backgrounds. So far, despite the particularities TMSs bring along, no modeling language or technique exists that addresses them (Peters and Leimeister 2013). Still, this would be very important as modeling techniques fulfill important functions such as: increased (shared) understanding, increased comparability between different service scenarios, improved communication because of using one agreed-upon unified technique. Also, it helps to identify critical process steps and (thereby) reveals potential parts for optimization.

Many research activities are interdisciplinary, but miss the opportunity to also include interdisciplinary research activities and considerations in their work. This paper is also an attempt to explicitly do so and use the interdisciplinary nature of the involved workshop participants as a distinctive feature that performs the activities and combines important aspects from different fields.

The development and application of domain-specific modeling techniques (in contrast to general modeling techniques) is not new at all (Van Deursen, Klint et al. 2000). Still, it has not been assessed in the field of telemedicine where the potential benefits described above are of utmost importance (Peters and Leimeister 2013), e.g. when finding consensus on service configurations between physicians and TMS providers or supporting the setup of new services. This paper closes this gap.

The remainder of the paper is structured as follows: In the next section, domain background for telemedicine is provided. Afterwards, TMS-specific requirements are presented which have been elicited in case studies performed earlier. Then, the research setting of action research is described in the context of the to-be-developed modeling technique. Thereby, the three iterations that have been conducted in the course of the research are presented and the typical five AR phases (diagnosis, action planning, action taking, evaluating and specify learning) are outlined. Afterwards, the results for both cycles, the problem-solving and the research cycle, are illustrated. This inherits the resulting BTPM and its characteristic features as well as advancements and findings made by the conduction of the interdisciplinary research setting that is – to the knowledge of the authors – new to the field of telemedicine. The artifact is then evaluated by assessing its suitability to meet the requirements elicited before and by showing its relevance in a proof-of-concept by modeling an existing and available TMS. At the end of the paper, limitations as well as considerations for future research are outlined before the paper’s overall contribution is presented.

11.2 Domain Background

The demographic shift in many industrialized countries has led to increased health care spending and a higher demand for care services, thus threatening existing public health and welfare systems (OECD 2009). Health care comprises highly complex and extremely expensive services that have a significant impact on economies and the quality of daily life of patients (Berry and Bendapudi 2007). In addition to social and economic consequences, health care is a field that continuously undergoes changes. The recent increase in technologies offers vast potential to enable new ways of health care provision at home, to improve existing health care services, and to create new services. One kind of such services is TMSs.

Telemedicine is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed 2011). The global market for such telemedicine services is expected to grow from $9.8 billion in 2010 to $23 billion in 2015 (BCC Research 2011). TMSs comprise a very heterogeneous market ranging from real-time telemonitoring, e.g. defibrillators that capture and transfer the patients' heart beat data in order to enable physicians to monitor the patients' heart functions remotely and to trigger alarm functions automatically, to teleconsultation services which enable experts to guide other physicians through the conduction of medical procedures, e.g. in telestroke units, to e.g. monitoring of chronically ill patients, where anamnesis, diagnosis and therapeutical decision making can take place timely independent of each other.

TMSs are characterized by a large number of stakeholders, such as patients, physicians, care personnel, lay person supporters, telemedical and internet service providers, technology manufacturers or telecommunication companies – all of them playing their role in the service system telemedicine. Maglio and Spohrer (2008) define such service systems as "value-co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information (e.g., language, laws, measures, and methods)."

Further, TMSs are characterized by a high degree of heterogeneity. Each patient's need is slightly different, a result of different age, life situations, state of disease, insurance coverage, etc. (Peters and Menschner 2012). Also, TMS providers face the challenge to deliver their services in a fast growing market in which not only the pace and technical advancements represent challenges. It is also about the flexibility to provide customer-centric, "tailored" services to a heterogeneous range of customers. A modeling technique that can respond to this challenge will be highly beneficial. TMSs can support a patient's quality of life and, where implemented, can reduce the cost of delivering health care. Despite being considered medically and technically viable, few TMS innovations have been put into practice (Cho, Mathiassen et al. 2008; Essén 2009). A unified modeling technique might foster according developments in effective and efficient service engineering and management.

Recalling that telemedicine is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed 2011), for TMSs, this is relevant from two perspectives. First, reflecting their given nature, TMSs consist of a combination of IT-parts and non-IT-parts per definition and are characterized through person-oriented parts as well (Peters and Leimeister 2013). This is especially important when it comes to the modeling of such services as it has to be represented in an adequate fashion.

11.3 Requirements

In order to create a modeling technique for TMSs, two case studies were conducted comprising four interviews and the intensive study of product documentations and provider brochures. This revealed the following main challenges which were broken down into requirements (R) for the assessment of BTPM:

Multi-stakeholder perspective: The modeling technique needs to able to clearly integrate several stakeholders (R1) as this is characteristic for the TMS environment. Also, their according boundaries (R2) need to be reflected adequately.

Expansion of the TMS market: The forecasted growth for TMSs is realized via a broader orientation along the value chain and by new customers, e.g. within the secondary health market. The arising requirements are supposed to be the clear illustration of interconnections between the stakeholders (R3) and the possible extension (R4) to completely new TMS stakeholders.

More patients with different needs: The demographic change was mentioned many times throughout the case study. This will not only increase the number of future TMS customers, but also their heterogeneity and diverse needs. That calls for the explicit consideration of the customer and its interaction levels (R5) within the service and the handling of easy customization and reconfigurations capabilities (R6) that can be conducted in an easy and time-saving manner, e.g. by tool support.

Cost pressure and high competition: The TMS market might rise, but still this requires a new level of flexibility in order to be successful in such a competitive setting. The newly developed technique needs to reflect this in providing possibilities to reuse (R7) already modeled services and processes in an efficient manner, e.g. by being able to be used in service blueprinting.

A list of requirements is provided in Table 11.1. The technique is evaluated against them at the end of this paper.

Requirement	Description
R1	Integration of several stakeholders
R2	Clear delimitation of stakeholders
R3	Illustration of stakeholders' interconnections
R4	Possible extension to additional stakeholders
R5	Representation of customer interaction levels
R6	Tool support for efficient reconfigurations
R7	Efficient reuse of already modeled services / processes

Table 11.1: List of Requirements
Source: own illustration

11.4 Methodology

This design science research (DSR) paper uses action research (AR) to realize the typical "build & evaluate" paradigm (Hevner, March et al. 2004) of an artifact. According to the "Framework and Context for Design Science Research" by Venable, AR is "one of several means of conducting naturalistic evaluation of a new and innovative 'solution technology'" (Venable and Box 2009). The research presented in this paper is characterized by a significant overlap of AR and DSR activities, i.e. "the action researcher actually is also conducting DSR, in that he/she is inventing a new, innovative artifacts or solution technology to better address the client's problem solving interest (a socio-technical problem). In this case, the research interest includes the development and evaluation of the solution technology" (Venable and Box 2009). The solution technology is the DSR artifact, the modeling technique for TMSs.

The research is guided by two overarching questions according to the "dual imperative" of AR according to (Marshall, Salas et al. 2006):

- How must a modeling technique for TMSs look like that fulfils elicited requirements (aiming at the solution technology)?
- How can a modeling technique for TMSs be developed in an interdisciplinary AR setting (aiming at providing insights regarding the process of AR)?

These two questions drive the “problem-solving interest” and the “research interest” in the double-cycle AR process (McKay and Marshall 2001).

11.5 Research Setting

Five telemedicine experts coming from the areas of information systems, medical informatics, controlling and health economics represent the continuous part of the overall action research setting. They were accompanied by affiliated colleagues in the specific action research cycles – resulting in a participation number ranging from 7-10 per cycle.

Resulting in the heterogeneous backgrounds of the participants, the initial familiarity with modeling languages and techniques was heterogeneous as well.

In terms of action research, one cycle represents the design and evaluation of the modeling technique. The other cycle is the research setting and learning perspective – regarding the innovative attempt to combine AR and DSR for the development of a domain-specific technique as well as the ability and confidence of all participants to model processes and services. Overall three iterations of the two cycles were performed. The paper follows this logic by presenting a brief description of these three iterations which were all conducted in workshop settings and then continues with the overall description of the five AR phases (Susman and Evered 1978; Baskerville 1999): diagnosis, action planning, action taking, evaluating and specify learning which are illustrated in Figure 11.1.

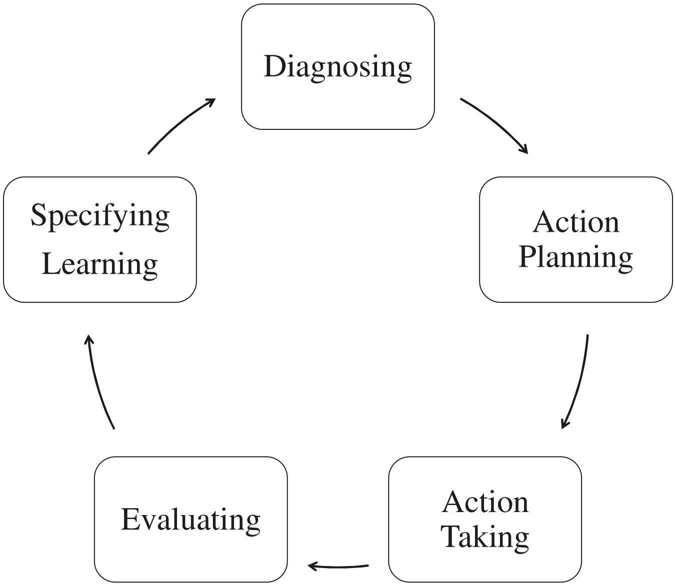


Figure 11.1: AR Cycle
According to Baskerville (1999)
Source: own illustration

11.5.1 The Iterations

In a first workshop the participants were introduced to principles and concepts of common modeling languages and techniques and their particularities, e.g. the unified modeling language (UML) (Object Management Group 2011), business process model and notation (BPMN) (Object Management Group 2011)and event-driven process chains (EPC) (Scheer, Thomas et al. 2005). This was accompanied by hands-on learning scenarios in which the participants were asked to model described services using the specific languages and techniques. The modeling was purely paper-based. The overall goal was to raise awareness about what modeling is all about and how it might help to leverage its potentials such as increased shared understanding and decreased misunderstandings by speaking / modeling an agreed-upon and unified technique, etc.

The second workshop was designed to model dedicated TMSs with the modeling technique of choice. A specific focus was set on identifying if and how TMS particularities could be represented, e.g. regarding the importance of person-oriented interactions, the flexibility of the TMS environment, etc. The modeling was conducted paper-based first. Afterwards, the agreed-upon models were transferred to Signavio (Signavio GmbH 2013), a cloud-based modeling tool which enabled the joint collaboration and discussion of the process models. In follow-up sessions, all participants were asked to further model additional TMSs that were familiar to them.

In a third workshop, the participants discussed the additionally modeled TMSs and the challenges they had with it. This should reveal potential weaknesses of the status quo modeling approach. Then, the participants were asked to realize reconfiguration attempts (in order to increase efficiency of the underlying services). This implied an active elaboration with the tool again.

11.5.2 The Five-phase AR Cycles

Diagnosis:

This phase mainly deals with the identification of the research's main objectives. The main objectives here can be described as the need and seek for a modeling technique that addresses the elicited requirements above and enables all relevant stakeholders to model TMSs accordingly.

Action Planning:

In this phase the joint collaboration between the researcher and all participants is needed to define sub-goals for reaching the overall objective. In this case, this was the assessment and redevelopment of existing languages and techniques. To provide one example: The first workshop was designed to narrow the range of potentially adequate techniques and to increase the participants understanding of modeling.

Action Taking:

In the phase action taking, the activities of the former phase are put into action. In the described research setting, this comprised the choice of BPMN as most suitable (in contrast to UML and EPC) to follow-up on. This decision was consensus between all participants and was due to its experienced ease of use and very comprehensive representation of different stakeholders.

Evaluating:

The evaluating phase tries to assess whether the decisions and actions taken before make sense and fulfill its purpose, i.e. whether the currently used technique is adequate for

TMSs. This was not the case in the first two iterations. As described earlier the first iteration revealed considerable shortcomings of UML and EPC. Whether these could be compensated by the application of BPMN was assessed in iteration two. During this iteration, when BPMN was chosen, it became obvious that although the separation of stakeholders with the use of the pools and lanes concept was adequate, the customer integration capabilities were insufficient. Also, the specific consideration of TMS devices was pointed out for even clearer representation needs than by the artifacts of BPMN. In the third iteration the evaluation could be regarded as successful as the re-developed technique met the requirements elicited before (please see Table 11.1).

Specify Learning:

In this last phase the gained knowledge of each iteration is integrated into next iteration redevelopments and preserved as "learnings" for future considerations.

11.6 Results

11.6.1 Cycle 1: BTPM and its Characteristics

BTPM is supposed (and in the context of our research proven) to be highly beneficial because of its integration of service blueprinting within BPMN and the tool support. Thus, two according sub-sections are included into this paper that try to give a brief overview of their meaning before the actual BTPM is outlined.

Service Blueprinting

Initially introduced by Shostack as early as 1984 (Shostack 1984), the service blueprinting was designed to describe service processes. This was achieved by two delimitations. First - represented by the line of visibility - the separation between activities at the service provider that can be observed by the customer. This line illustrates onstage and backstage activities at the provider side. Second – represented by the line of interaction – the activities that are located on the customer or the service provider side. This line makes the communication between them eminent. The concept was further developed and extended by additional lines, e.g. the line of internal interaction (as one of four additionally added lines) by Kingman-Brundage (Kingman-Brundage 1989).

Tool-driven Modeling

Modeling techniques can be used in different scenarios, for different purposes and also with different tools. In the course of the presented research activities, the use of Signavio (Signavio GmbH 2013), a cloud-based modeling tool, fulfilled the purpose of steady redevelopments best. Its functionality allows for commenting the work of others and also includes a change history and versioning which increased transparency between the participants in regards to both, work progress and communication of new ideas or challenges.

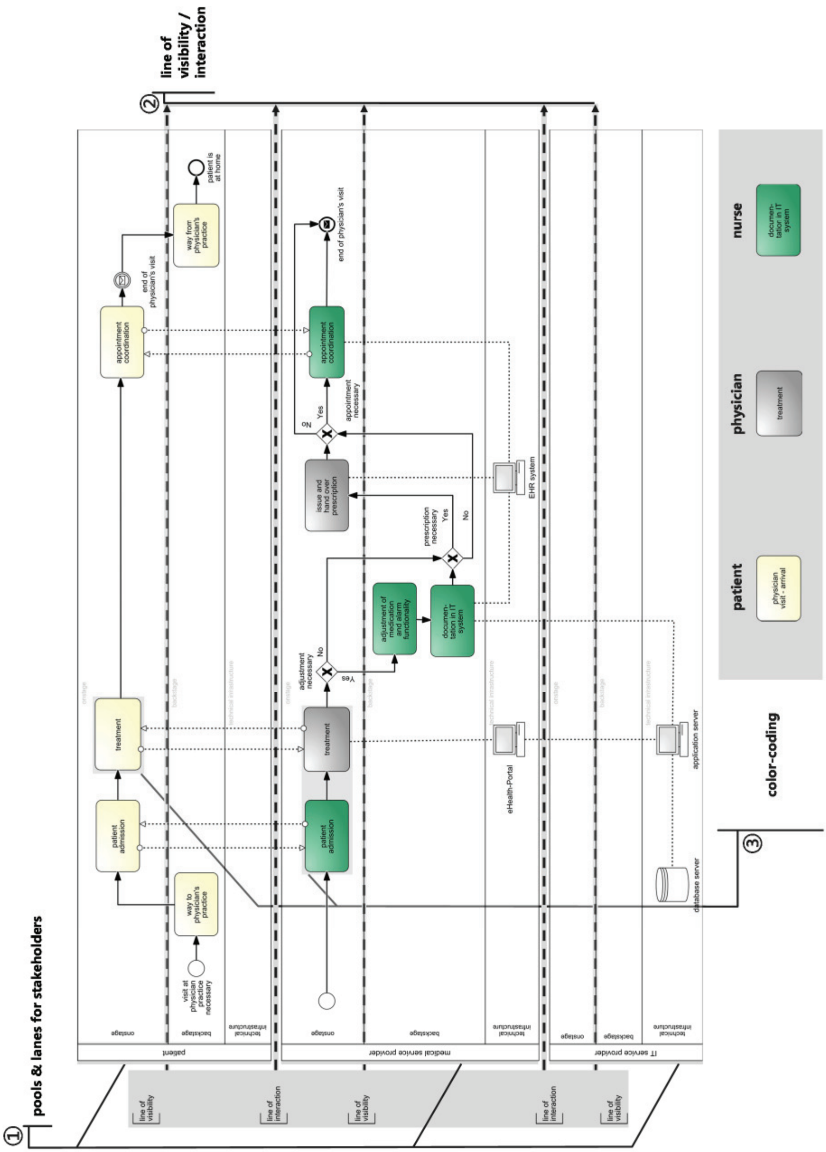
The Newly developed Technique and its Characteristics

The resulting artifact of this design science paper is the modeling technique for TMSs. Its design and evaluation was iteratively conducted having used three iterations of a two cycle action research setting. In the course of this setting and in project-related work, the newly developed BTPM is already applied in several TMS settings. Inspired by BSBM (Meis, Menschner et al. 2010), it is based on BPMN elements, but also integrates the service blueprinting idea that allows to model the TMS stakeholders' interactions transparently. Thus, it can be applied easily as BPMN is commonly known and is enriched by service elements which explicitly consider the person-oriented parts of the service as important. In the following paragraphs, its main characteristic elements are described:

Pools and lanes:

The BPMN-typical pools are used for the according stakeholders of the TMS environment (please see Figure 11.2, characteristic feature 1). With the help of the lanes, further distinctions per stakeholder can be realized, e.g. the representation of on-stage and backstage activities for the according stakeholder. Also, BTPM integrates a specific technical infrastructure lane at the patient's side in order to clearly locate the technical processes here, but to emphasize that no patient-triggered action happened (think of an implanted defibrillator that sends the patient's vital data for monitoring purposes 24/7 automatically). Additionally, the pools and lanes concept allows for the flexible and modular extension of stakeholders as a new TMS player can easily be integrated.

Figure 11.2: Overview of BTPM and Characteristic Features
Source: own illustration



Lines for level of involvement:

Thereby, the relevant lines of the service blueprinting approach (Shostack 1984), e.g. the line of interaction (between the pools) and the line of visibility (between the onstage and backstage-lanes of a pool), can be represented (please see Figure 11.2, characteristic feature 2). This was considered especially important as the participants emphasized the importance of customer integration capabilities and co-creation (Vargo, Maglio et al. 2008; McColl-Kennedy, Vargo et al. 2012) options.

Color-coding:

The color coding helps to visualize subcategories of the considered stakeholders (please see Figure 11.2, characteristic feature 3). When consider the “medical service provider”, it makes sense to have (only) one pool for this stakeholder. This makes the overall model readable and the interactions, e.g. with patients, can be represented in a clear manner. Still, there are occasions when the distinguished consideration between nurses and physician makes sense, i.e. when it comes to costs per working hour or actions that require a certain level of responsibility.

11.6.2 Cycle 2: Learning Experiences

As to the second main question that is addressed by this AR paper, namely: How can a modeling technique for TMSs be developed in an interdisciplinary AR setting, it can be concluded that the workshop setting and three iterations represent a very useful setting. The joint acquisition of (partly) new knowledge and the application of the currently used techniques in each iteration fostered shared understanding. Also it was possible to enable participants of completely different backgrounds to work with BTPM which emphasizes its ease of use.

11.7 Proof-of-Concept

After having developed the BTPM technique elements itself, a proof-of-concept in a practical case has been executed. Therefore a telemonitoring service for chronically ill patients has been modelled. In this telemonitoring service four pools have been used consistently: for a patient, for a lay person supporter of the patient or a professional care giver person, for a physician, and for the web-based internet application infrastructure gluing all person related activities.

The telemonitoring service itself has been modelled from the day to day use perspective to show the essential steps in using the service.

To illustrate how BTPM has been used, the patient’s activities and its interfaces to the other pools are shown in Figure 11.3.

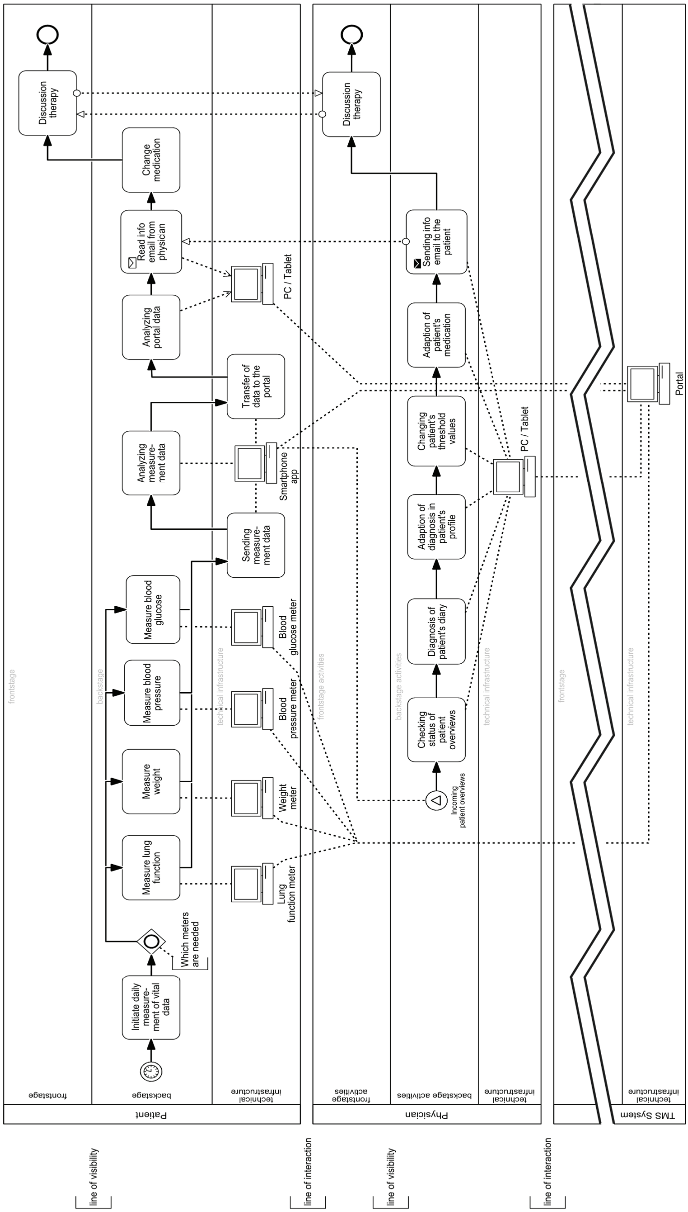
Here use of the backstage modeling is shown, in which the patient measures daily her vital data, using medical sensors modelled in the technical infrastructure lane, as well as using a mobile application for further processing of his data prior to submitting them into the web-based internet application infrastructure in the fourth pool. Additionally, data from the internet application can be accessed using an Internet browser and the discussion of her health status and details of her treatment with her lay person supporter or her physician are realized and visualized in the on-stage lane.

Modeling the existing telemonitoring service revealed again that a good interdisciplinary cooperation between experts is essential to establish a feasible and efficient model. In this case, it was the cooperation between domain experts for the application of the telemonitoring service, development experts knowledgable about the technical details of the available infrastructure as well as modeling experts giving a consistent structure to the use of the BTPM technique.

Furthermore, the developed process modeling results can be effectively used for further processing, e.g. for communication in marketing, for the configuration of new service offerings inheriting elicited variants or optimization potentials for service delivery and service management.

Figure 11.3: Activities of the Patient within the Telemonitoring Service, Including Interfaces to other Pools

Source: own illustration



11.8 Evaluation

The evaluation of the newly developed artifact BTPM can be considered highly successful as it meets all requirements elicited earlier. In the course of the research, even the integration of upcoming requirements could be realized, e.g. by the use of color-coding. An overview of the met requirements is shown in Table 11.2 below.

Requirement	**Description**	**Addressed by**
R1	Integration of several stakeholders	By pools and lanes concept
R2	Clear delimitation of stakeholders	By pools and lanes concept
R3	Illustration of stakeholders' interconnections	By integration of service blueprinting: lines of visibility and lines of interaction
R4	Possible extension to additional stakeholders	By modular extension (one more pool per additional stakeholder)
R5	Representation of customer interaction levels	By integration of service blueprinting: lines of visibility and lines of interaction
R6	Tool support for efficient reconfigurations	By using Signavio
R7	Efficient reuse of already modeled services / processes	By tool-supported copy and paste functionalities
R8 (new)	Distinctions per stakeholder	By color-coding
R9 (new)	Device-specific considerations of TMSs	By adding an additional device lane

Table 11.2: List of Met Requirements
Source: own illustration

11.9 Limitations and Future Research

As many papers that try to present an extensive AR setting, this paper faces the challenge to comprehensively describe all cycles in all iterations including their according results in a rigorous manner. If having much more space, the step-by-step redevelopments might be outlined in a more illustrative fashion, e.g. by using much more screenshots to present the iterative character of the redevelopments. In our research setting, BTPM was used for five dedicated TMSs.

In terms of future research, this might be extended to a much wider range of TMSs. Although the developed BTPM models have been assessed successfully for their application as part of systematic service modularization attempts already (Burr 2002; Böttcher, Becker et al. 2011; Peters and Leimeister 2013), additional scenarios, e.g. in related domains that deal with smart interactive services (Wünderlich, Wangenheim et al. 2012), might be relevant.

11.10 Contribution

This paper develops the domain-specific BTPM technique, a modeling technique for TMSs and processes that is based on BPMN and service blueprinting. This is done by conducting action research and design science research in an interdisciplinary setting using two cycles, a problem-solving cycle and a research cycle. Thereby, three iterations are used which are all integrated into workshop settings with telemedicine experts, followed by a proof-of-concept by modeling an existing TMS.

The newly developed technique inherits the well-known BPMN-concept of pools and lanes which allows for modular stakeholder-extensions. It integrates blueprinting-specific elements, e.g. the line of interaction or the line of visibility, in order to represent both, value-creating face-to-face momenta as well as front- and backstage activities. Also, BTPM explicitly considers telemedical devices and distinguishes between stakeholder groups using color coding. It could be shown that BTPM not only meets requirements which have been elicited in case studies performed earlier, but also all additional ones that came up during the three iterations in the workshops. Furthermore practical relevance of using BTPM could be shown. In the course of our research we can answer the two overarching questions "How must a modeling technique for TMSs look like that fulfils elicited requirements (aiming at the solution technology)?" and "How can a modeling technique for TMSs be developed in an interdisciplinary AR setting (aiming at providing insights regarding the process of AR)?". In addition, it can be stated that BTPM – in contrast to existing modeling languages and techniques – allows more efficient and easier modeling of the relevant services and the resulting models in turn effectively support communication, analysis and optimization of the underlying services.

Thus, we contribute to practice by presenting a modeling technique that is adequate for telemedicine as it respects the particularities of this service system. It explicitly assists all stakeholders, especially TMS providers, to model their service experience scenarios in an easy manner. The theoretical contribution lies in the iterative design and evaluation of the artifact, the BTPM, and the successful implementation of an interdisciplinary research setting for domain-specific development of modeling techniques.

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12 Together They are Strong - The Quest for Service Modularization Parameters

Peters, Christoph

Abstract:

This research-in-progress paper deals with service modularization of complex services. The successful creation of powerful modules allows for leveraging modularization benefits such as reuse, faster development, module-wide innovation, and rapid reconfiguration. Consequently, service provider efficiencies as well as user centricity can be realized. Therefore, the principles of modularization, i.e. cohesion and loose coupling, need to reflect interdependencies between the “right” attributes. These attributes, e.g. know-how specificity or IT support, serve two functions. First, they are attributes of the underlying processes that make up the service which needs to be modularized. Second, they serve as candidates for modularization parameters. The paper’s research setting comprises expert workshops and in which modularization parameters are applied. As a first result, I (1) suggest a set of mandatory modularization parameters that are derived from the literature and (2) call for domain-specific extensions. The paper contributes to service modularization research by providing the ingredients (modularization parameters) for the recipe (the overall method) for systematic service modularization of complex services. Thus, I also assist service providers in their modularization attempts which might be in need of “ingredients” as well and thereby make a contribution to practice.

Keywords: service modularization, complex services, modularization parameters.

12.1 Introduction

Service has grown into an important field for research in information systems (Rai and Sambamurthy 2006), as information technology (IT) is currently revolutionizing the way services are delivered. Many services hereby not only play a key role for societal advancements, but become necessary for it (Leimeister and Peters 2012). On the one hand, IT enables new forms of cooperation and communication in service (Rai and Sambamurthy 2006); on the other hand, it enables automation, standardization, and new concepts for customer integration (Fitzsimmons and Fitzsimmons 2005). Regarding both, service modularization plays a key role.

There are first attempts to perform service modularization in a systematic manner (Peters and Leimeister 2013). So far and to the best knowledge of the author, none of such attempts show or explain how modules are created out of a process repository. This is because the actual and quite operational act of modularization relies on the rigorous selection of modularization parameters and is complicated as well as time-consuming. Modularization parameters can be regarded as the set of criteria that processes are assessed on. Consequently, the modularization parameters predefine if and how processes are tied together in one module or not. Modules are formed by cohesion and loose coupling, i.e. the interplay between dependencies of processes. That is why parameters for modularization that are well selected, create powerful modules. The paper's title "Together they are strong" applies for the processes constituting such modules.

This paper has the ambition to make service modularization more explicit. It provides insights into the "black box" modularization which is often encountered. Thereby it makes a difference to other modularization projects that leave both, researchers and practitioners with a "magic happens here" when it comes to the core of modularization. When service modularization can be described as "the act of module creation" for non-modular services, then the research gap is the recipe to do so for complex services in a repeatable manner that is based on a certain set of criteria which are named modularization parameter in the remainder of this paper. That is why the aim of this paper is to shed light on the question: How can modularization be operationalized? My answer is: by using modularization parameters and thereby constituting the mechanism which brings service providers from non-modularized services to modularized ones that can leverage modularization potentials as described in section 12.2.1.

The paper at hand is structured as follows: In the following section, foundations are laid by defining and describing core concepts of this paper: service modularization, modularization principles and complex services. Next, I outline modularization parameters that are derived from the existing body of knowledge and give an example why a set of these criteria is needed. In a detailed fashion, I describe the research setting. The research design incorporating expert workshops is outlined. First results and preliminary findings follow, before I conclude and summarize our main contributions and present future research's potentials.

12.2 Background

12.2.1 Service Modularization

While many authors have dealt with service modularization already (Voss and Hsuan 2009; Bask, Lipponen et al. 2010; de Blok, Luijkx et al. 2010; Tuunanen and Cassab 2011) and the concept and effects of service modularization have been elicited (Dörbecker and Böhmann 2013), it can be seen that the systematic modularization in form of modularization methods is very rarely applied to the field of services. Existing methods (Böhmann, Langer et al. 2008) are not adequate for dealing with complex services (Peters and Leimeister 2013). Thus, I identified the research gap of systematic service modularization of complex services and we already elaborated an according method (Peters and Leimeister 2013).

Common potentials of service modularization (Schermann, Böhmann et al. 2012) are manifold: reuse – the repeated use of one specific module within different services; faster development – the increase of overall development speed through higher manageability due to smaller objects of consideration (the modules) that have defined interfaces; module-wide innovation – the possibility to concentrate innovation efforts within one strategically important module that is supposed to provide competitive advantages; rapid reconfiguration – the efficient (re-) configuration of modules enables a customer-centric service provision in a mass customization manner (Peters and Leimeister 2013).

From a granularity perspective, modules can be considered an aggregation of one or more processes. In this paper, a service has the lowest granularity level while processes have the highest granularity level considered. Subsequently, modules are positioned between processes and services.

12.2.2 Modularization Principles

Modularization rests upon the basic principles of cohesion and loose coupling (Balzert 1996). Cohesion describes the extent of intra-module dependencies. A high cohesion is a requirement for well-specified modules that can be reused and combined with other service modules. Loose coupling (Böhmann and Krcmar 2006) means that there are only few inter-module dependencies between the elements of the different modules. So, loose coupling directs to the independence of the modules. Modules serve a specific function

(Schilling 2000) and “information hiding” takes place, i.e. module-internal attributes are hidden to the outside (Parnas 1972).

Modules are connected by interfaces which have to be specified appropriately (Ulrich 1995; Baldwin and Clark 1997). In the context of complex services, this means that coming from a process-perspective, several processes can be combined to one module while they all together make up one service offering.

12.2.3 Complex Services and Domain Specifics

A service itself is “(a set of) activities being part of interactions between the components of service systems” (Leimeister 2012). It is a complex phenomenon. Within the scope of this paper, complex services consist of a combination of both, IT and non-IT services, while the latter also integrate highly knowledge-intense, person-oriented (Menschner, Peters et al. 2011) and interactive parts as well.

Within the service sector, more and more complex services come into existence. As an example for such complex services, the field of telemedicine can be taken and is used for illustration purposes in the remainder of this paper. Complex services are further characterized by a large number of stakeholders (Georgi and Peters 2013), e.g. in the field of telemedicine by physicians, care personnel, service providers, technology manufacturers or telecommunication companies. Telemedicine hereby is the provision of medical services over geographic distances through the use of information and communication technology (DGTelemed 2011) and is outlined in 12.2.4 in more detail.

In this setting, modularization has the potential to foster service aggregation even across different stakeholders. Additionally, complex services are defined by a high degree of heterogeneity because of their person-oriented fashion. Modularization can offer the possibility to mass customize individual offerings, e.g. by allowing optimal treatment at reasonable cost (Peters and Menschner 2012) in telemedicine where each patient’s need is slightly different, a result of different life situations, state of disease, insurance coverage, etc.

12.2.4 The Field of Telemedicine

Telemedical services (TMSs) comprise a very heterogeneous market (Leimeister and Peters 2013), ranging from telemonitoring services (e.g., defibrillators that capture and transfer the patients’ heart beat data in order to enable physicians to monitor the patients’ heart functions remotely and to trigger alarm functions automatically) to teleconsultation services that enable experts to guide other physicians through the conduction of medical procedures, e.g., in telestroke units. TMSs are therefore beneficial in supporting a patient's quality of life (Berry and Bendapudi 2007) and, where implemented, can reduce the cost of delivering health care. Despite being considered medically and technically viable, few TMS innovations have been put into practice (Cho, Mathiassen et al. 2008; Essén 2009). The reasons TMSs are not seeing a widespread implementation include a lack of suitable business models, difficulties in integrating them into existing health care treatment processes, and usability and acceptance issues on the part of physicians and patients. The market for telemedicine is continuously growing, from $9.8 billion in 2010 to $23 billion in 2015 (BCC Research 2011) worldwide and reaching $5 billion in 2015 within the European market (European Commission 2014). For service providers who want not only to benefit from this expected growth but also to leverage their own market potentials in a competitive market, this prospect calls for flexibility in this fast-changing market.

12.3 Modularization Parameters

Modularization efforts always need to be dependent on its costs and benefits. While modularization reduces the module-internal complexity, it also increases dependencies between processes which cause higher needs for communication and coordination as well as resource constraints and costs accordingly (Schantin 2004). This trade-off needs to be taken into account. It is also reflected in the choice of the service provider for relevant and strategically critical modularization parameters. This is important as these parameters influence whether modules become basic / mandatory modules of a service offering guaranteeing the main functionalities, or whether the module is defined as optional add-on.

Existing modularization parameters in the literature could be identified (Schantin 2004; Peters and Menschner 2012) and are as follows: Geographical specificity, device-specificity, time-critical path dependencies, know-how specificity, IT-support / (semi-) automation, personal encounter / customer integration. They are discussed in more detail in the research design section (workshop 2) below.

As described above a module is characterized by a high cohesion, i.e. strong intra-module ties, and loose coupling, i.e. low inter-module dependencies. Taking the example of geographical specificity and assuming that it would be the sole modularization parameter, this would mean that processes that take place at the same location qualify to be included in the same module. Of course (as geographical specificity is only one of many parameters), other parameters have to be considered as well.

12.4 Research Setting

This research can be seen as one important part in a bigger project developing a modularization method that is displayed in Figure 12.1.

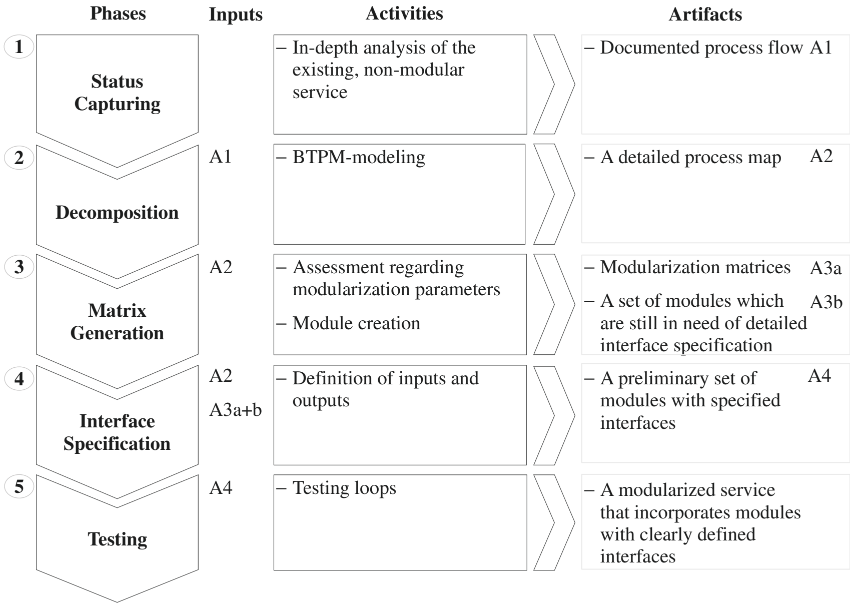

Figure 12.1: Modularization Method and Phases
Source: own illustration

This project aims to develop a method that allows for the systematic modularization of services. In contrast to other successful modularization methods (Böhmann, Langer et al. 2008), it is adequate for complex services. The method itself consists of five phases, namely: (1) status capturing, (2) decomposition, (3) matrix generation, (4) interface specification, and (5) testing. Each of the phases incorporates according activities and resulting artefacts that are used as input for consecutive phases (Peters and Leimeister 2013). The identification, selection and redevelopment or extension of relevant modularization parameters plays a key role of every modularization attempt and is located in Phase 3 (Matrix Generation) of the method.

12.4.1 Research Design

The conducted research is of qualitative nature and mainly incorporates expert workshops. The workshops are conducted at the site of a service provider in the field of telemedicine who serves as a partner in the overall project. An overview of the overall setting is illustrated in Figure 12.2.

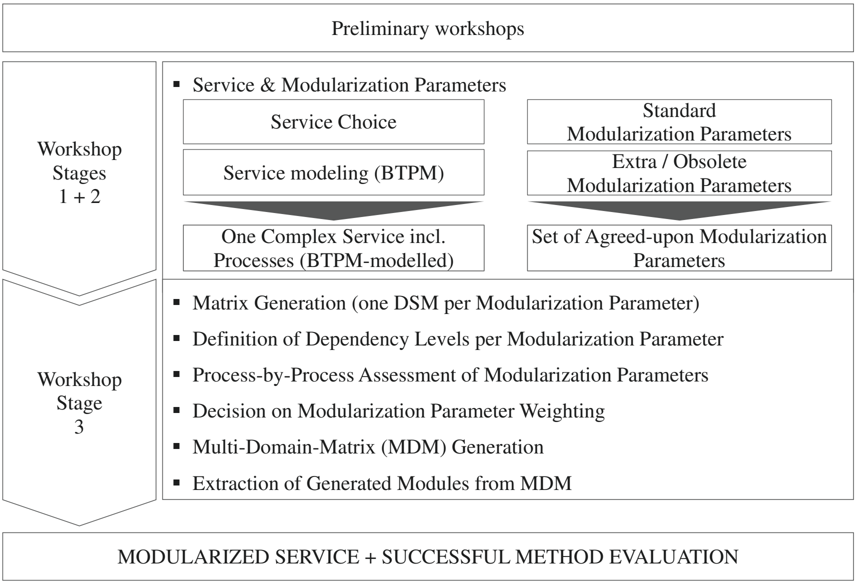

Figure 12.2: Overview of Evaluation Workshops
Source: own illustration

The Preparatory Workshop

Within this workshop, the fundamentals of modularization are outlined and an initial instantiation of the method and its application in the field is presented. The preparatory workshop was designed to last three hours. Its goal was to depict the benefits modularization of complex services is going to provide. It also served as the basis to decide on the to-be-modelled service. Also, the overall workshop setting in regards to content and timeframes was planned within the preparatory workshop.

Workshop 1: Service Decomposition and Modeling

The workshop has two functions. First, it is a follow-up from the preparatory workshop. Second, it delivers outcomes that are prerequisites for the following workshops. It comprises:

Service identification and illustration: one dedicated service needs to be chosen that needs to fulfill the following criteria. It should be a frequently provisioned service. It should be not a trivial, but a complex service, i.e. - as defined above – it consists of IT as well as non-IT parts and comprises the integration of other stakeholders. Then, this service should be clearly described and illustrated.

Service Modeling: The chosen service is modelled with BTPM (Peters and Leimeister 2014), the Blueprint-driven Telemedicine Process Modeling technique, a specific modeling technique for the field of telemedicine.

Modeling assists in the clear representation of services. This is of special need in service systems such as telemedicine which inherits complex services. That is why the decomposition in phase 2 of the modularization method explicitly addresses that by using BTPM. This language was further developed and evaluated (Peters and Leimeister 2014). This is described in detail in the paper which presents how the workshop-informed, iterative design and two-fold evaluation (by application and by criteria) of BTPM was conducted in an action research (AR) setting.

The newly developed language inherits the well-known BPMN-concept of pools and lanes which allows for modular stakeholder-extensions. It integrates blueprinting-specific elements, e.g. the line of interaction or the line of visibility, in order to represent both, value-creating face-to-face momenta as well as front- and backstage activities. Also, BTPM explicitly considers telemedicine devices and distinguishes between stakeholder groups using color coding. It could be shown that BTPM not only meets requirements which have been elicited in case studies performed earlier (thus standing the criteria-based evaluation), but also all additional requirements that came up during the three iterations in the workshops. When applying it (evaluation by application), its adequacy to also assist with the separation of main and sub-processes of services and the identification of (semi) automation and customer integration potentials, could be shown.

AR's dual imperative, i.e. its problem-solving and research interest, corresponds to the paper's contribution which lies in the design and two-fold evaluation of the modeling technique and in the interdisciplinary research setting for its development.

Workshop 2: Modularization Parameters

On the journey to beneficial modularization of complex services, the right choice of modularization parameters can be regarded critical as reasoned above.

That's why within this workshop, the final set of parameters for the modularization matrices is determined. Based on these, the process-by-process analyses are carried out in workshop 3 accordingly. The derivation of parameters evolved by:

Reflection of already existing modularization parameters: The described modularization parameters that are known from the literature are studied and discussed. So far, the following parameters could be elicited:

- Geographical specificity: There are processes that require a certain surrounding and others taking place in different locations. Non-virtual processes that are closer (in a geographical sense) might be important to consider here. The pools and especially lanes of the process map provide indicators here.
- Device-specificity: Some processes are coupled to a certain device. If so, modularization which is performed in awareness of device specificity tries to avoid frequent media breaks.
- Time-critical path dependencies: All processes within paths that run in parallel and are merged later on need to be checked whether they inherit critical time constraints which have crucial effects on the after-merge processes.
- Know-how specificity: There are processes which require a high knowledge and know-how which is closely related to the person's educational background performing it. An example for a process with high know-how specificity is a surgery.
- IT-support / (semi-) automation: Here, a check for potential IT-support and (semi-) automation is performed. This is important when it comes to cost reduction purposes. All parts which are not value-creating, but can be considered commodity highly qualify here.

- Personal encounter / customer integration: In complex services, many services integrate person-to-person parts; many of these personal encounters make up a high fraction of value-creating moments. Stakeholders, especially customers, can be integrated in the service provision. According to (Glushko 2009), there are different levels of integration; the highest one being a self-service setting.

Extra / obsolete modularization parameter: Additional and obsolete parameters can be suggested and are then discussed and agreed upon. This might be necessary due to specifics inherent to the company and its strategic goals, the field and according regulations, etc.

After successful conduction of these steps, the third workshop can be conducted. In terms of the overall project and the according method, this is the point in which the matrix generation can start.

Workshop 3: Modularization Matrices, Specification and Testing

Workshop 3 builds on the steps outlined before. It is designed to last 4 hours. This determination is based on extensive workshop experience. All participants are provided with the service which is modelled in BTPM. Then, the dependency levels for each parameter are defined before all process steps are assessed in regards to the modularization parameters in a process-by-process manner. This is done for all modularization parameters that were agreed on before. For every modularization parameter one dedicated design structure matrix is created. A design structure matrix is "a straightforward and flexible modeling technique that can be used for designing, developing, and managing complex systems" (Eppinger and Browning 2012). The several process steps of the service make up the matrix axes and the process dependencies are represented in the according fields of the matrix. As there will be more than one modularization parameter, consequently there will be more than one created matrix. In case particular modularization parameters are of higher importance than others, a weighting of the parameters is performed now (by multiplying the values of more important parameters with an according factor). It is also considered to combine all these matrices into one so-called multi-domain matrix (Maurer and Lindemann 2008) as they are used in complexity management and systems engineering. Doing so would allow assessing the modularization parameters in a very structured manner. It would also provide module solutions that are derived based on calculation and thus, could be easily compared. So far, the multi-domain matrices could be assessed to be suitable, but a tool for proper use could not be identified. Still, the creation of this matrix is supposed to identify modules that should be created. The created modules are then analyzed in regards to their interfaces to other modules or service parts and after the newly created structure of the service is established, it is tested. It is planned to integrate elicited matrix-driven modularization approaches (Dörbecker and Böhmann 2014) in this workshop.

12.5 Findings so Far and Preliminary Conclusion

The first workshop has been already conducted and is of preparatory nature. Four experts from the field of telemedicine were involved. Their roles are best described as: (1) founder and CEO, (2) chief developer, (3) process analyst and requirements engineer as well as (4) service process expert.

In the workshop, the understanding of modularization was sharpened and illustrated using an example service which has been successfully modularized in an earlier setting. It was agreed that one service from the provider will be modelled collaboratively in an online cloud environment that allows all modellers to adapt and comment existing service models. Therefore, BTPM will be used. Also, several service candidates were already discussed which might be most valuable to modularize. The final choice for the pilot service will be chosen soon; in regards to its potential for strategic competitive advantages. The existing modularization parameters were briefly introduced and discussed. This can be regarded successful as it became clear by the illustrated example service. I consider these existing parameters as the mandatory set every service modularization of complex services should include. The expectation is that there will be two or three extra modularization parameters. They are then used in the main workshop and emerge from the domain specifics, e.g. the law for medical products in Germany that asks for certification and data protection requirements.

An important finding that could be made already is that modularization parameters can and must be distinguished between the ones that can be assessed by a single process and the ones that need pair-wise assessment. As an example for single process assessment, the know-how in a specific field for one process can be taken, while the time-critical path dependencies serve as an example for assessments in need for pair-wise assessments of processes.

As next steps, last preparations for the following workshops are undertaken. The aim and expectation of the workshops is that the one chosen service can be transformed from a completely non-modularized fashion to a modular service. Thus, the potential benefits of service modularization are going to be leveraged.

12.6 Expected Contribution and Future Research

This paper outlines a suggestion how to operationalize modularization attempts using modularization parameters. Thus, it contributes to the research agenda for service systems engineering stating “novel work should seek to enhance the possibilities for modularization, standardization, contextualization and reconfiguration of service components and resources” (Böhmann, Leimeister et al. 2014). In terms of practical contribution, it aims to allow service providers to realize modularization benefits by providing services in an efficient manner on the one side and in a customer-centric fashion on the other side and increases awareness for modularization needs and potentials.

In terms of future research, it fosters further developments of modularization methods such as TM³ (Peters and Leimeister 2013) and reveals insights for modularization approaches in related areas dealing with complex services as well. In this context, first attempts to systematically create culture-related modules (Janson, Peters et al. 2014) is worth mentioning. The integration of the presented findings in settings that deal with whole service architectures and portfolios (Duennebeil, Sunyaev et al. 2013) seems promising as well.

12.7 Acknowledgements

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13 Service Modularization in Service Systems - Supporting Service Design, Customization, and Provisioning with the SMART Method

Peters, Christoph; Leimeister, Jan Marco

Abstract:

Service systems that comprise combinations of highly person-oriented services and IT services, such as telemedicine, face tremendous challenges concerning efficiency and customer orientation as well as fast-changing, multi-stakeholder environments. Here, service providers need to demonstrate that they maintain value-creating and trust-supporting momenta while using IT in order to increase efficiency and enrich their value creation for their customers. We propose modular service structures as a solution. Following the design science research methodology, we present the five-phase SMART method as an approach to modularize existing services. We evaluate the method in a three-fold manner: firstly criteria-based, secondly by applying it to the field of telemonitoring, demonstrating its applicability and feasibility, and thirdly by showing the usefulness of the approach and providing precise effects for 20 services from a service portfolio of a telemedical service provider. For SMART, we synthesize findings from the fields of service modularization, service modeling, service systems, service interaction design, and service engineering, resulting in an applicable, feasible, and repeatable method for the modularization of such services. The application of SMART leads to (1) increased transparency and awareness of the stakeholder's interactions visualized in service process maps, (2) efficiency gains by means of the creation of reusable modules, and (3) provision of a basis for a service portfolio in person-oriented fields capable of integrating digitized services. While applying SMART to 20 services, we demonstrate its usefulness using according metrics, e.g., reuse rates, and show that SMART helps developing new services and reengineering existing services alike.

Keywords: service modularization, SMART method, modularization method, design science research, service science, service system, service process modeling, service interaction design, case study, telemedicine

13.1 Introduction and Motivation

This paper presents the Service ModulARizaTion (SMART) method as an approach to help service providers improve service design, customization, and provision in service systems that comprise person-oriented and IT-based service components. Following a design science research (Hevner, March et al. 2004) approach, SMART has been designed to modularize services that integrate combinations of person-oriented services and IT services in a repeatable, five-phase manner. We evaluate the method (amongst others) by applying it to real-world services from a telemedicine services (TMSs) provider and illustrate its applicability, usefulness, as well as outcomes of its application. All societies need healthcare services – truly an enormous market. Global expenditure on health care has reached $7.2 trillion (Deloitte 2015). In the last decade, great advancements have been realized, e.g., in the field of TMSs which constitutes the provision of medical services over geographical distances through the use of information and communication technology (DGTelemed 2011). TMSs have had enormous growth rates, e.g., the European market alone is expected to reach $5 billion in 2015 (European Commission 2014); globally, it is predicted to reach from $9.8 billion in 2010 to an expected $23 billion in 2015 (BCC Research 2011) and 43.5 billion in 2019 (BCC Research 2014). Although in many different forms (Gartner 2012), TMSs are relevant for all continents.

In this context, digitization plays an important role. Telemedicine dedicated device and software markets – estimated at $843 million in 2012 - are anticipated to reach $2.9 billion by 2019, while mobile health markets related to telemedicine at $1.4 billion are anticipated to reach $1.5 trillion by 2019 due to the use of 7 billion smart phones plus half that many connected tablet devices (Wintergreen Research Inc. 2013). These promises also incur new challenges, one of which is to combine increased quality of such services and more efficient provision of such services. In order to conquer this challenge and succeed in the endeavor of providing good healthcare services and TMSs in particular, we consider four key areas: value co-creation and customer orientation; new information technologies (IT) enabling completely new services while still supporting traditional services; a service system's perspective considering all stakeholders; and the design of services and service processes in a systematic manner.

While addressing all of these key factors, we place emphasis on the latter, identifying service modularization as an important means for a parallel increase in service efficiency and quality that can respond to the heterogeneous needs of patients and all stakeholders of the TMS market. As current research lags behind in providing guidance on the systematic modularization of services and assisting TMS providers in leveraging these potentials, we develop a method allowing for such a systematic step-by-step modularization.

According to Brinkkemper (1996), a method provides a detailed prescription of how to perform a collection of activities. The term is closely related to method engineering (Brinkkemper 1996), where method refers to a particular procedure for attaining something (Odell 1996). A method is hence a process that is planned and systematic in terms of its means and purpose (Braun, Wortmann et al. 2005). Characteristic features of methods are goal orientation (here, the modularization of TMSs), a systematic approach (here, the clear separation of activities in five phases with dedicated resulting artifacts) and repeatability. Motivated by the recent call for research on service design (Bitner 2015), we present the SMART method capable of service modularization and show its applicability, usefulness, efficiency and quality gains of the modularized services in TMSs.

The rest of this paper is structured as follows. In the next section, we lay the foundation for the main concepts of our paper. Therefore, we outline service systems and modularization foundations before we define and describe our understanding of services, processes and modules and their interdependencies. Also, we describe telemedicine and telemonitoring, which are the chosen fields of application for the SMART method. We then present the design science research methodology that guides our research and the design and evaluation of our artifact, the SMART method. This is followed by a detailed description of the SMART method with its five phases, the according activities, and resulting artifacts. After this, we evaluate the method and demonstrate the SMART method's applicability, using the field of telemonitoring and integrating insights from an in-depth case study. The results are then presented and discussed. Limitations as well as potential future research activities are outlined before we conclude with our main contributions.

13.2 Related Work

13.2.1 Service Systems

Maglio and Spohrer (2008) define the term service systems as "value-co-creation configurations of people, technology, value propositions connecting internal and external service systems, and shared information (e.g., language, laws, measures, and methods).", Vargo and Lusch (2011) referring to them as ecosystems and Alter (2013) defines them as "work systems producing a service". Given these various definitions, one can agree on the many-to-many service experiences (Chandler and Lusch 2015) service systems are based on.

These service experiences are made during the co-creation of services (Vargo and Lusch 2004; Vargo, Maglio et al. 2008). The path of co-creation is not simple or uni-faceted, but rather co-creation involves a "complex combination of activities and interactions between lead firms and network actors, characterized by both lead firm and network-based innovation" (Perks, Gruber et al. 2012) in which not only the service provider is making value propositions, but "can engage itself in customers' value fulfillment as well'' (Grönroos 2008). When considering the magnitude of service system's resources, their integration in the value co-creation process is critical. Here, the actors' resource integration should be "informed by both the value proposition and the service and social structures (with the dimensions of legitimation, domination, and signification) of the service system" (Edvardsson, Skålén et al. 2012).

TMSs are always part of these service systems. As IT and non-IT services are inherent to any TMS by definition, TMSs differ much in regards to their standardization and interface specification capabilities. That is why "innovative assembly of ICT as well as non-ICT resources" is needed (Srivastava and Shainesh 2015) in service systems.

13.2.2 Modularization

Modularization comprises the decomposition of one object into decoupled single components with specified interfaces that can be combined to create new single components (Böhmann and Krcmar 2006). First ideas go back to Parnas (1972), who postulated that decomposing systems into modules improves overall manageability, as not all (sub-) functions (of a module) need to be visible but can be hidden if the overall module function is clearly specified, i.e., information hiding.

Modularization rests upon the basic principles of cohesion and loose coupling (Balzert 1996). Cohesion describes the extent of intra-module dependencies. A high cohesion is a requirement for well-specified modules that can be reused and combined with other service modules. Loose coupling prescribes that there are only few inter-module dependencies between the elements of the different modules (Böhmann and Krcmar 2006). Thus, loose coupling relates to the independence of the modules. Modules serve a specific function (Schilling 2000) and are connected by interfaces which have to be specified appropriately (Ulrich 1995; Baldwin and Clark 1997).

The potentials of service modularization (Böhmann and Krcmar 2006) are manifold: (1) reuse – the repeated use of one specific module within different services; (2) faster development – the increase of overall development speed through higher manageability due to smaller objects of consideration (the modules) that have defined interfaces; (3) module-wide innovation – the possibility of concentrating innovation efforts within one strategically important module that is supposed to provide competitive advantages; (4) rapid reconfiguration – the efficient (re-) configuration of modules enabling a customer-centric service provision in a mass customization manner.

In the field of product development, applying modularization has a profound history that has been examined in management and organizational contexts for almost two decades (Baldwin and Clark 1997; Baldwin 2008). The building of a specific modularization theory has also been attempted (Schilling 2000).

Thus far, only few studies have dealt with service modularization (Voss and Hsuan 2009; Bask, Lipponen et al. 2010; de Blok, Luijkx et al. 2010; Tuunanen and Cassab 2011) in greater detail; the modularity of service process architectures has been examined (Frandsen 2012), modular design has been elicited as a viable strategy for coping with the complexity faced in service networks (Becker, Beverungen et al. 2013) and service modularity has been put into context with business model development (Rajahonka 2013) and customization (Rajahonka, Bask et al. 2013). While the concept and effects of service modularization have been elicited (Dörbecker and Böhmann 2013) and there have been attempts to consider service modularity and customization systematically (Bask, Lipponen et al. 2011), systematic modularization – as the act of identifying and forming modules – in the form of a repeatable method still needs to be investigated further. This is exactly the gap which this paper intends to close.

It is also crucial to understand that modularity or the extent of modularization (the measure of how much of the overall service is finally modular) might not be 100 percent for most services. The reason for this lies in the continuum between a fully integrated and a fully modularized service (Gershenson, Prasad et al. 2004), and thus modularity is always a relative measure. While first works have presented meaningful modularization measures for services (Dörbecker, Böhm et al. 2015), we believe to contribute the first paper that not only presents the SMART method as a powerful means for service modularization, but also measures its effectiveness with modularization measures such as the service module reuse rate.

13.2.3 Services – Service Processes – Service Modules

Services and service processes have been widely discussed and heterogeneously defined. Although we do not want to outline sets of definitions for the used terms here, we still want to provide an overview of how the four main terms of this paper (service, service process, service module and modular service) are interdependent. This is visualized in Figure 13.1:

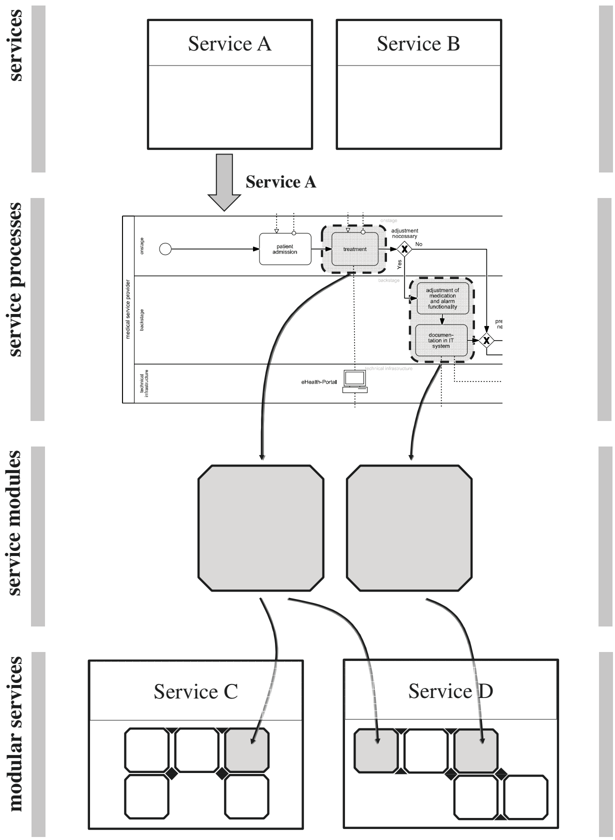


Figure 13.1: Services, Service Processes, Service Modules and Modular Services and their Interdependencies
Source: own illustration

All services can be decomposed into a set of service processes representing all activities for the conduction of this service. Using systematic modularization, such a decomposed service can be used to create service modules that comprise service processes. For successful service modularization, these service modules are used to build modular services. It is exactly this terminology which underlies the logic of this paper and the SMART method, which closes the gap of performing such service modularization.

13.2.4 Service Systems in Healthcare – Telemedicine and Telemonitoring

TMSs comprise a heterogeneous market, ranging from telemonitoring services (e.g., defibrillators that capture and transfer a patient's heart beat data in order to enable physicians to monitor the patient's heart functions remotely and to automatically trigger alarm functions) to teleconsultation services enabling experts to guide other physicians through the conduction of medical procedures, e.g., in telestroke units. The heterogeneity also applies to the TMS contexts. TMSs are used at various stages of the overall treatment process of patients, e.g. before the discharge of patients from hospitals in order to assist in improving the patients understanding and curation (San Nicolas-Rocca, Schooley et al. 2014). They might be applied to very remote locations where different concepts and levels of existing knowledge exist (Miscione 2007) or in developing countries facing very low ratios of health professionals to population where TMSs mitigate the shortage of medical personnel (Abera, Mengesha et al. 2014). Also, TMSs span all age groups which requires specific handling and different practice styles (McColl-Kennedy, Vargo et al. 2012), e.g. in the service co-creation processes with older people (McLoughlin, Maniatopoulos et al. 2012).

TMSs always comprise a combination of IT services and non-IT, highly person-oriented services. IT services might involve the data transfer of a TMS device to a monitoring facility. Due to industry standards or technical input / output requirements, these parts are highly standardized. Non-IT parts might be knowledge-intensive and person-oriented (KIPO) service parts, e.g., an interaction between physician and patient that could be highly individual because of the patient's individual state and situation.

Such TMSs are beneficial in supporting a patient's quality of life (Berry and Bendapudi 2007) and, where implemented, can reduce the cost of delivering health care. Despite being considered medically and technically viable, few TMS innovations have been put to practice (Cho, Mathiassen et al. 2008; Essén 2009).

13.3 Research Methodology

We follow a design science research approach for developing and evaluating the SMART method. Design science aims to develop solutions for organizational and business problems through the design and evaluation of novel artifacts (Hevner, March et al. 2004). Such artifacts can be methods (Gregor and Jones 2007). They can be understood as theories for design and action (Gregor 2006) and design science research is especially fruitful and promising for generating novel solutions and knowledge.

Design science is performed in an iterative way; generation/test cycles are therefore carried out repeatedly before leading to a solution (Simon 1996; Hevner, March et al. 2004). This paper applies the design science research methodology by Peffers et al. (2007) and follows the guidelines defined by Hevner et al. (2004).

The design science research process model of Peffers et al. consists of six activities that need to be conducted (Peffers, Tuunanen et al. 2006):

1. Problem identification and motivation: The research problem and its importance are defined.
2. Objectives of a solution: The objectives of a solution need to be defined in order to guide the subsequent activities and to allow for the evaluation of the designed artifact.
3. Design and development: The actual solution is designed and developed.
4. Demonstration: The suitability of the designed solution to solve the targeted problem needs to be demonstrated.
5. Evaluation: The observations made in the demonstration step are analyzed regarding the suitability of the proposed solution. The evaluation results can be integrated in the next build-and-evaluate iteration of the artifact.
6. Communication: This comprises the publication of the result and its importance to relevant audiences from research and practice.

The research process followed in this paper is problem-centered, meaning it is initiated by a problem definition. The problem definition has been derived from the need of service providers in the field to realize efficiency as well as user orientation during service provision.

Table 13.1 summarizes our research setting following these activities, and outlines how we implemented and addressed them. For each phase of the DSRM, we outline the parts of the paper addressing them.

DSRM Activity	**Our Implementation**
1) problem identification and motivation	Service provision of TMSs (services that comprise a combination of highly person-oriented services as well as IT services) that is both efficient and user-centric; more detailed in the introduction section
2) definition of the objectives for a solution	An approach for the modularization of TMSs that is systematic and repeatable (a method) and respects the particularities of service systems for TMSs (multi-stakeholder environments; interfaces between person-oriented and IT services); more detailed in the introduction and related work section
3) design and development	The SMART method; presentation of the according phases and resulting artifacts; as outlined in the section "The Method and its Phases"
4) demonstration	The application in the TMS sector; as outlined in the according section
5) evaluation	Three-fold: criteria-based, by application in the field, and by presenting effects of the SMART method in the effect elicitation phase
6) communication	Outlining the problem and its importance, the design and evaluation of the created SMART method (the DSR artifact) and its effects, implications for the scientific community and future research as well as for practice and managerial audiences

Table 13.1: Research Methodology following the DSRM Activities
Source: own illustration

13.4 The Method and its Phases

After addressing the first two activities of the DSRM as described in Table 13.1, the third phase "design and development" is presented in this section. Here, the SMART method is introduced. It consists of five phases: (1) status capturing, (2) decomposition, (3) matrix generation, (4) interface specification, and (5) testing. These phases, the main activities as well as the resulting artifacts are illustrated in Figure 13.2 and are then explained in subsequent sections.

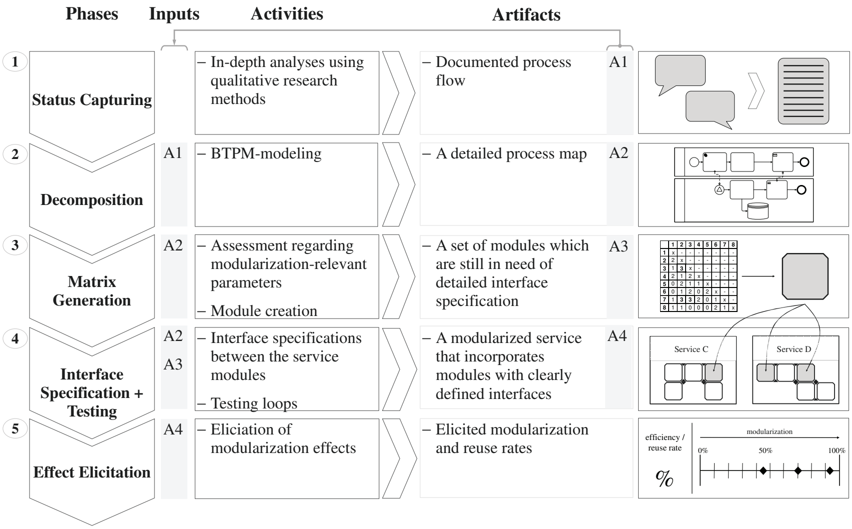


Figure 13.2: Overview of SMART with its According Phases, Activities, and Resulting Artifacts
Source: own illustration

13.4.1 Phase 1: Status Capturing

The intention of the method's starting phase is to receive a detailed picture of the object of modularization, i.e., the person-oriented IT service that is about to be modularized. This is in line with Dubberly et al. (2008), who state that any design or engineering process starts with observations and the investigation of the initial situation. We therefore perform in-depth analyses that are realized using interviews, observations, questionnaires, document analyses, etc. (Miles and Huberman 1994) and are focused on the process flow of the service. We also discuss the interaction points between the service system's participants as well as the consideration of systems and devices in use.

As resulting artifacts, phase 1 delivers a documented service process (flow) in either written or spoken form considering: 1) the other participants of the service system (A1a), 2) the interactions with and between them, 3) the technical systems and 3) the devices in use.

13.4.2 Phase 2: Decomposition

Here, artifact 1a, the documented service process flow, is used to decompose the service to a granularity stage consisting of service processes only. This is formalized and visualized using a modeling approach, which has been specifically developed for such person-oriented IT services (Peters, Elm et al. 2014) and has already been applied in several settings (Peters and Leimeister 2013; Janson, Peters et al. 2014). Inspired by the work of Patricio et al. (Patrício, Fisk et al. 2008; Patrício, Fisk et al. 2011) as well as by similar attempts such as Business Service Blueprinting Modeling (Meis, Menschner et al. 2010). This approach is based on Business Process Model and Notation (BPMN) elements, but it also integrates the service blueprinting (Shostack 1984) idea that allows to model transparently the person-oriented IT service stakeholder interactions.

Thus, as BPMN is commonly known, it can be easily applied and enriched by service elements that explicitly consider the person-oriented parts of the service. The BPMN-typical pools are used for the corresponding service system participants with the help of the lanes, as well as the front- and backstage activities. The technical infrastructure can also be represented for the respective stakeholder pool. Thereby, the relevant lines of the service blueprinting approach (Bitner, Ostrom et al. 2008), e.g., the line of interaction (between the pools) and the line of visibility (between the frontstage and the backstage lanes of each pool), can be represented. All these features will be of high importance in the next two phases, as they enable an adequate and comprehensive representation of person-oriented IT services from a service process perspective, thus constituting the basis for the module creation, as well as potential service (re-) configurations and (re-) developments.

Phase 2 delivers one artifact, a detailed service process map of the service (A2), which is modelled by means of BTPM.

13.4.3 Phase 3: Matrix Generation

The phase of matrix generation builds on the artifact A2. The service process map provides the basis for the pair-wise assessments of modularization parameters for all service processes. Thus, this phase clarifies where modularization makes sense (resulting in the extent of modularization) and which service processes are combined for module creation (resulting in the modules and their boundaries). The phase is subdivided into three main parts: (1) the creation of the initial matrix structure, (2) the assessment of modularization parameters and (3) the actual matrix processing for the module creation.

The Creation of the Initial Matrix Structure

The service process map of phase 2 allows a step-by-step or process-by-process assessment of modularization-relevant parameters, which is why the service processes from the map are numerated. When the last service process of the map is the a^{th}, a matrix with the dimensions a x a is built. As service processes are assessed pair-wise and in a dichotomous manner, the diagonal remains empty, and only one part – either below or above the diagonal – needs to be assessed. For each modularization parameter, one matrix is built, after which the assessment of modularization parameters can begin.

The Assessment of Modularization Parameters

Modularization is based on the strong cohesion and loose coupling of modules consisting of service processes; thus, dependency measures are needed. The SMART method therefore builds on a set of modularization parameters elicited in (Peters 2014), derived from Schantin (2004) as well as from (Peters and Menschner 2012) and refined within dedicated parameter workshops with providers of person-oriented IT services. These parameters are, and have to be, distinct. They are dichotomous, i.e., the pair-wise assessment of the service processes either results in a dependency (rated as 1) or as an independency (rated as 0). In the following, each of these modularization parameters is described.

Personal interaction dependency:

Person-oriented IT services comprise personal interaction by definition. Many of these personal encounters make up a high fraction of value-creating moments. Stakeholders, especially customers, can be integrated in the service provision as they co-create value. This parameter reflects direct person-to-person interaction. Interaction takes place above the visibility line.

IT-enabled interaction dependency:

This parameter reflects interactions encountered between one service stakeholder and a system or device. The system or device in this case has an interaction dimension, as it responds according to the user’s input and stored feedback rules. Interaction takes place below the visibility line.

Geographical dependency:

When two service processes are required to be in the same geographic location, they are considered to be geographically dependent. The pools and especially lanes of the service process map provide indicators here.

Device and system dependency:

Some service processes are coupled with a certain device or system. If so, modularization performed in awareness of device and system specificity tries to avoid frequent media breaks within modules.

Time-critical path dependency:

All service processes within paths running in parallel and merging later on need to be evaluated concerning whether they inherit critical time constraints, as they have crucial effects on the after-merge service processes.

Know-how dependency:

Different service processes require different levels of know-how, which is closely related to the performing person's educational background. If two service processes require the same level of know-how, the corresponding dependency is given; otherwise, the assessment of corresponding service couples is assessed as being independent for this parameter.

Connectivity dependency:

For TMSs, connectivity is crucial at one point or another. Two service processes are assessed if they both need online, offline, or no, IT connectivity. While the data transfer from a device to a portal is an example for online requirements, an app with an offline storage might inherit service processes that require IT, but on an offline basis.

The following table indicates the criteria for the pair-wise and dichotomous assessment of the modularization parameters.

In terms of modularization parameter …,	**… two service processes are rated as dependent (=1), if…**	**… and as independent (=0) if …**
personal interaction dependency	there is a direct interaction between the service processes stakeholders*	there is no direct interaction between the service processes stakeholders.

In terms of modularization parameter …,	… two service processes are rated as dependent (=1), if…	… and as independent (=0) if …
IT-enabled interaction dependency	there is an interaction between a person and an event-triggered system*	there is no interaction between a person and an event-triggered system.
geographical dependency	they need to be performed in the same location	they do not need to be performed in the same location.
device and system dependency	they require the same device or system*	they do not require the same device or system.
time-critical path dependency	one service necessarily needs to be performed before or after the other	one service does not necessarily need to be performed before or after the other.
know-how level dependency	they require the same know-how level*	they require a different know-how level.
online IT dependency	direct online data exchange is required between them*	offline or no data exchange is required between them.

Table 13.2: Modularization Parameters: Rules for the Pair-wise Assessment of Service Processes
Source: own illustration

All modularization parameters marked with an asterisk (*) can be directly assessed by referring to the BTPM-modeled service process map, given the inherited design of the model. While a service process within the onstage lane of a stakeholder compared to a second service process from the onstage lane of another stakeholder indicates personal interaction, IT-enabled interaction can be assessed if one service process is in the backstage lane of a stakeholder and the second service process is in the technical infrastructure lane of another stakeholder. As all service processes indicate their use of a system or device by dotted lines, the assessment of two service processes here is a check of whether these services are connected to the same device or system. Know-how levels are transported by the color-coding of service processes, e.g., grey for physicians, green for nurses. Additional fields of know-how might be added at any time and need to be considered accordingly. Online IT dependency can be assessed indirectly by checking whether the used device of the service processes needs an online, offline, or no, data transfer.

The Actual Matrix Processing for the Module Creation

After all matrices have been built and all modularization parameters are assessed accordingly, one additional aggregating matrix is built. For this matrix, highly accepted matrix generation and clustering algorithms are needed to facilitate the module creation process. That is why we rely on the design structure matrix developed by (Steward 1981) as well as on the clustering algorithms that were specified in consecutive research (Browning 2001; Eppinger and Browning 2012).

Based on this assessment dependency, matrices which inform the building of modules and their size can be drawn. As described above, a module is characterized by high cohesion (strong intra-module ties) and loose coupling (low inter-module dependencies). Taking the example of geographical dependency and assuming that it was the sole modularization parameter, service processes taking place at the same location would qualify to be included in the same module. Of course (as geographical dependency is only one of many parameters), the other parameters need to be considered as well. Depending on the method's application context, a weighted consideration of the different parameters makes sense.

As an artifact, phase 3 delivers a preliminary set of modules (A3) still in need of detailed interface specification.

13.4.4 Phase 4: Interface Specification and Testing

The proposed set of modules (A3) and the BTPM-modeled service process map (A2) serve as inputs for this phase. The main goal of this phase is the interface specification of modules which themselves then show a black box character, i.e., they have defined inputs and outputs, but their internal functionalities and activities do not need to be evident to outsiders.

The main challenge here is the different level of interface specification clarity for different service modules. While merely technical modules can have standardized and widely accepted formats for interfaces, e.g., in the form of protocols, the efforts for the precise specification of interfaces for person-oriented service modules should be higher. "Precise" in this case correlates with measurability of inputs and outputs. At the end of this phase, the method runs testing loops for the functioning of the service, thereby checking the configuration of the modularized service.

Phases 3 and 4 can be iterated as long as no satisfactory results are attained. A tested set of modules with specified interfaces (A4) constitutes the artifact of the fourth phase.

13.4.5 Phase 5: Effect Elicitation

The final phase of the SMART method is used for a detailed analysis as well as effect elicitation and measuring of the modularization objects, i.e., the services, respectively, the service portfolio. This is done in a semi-automatic way using macro-coded spreadsheets that transform the modularization matrices into measurements, e.g., the modularization rates for specific services at different module strength levels will reuse rates for modules or minimum, maximum and average values for the size of service modules.

The artifacts of phase 5 are modularization measures for the services applied using the SMART method.

13.5 Application in the Telemonitoring Sector

Addressing the fourth activity of the DSRM, we demonstrate the method's suitability for its intended use in this section. For this application of the SMART method, we conducted an in-depth case study at the service provider's site. Following a preparatory workshop in 2013, this case study spanned a total of eight workshops conducted between January and August 2014. These workshops lasted between three and five hours, involving all relevant roles at the provider's site, i.e., the founder and CEO, the director of marketing and sales, the director of finance and administration, the head of product development, the medical device safety officer, the quality assurance manager and requirements engineer. Each of these had sound experience in the health sector. The workshops were supported by three interviews conducted at the beginning, in the middle, and at the end, of the case study project. In total, we analyzed 20 TMSs with four different treatment foci, i.e.: TMSs for patients from cardiac insufficiency, chronic obstructive pulmonary disease, diabetes, and blood pressure problems.

Some of the many features that the telemedical treatment inherits in comparison to the solely traditional medical treatment include automatic real-time data transfer and documentation of measured vital data, worldwide on-demand access to these data, definition of threshold values and corresponding information, alarm services for involved stakeholders such as physicians, care personnel or relatives, and long-term overview of the health status and development.

Within the preparatory workshop, the fundamentals of modularization were outlined, after which an initial instantiation of the method and its application in the field was presented. The preparatory workshop was designed to last three hours, the main goal of which was to depict the benefits of TMS modularization, but it also served as the basis for deciding on the to-be-modeled services. The overall workshop setting in regards to content and timeframes was planned within the preparatory workshop.

In the following sections, we outline the five phases of the SMART method and elaborate on the mentioned treatment scenarios.

13.5.1 Phase 1: Status Capturing

After selecting TMSs with our case study partners in the preparatory workshop, we analyzed and captured the status of these TMSs in two consecutive workshops and interviews with our case study partners. Accompanying information comprised descriptions of the service process flows, requirement sheets for all manuals of the devices, technical specifications for all systems and devices used for the services, marketing brochures for customers and partners, and the service offering descriptions on the provider's website. These inputs helped us to consolidate profound service descriptions. The TMS provider acted as a service system integrator, as she received the monitoring devices from an external supplier and was in direct contact with the patient as the service co-creator. The service payments were settled by the health insurance company or on a private basis.

13.5.2 Phase 2: Decomposition

The service process flow was then formalized and visualized using the Blueprint-driven Telemedicine Process Modeling (BTPM) technique, a specific modeling technique for the field of telemedicine (Peters, Elm et al. 2014). Thus, the complete service was decomposed into service processes. This was done in three dedicated workshops for joint service modeling. According to BTPM, we modelled all services using one pool for every stakeholder and three lanes in each pool, i.e., a frontstage lane, a backstage lane and a technical infrastructure lane. Lines of interaction separated the pools from each other, and lines of visibility bordered the front- and backstage lanes for each stakeholder. This resulted in one big service process map per service. Due to space restrictions and readability, they cannot be shown in full size here. For one service, an exemplary part is visualized in Figure 13.3.

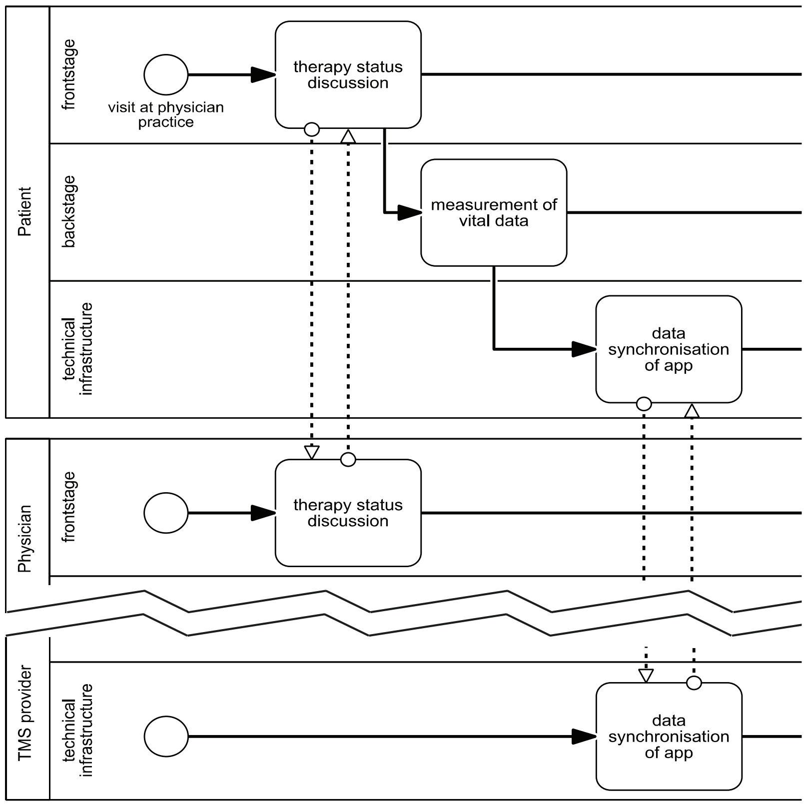


Figure 13.3: Exemplary Service Process Map Modeled with BTPM (extract only)
Source: own illustration

In this example, all pools represent a stakeholder, shown here in the three lanes described above. For the physician and the provider of the TMS, two lanes are cut out for illustration purposes.

We modelled the services with an online, cloud-based tool that allowed us to collaboratively redevelop and adjust the service process modelings. Here, direct successes and an increase in service process awareness was realized during the workshops, e.g., when the participants first wanted to refuse to model "these unimportant parts," we asked them again to model these parts; however, they argued that they – based in these modelings - could easily enhance the service quality at this stage by providing additional documentations and explaining figures to the stakeholders that would create value for them and would not take any extra effort on their part.

13.5.3 Phase 3: Matrix Generation

In this phase, we focused on the modularization parameters and the matrix generation based on the service process maps from the last phase. This was part of two intensive workshops.

On the journey to beneficial modularization of services, the right choice of modularization parameters was regarded to be critical, as reasoned above. That is why in this phase, the final set of modularization parameters was determined as follows: personal interaction dependency, IT-enabled interaction dependency, geographical dependency, device and system dependency, time-critical path dependency, know-how level dependency and online IT dependency.

For the generation of the matrices, all participants were provided with the service process maps modeled in BTPM. The several processes of the service made up the matrix axes. For each agreed-upon modularization parameter, one matrix was created. We then performed a process-by-process analysis for each modularization parameter. For each service process couple, their dependency was assessed with regards to the corresponding modularization parameter and was assessed as either dependent (represented as “1”) or as independent (“0”). As the assessment for each modularization parameter is dichotomous and undirected for all service process couples, only the part below the diagonal axis contains values (one could mirror the values, but we avoided that for better readability). The generated matrices were then added up to an accumulated dependency matrix. As the real matrices are quite big, this procedure is illustrated in an exemplary manner in the following Figure 13.4.

As is evident, the service process couple (1,2) (represented in column 1, row 2 of the matrices) is assessed as dependent in regards to modularization parameter #1 and #3, while it is assessed as independent in regards to modularization parameter #2.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	x	-	-	-	-	-	-	-
2	1	x	-	-	-	-	-	-
3	0	**1**	x	-	-	-	-	-
4	1	1	0	x	-	-	-	-
5	0	0	1	1	x	-	-	-
6	0	1	0	0	1	x	-	-
7	0	**1**	**1**	1	0	0	x	-
8	1	0	0	0	0	1	0	x

Matrix modularization parameter #1

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	x	-	-	-	-	-	-	-
2	0	x	-	-	-	-	-	-
3	0	**1**	x	-	-	-	-	-
4	1	0	1	x	-	-	-	-
5	0	1	0	0	x	-	-	-
6	0	0	1	0	1	x	-	-
7	1	**1**	**1**	1	0	0	x	-
8	0	0	0	0	0	0	1	x

Matrix modularization parameter #2

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	x	-	-	-	-	-	-	-
2	1	x	-	-	-	-	-	-
3	1	**1**	x	-	-	-	-	-
4	0	0	1	x	-	-	-	-
5	0	1	0	0	x	-	-	-
6	0	0	1	0	0	x	-	-
7	0	**1**	**1**	0	0	1	x	-
8	0	1	0	0	0	1	0	x

Matrix modularization parameter #3

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	x	-	-	-	-	-	-	-
2	2	x	-	-	-	-	-	-
3	1	**3**	x	-	-	-	-	-
4	2	1	2	x	-	-	-	-
5	0	2	1	1	x	-	-	-
6	0	1	2	0	2	x	-	-
7	1	**3**	**3**	2	0	1	x	-
8	1	1	0	0	0	2	1	x

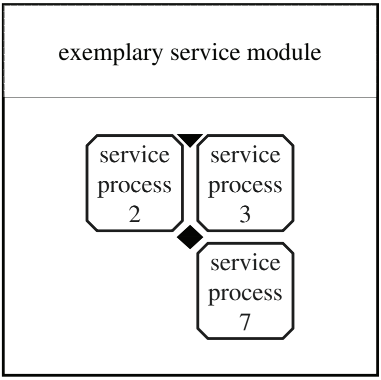
Accumulated matrix

Figure 13.4: Matrices for each Modularization Parameter and the Resulting Accumulated Matrix
Source: own illustration

For the considered services, no weighting of specific modularization parameters was performed, and thus they are equally represented. Based on these manually performed assessments, the service modules were created in a semi-automatic manner. For each module strength, the corresponding set of modules was created. The module strength represents the number of modularization parameters considered to be dependent. Thus, all service process couples formed modules with a given module strength x that had at least x modularization parameters for which a dependency was assessed.

This can be easily verified in the accumulated dependency matrix. For module strength 3, all process couples with a value of 3 or higher qualify for the respective modules at this level. The size of created modules depends on whether certain service processes are part of other service process couples as well and thereby extending modules, e.g., if service process couples (2,3), (2,7) and (3,7) are within the considered module strength, they form a service module comprising the service processes (2,3,7). This is visualized in Figure 13.5. In this example, the service consists of eight service processes that build both the horizontal and vertical axis of the matrix. The figure represents the accumulated matrix which comprises the assessments for all modularization parameters. In this case, only one module is created, as all service processes that are assessed with the module strength 3 are interconnected.

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	x	-	-	-	-	-	-	-
2	2	x	-	-	-	-	-	-
3	1	**3**	x	-	-	-	-	-
4	2	1	2	x	-	-	-	-
5	0	2	1	1	x	-	-	-
6	0	1	2	0	2	x	-	-
7	1	**3**	**3**	2	0	1	x	-
8	1	1	0	0	0	2	1	x



Accumulated matrix for an exemplary service with eight service processes

Service module built from the accumulated matrix; service module strength: 3

Figure 13.5: Visualization of the Accumulated Matrix of an Exemplary Service and the Created Module
Source: own illustration

Following these analyses, modules were created at the module strengths 1, 2 and 3. We outline a selection of created modules at module strength 3 below and describe them.

The module "Adaption" comprises the service processes "editing patient profile," "changing patient's threshold values," "adaption of patient's medication" and "adaption of diagnosis in patient diary." This is visualized in Figure 13.6.

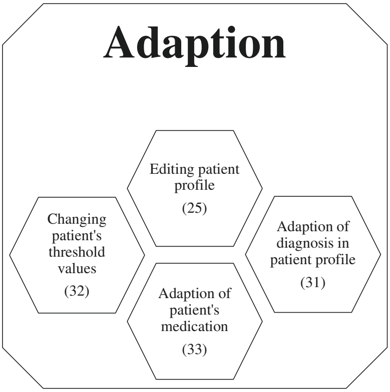


Figure 13.6: Service Module “Adaption” and its Service Processes
Source: own illustration

The service processes within this module were performed by physicians or nurses. This would happen after one of the continuing discussions with the patient regarding the therapy status or after certain observations regarding the monitored data required it. The adaptions were made by accessing the TMS portal.

The module “Data Exchange” comprises the service processes “data transfer to portal,” “receiving data from app” and “data transfer to external systems” visualized in Figure 13.7.

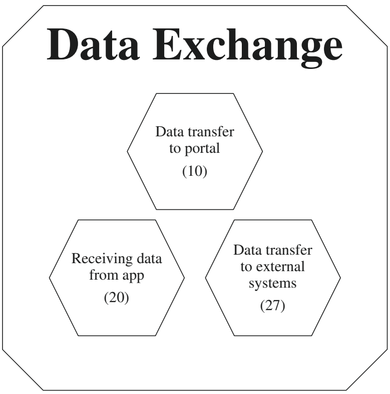


Figure 13.7: Service Module “Data Exchange” and its Service Processes
Source: own illustration

The service processes within this module are located in the technical infrastructure lane and are either performed automatically (e.g. app-induced) or initiated by a patient, physician, nurse or a lay person. This module comes into play after measurement or adaptions have been made.

At the end of this phase, we created the modules for each module strength, almost 130 service modules in total.

13.5.4 Phase 4: Interface Specification and Testing

In the fourth phase, serving as the finalization of the created service modules, the interfaces were analyzed and tested. This was done in another workshop at the site of the TMS provider. With respect to interfaces, we demonstrate this phase of the SMART method using the following example: the module "Measurement" comprising the service processes "measure vital data" and "sending measurement data." This is visualized in Figure 13.8.

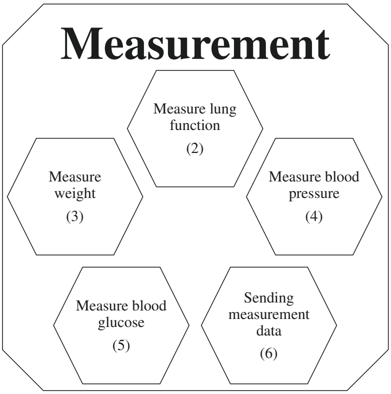


Figure 13.8: Service Module "Measurement" and its Service Processes
Source: own illustration

It is clear that the "measure vital data" can be distinguished into several vital data measurements. Of course, not all TMSs require the measurement of all measurable vital data. Nevertheless, the detailed interface analysis prompted the consolidation of these partly distinctive measurements within one service module.

Further testing included plausibility checks regarding the service processes in service modules, but also the configuration checks of interfaces, e.g., whether the created service modules had clearly specified inputs and outputs. This was the case for all examined services and corresponding service modules.

The results of this SMART phase are the complete service modules that made up the services.

13.5.5 Phase 5: Effect Elicitation

In order to prove not only the applicability of the SMART method but also the effects of modularization on the examined services, we conducted corresponding analyses. Overall, the application of the SMART method can be considered to be highly successful for all services under study. The effects vary, depending on the chosen module strength. Detailed effects are illustrated according to their module strengths below.

The 20 services of study comprised 235 service processes, which led to 40 service modules (module strength 1), 41 service modules (module strength 2), and 47 service modules (module strength 3).

We show statistics and effects of the SMART method and use four entities for doing so: 1) the number of service processes; 2) the number of modularized service processes (i.e., all service processes that are part of the created service modules); 3) the number of service modules; and 4) the ratio between service processes and service modules (i.e., the number of service processes that an average service module comprises). The statistics for module strength 1 are shown in Table 13.3.

	# service processes	**# modularized service processes**	**# service modules**	**modular service processes / service modules**
for all 20 services	235	219	40	5.48
avg (all services)	11.75	10.95	2	5.48
median	10	9	2	
min	7	6	1	
max	20	19	4	

Table 13.3: Overview of SMART Statistics for Module Strength = 1
Source: own illustration

With the exception of the service processes / service modules ratio, we provide the average, median, minimum and maximum values for all of these entities. For module strength 1, there are 20 services with 235 service processes, which led to 40 modules comprising 219 service processes. The statistic for module strength 2 are shown in Table 13.4.

	# service processes	# modularized service processes	# service modules	modular service processes / service modules
for all 20 services	235	165	41	4.02
for 18 services	218	165	41	4.02
avg (all services)	10.90	8.25	2.05	4.02
avg (used services)	12.11	9.17	2.28	4.02
median	10.5	8	2	
min	8	7	1	
max	20	16	4	

Table 13.4: Overview of SMART Statistics for Module Strength = 2
Source: own illustration

As can be seen, we added two additional rows here. This is because this module strength could only be realized for 18 of the 20 overall services and their corresponding 218 service processes. However, we left the rows for the overall 20 services and 235 service processes in the table for benchmarking purposes and as an explanation of the overall modularization rates below. The statistics for module strength 3 are shown in Table 13.5.

	# service processes	# modularized service processes	# service modules	modular service processes / service modules
for all 20 services	235	105	47	2.23
for 18 services	218	105	47	2.23
avg (all services)	10.90	5.25	2.35	2.23
avg (used services)	12.11	5.83	2.61	2.23
median	10.5	5	2	
min	8	4	2	
max	20	10	4	

Table 13.5: Overview of SMART Statistics for Module Strength = 3
Source: own illustration

As is evident, the increase in module strength leads to a decrease of modularized service processes, but to an increase of created service modules. The higher the module strength, the less service processes are part of one service module.

To demonstrate the effects for service efficiency, we also analyzed the created modules in terms of their reuse over the 20 services. As reuse is one of the main modularization benefits, we present realized reuse rates for the service modules of 17% (module strength 1), 19% (module strength 2), and 23% (module strength 3). These high reuse rates demonstrate that many services can build on the very same service modules, thus providing great efficiency at the service provider side.

We can also show powerful modularization rates, i.e., the ratio of service processes that were modularized at a certain module strength to the overall service processes, was realized. For module strength 1, a modularization rate of 97% was realized (see Table 13.3: 219 modularized service processes / 235 overall service processes. For module strength 2, a modularization rate of 77% was realized if you consider only the 18 services at this module strength (see Table 13.4: 165 modularized service processes / 218 overall service processes); if you consider all service processes, the modularization rate still reaches 70% (165/235). For module strength 3, a corresponding modularization rate of 48% (respectively 45%) was realized (see Table 13.5).

13.6 Further Evaluation and Discussion

For the rigorous evaluation of the designed artifact, the SMART method, this section gives an according overview of the three-fold evaluation and thereby addresses the fifth activity of the DSRM. The application of the SMART method revealed the great benefits and substantial effects service modularization can realize. It is characteristic for systematic service modularization to not consider service efficiency and increased user centricity and consecutive service quality as opposing goals; it rather fosters the promotion of both goals. The realized effects that could be presented during the effect elicitation phase during the method's application represent one part of our three-fold evaluation.

The overall application of the method presented in the section above represents a second part and we accordingly structured this discussion section in line with the SMART phases.

For the application of SMART in the described context, the access to additional materials and service descriptions was key for the status capturing. We are aware of this and consider such access a great foundation for applying SMART in other contexts.

When it comes to the TMS decomposition in the second phase, one can argue that there is a considerable effort required to decompose all the services and to model them with BTPM. This is a good observation; however, this is just a formal way of describing the services a TMS provider wants to manage. For many reasons, it should be a top priority to have a detailed and easy-to-understand picture of the provided services, e.g., increased shared understanding of all involved service system participants. This is confirmed by quotes from the workshop participants stressing the effectiveness and easy-to-apply characteristic of BTPM: "Modelling the services and service processes totally pays off […] and now [after the workshop] I feel confident to model other services on my own." Further comments regarding the benefits include: "Through the modelling, we had a real gain of awareness in regards to our own processes" of the second SMART phase.

In the third phase, the modularization parameters were used. Here, future settings might also require additional parameters or might exclude obsolete parameters. If needed, such adaptions should be considered wisely, but could feasibly be applied without altering the overall SMART method. Also, further application scenarios might require a weighting of modularization parameters. This could easily be achieved by integrating weighting factors for specific modularization parameters when creating the accumulated matrix. The matrix generation could be considered the core of the SMART method. In earlier attempts, the assessment of service couples was not dichotomous, but rather consisted of various stages. During the workshops, it became clear that more differentiated modularization parameters should be used in order to allow for a distinctive assessment of service process couples either dependent or independent.

We were pleased to learn that workshop participants considered SMART to be worth applying in a business context: "My impression is that the method is simply practical." and that they saw potentials in future settings: "I love this approach! And I think the method has huge potential."

Interface specifications and testing were conducted in the fourth phase of the method. Here, the way the created modules were used in services plays an important role. Therefore, decisions on the different functions of modules might be worthwhile discussing, i.e., whether a module is part of a set of basic or mandatory modules of a service offering, whether the main functionalities are guaranteed, or whether the module is defined as an optional add-on. In this context, add-on modules might integrate other stakeholders, e.g., a layperson for COPD patients or parents for children suffering from diabetes.

Effort elicitation of the last SMART phase provides convincing proof of the method's applicability and effectiveness. Regarding statistics, we are aware that there are many further considerations we have not taken into account, which could yet even strengthen the method's potential in the future. Also, some of the presented statistics benefit from an interpretation, e.g., the modularization rates. When examining the rates of modularization, it is important to note that modularization is a continuum, as depicted in Figure 13.9.

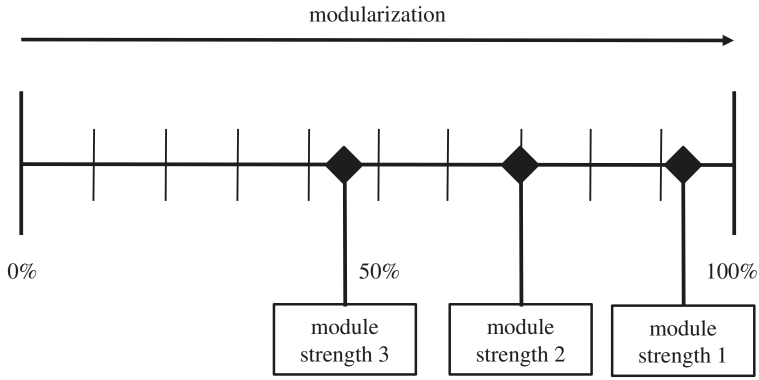


Figure 13.9: The Modularization Continuum and Module Strengths
Source: own illustration

This continuum ranges from completely integrated offerings (modularization = 0%) to completely modular offerings (modularization = 100%). While we clearly argue for more modular settings, we also know how much effort the design of modular structures entails. Without a systematic approach such as the SMART method in such a complex domain as TMSs, it would be almost impossible to leverage modularization potentials, such as the reuse in an efficient manner.

For an overall perspective on the method's application, we argue that all service modularization efforts need to be dependent on costs and benefits. While modularization reduces the module-internal complexity, it also increases dependencies between service processes, which accordingly not only cause higher needs for communication and coordination but also resource constraints and costs (Schantin 2004). This trade-off needs to be taken into account. When considering the immense reuse rates, we are confident that the application of SMART clearly paid off and would pay off in similar settings as well.

Next to this phase-by-phase discussion of our results, we want to stress two important aspects in this section. First, as outlined in the beginning, TMSs – as all health services – are provided in service systems and require co-creation. The main focus of our case study setting was the service provider, which was an intended choice based on the assumption that the service provider manages the service system in order to co-create value and implement promised value propositions. The service provider acts as the service aggregator in a complex network of co-creating entities and service system participants.

The second important aspect to reflect on is the case study that we carried out in earlier research, which elicited the following challenges for successful service provision in the TMS domain: multi-stakeholder perspective, expansion of the TMS market, more patients with different needs, and cost pressure in conjunction with high competition between the players. Each challenge represents one criterion for our criteria-based evaluation which represents the third part of our three-fold evaluation.

We believe that the newly designed SMART method is capable of responding to these challenges as follows: The consideration of new stakeholders is part of the SMART method through the integration in the in-depth analysis of the first phase; further, the service process maps built in the second phase realize a sustainable multi-stakeholder perspective, as BTPM can be modularly extended for each new stakeholder. When it comes to the expansion of the TMS market, the SMART method realizes customer integration not only through the in-depth analysis in phase 1 but also by the dedicated modularization parameter “personal interaction” of phase 3 and the interface specifications of phase 4, thus building on the BTPM-specific line of interaction of phase 2. With respect to new players in the market and new participants of future service systems, the method’s possible extension to new TMS stakeholders has already been outlined.

At the core of the SMART method stands the coping with an increasing number of patients with different needs, thus motivating TMS providers to deliver customer-centric, tailored service offerings. With the help of the dependency matrices of phase 3 and the interface specifications of phase 4, modularization designed for this purpose can take place.

Cost pressure and high competition call not only for the realization of economies of scale but also for intelligent and innovative solutions. Both characteristics are fostered by the application of the SMART method, which creates a set of modules and realizes considerable reuse rates. As a result, more efficient service provisioning takes place. Further, module-wide innovation and fast development cycles foster new services that provide competitive advantages. We consider this as innovation mechanism, namely "a self-reinforcing process by which new products and services are created as infrastructure malleability spawns recombination of resources" (Henfridsson and Bygstad 2013) which is inherent to the modular service structures we create by applying our SMART method.

It is our fondest hope to use the gathered experience to extend the SMART application scope to other TMSs and health-related contexts. We look forward to this endeavor, especially given statements such as, "I think it's gonna be fun to apply the method [to other services]" by workshop participants.

13.7 Limitations and Future Research

Thus far, we have been able to apply the SMART method to 20 services and 235 service processes. Although this has led to clear insights in the area of TMSs, we see great opportunities for future research to extend the method to more TMSs as well as other domains.

Many phases of the SMART method are already tool-supported. We have implemented the time-consuming parts of the SMART method in a tool-supported fashion and can thus describe the application of the SMART method as being semi-automatic. Nevertheless, future developments of a tool supporting the method's application could foster further realization of the intended SMART benefits, e.g., tools that enable the process-by-process assessment of services and definition of modularization parameters with all service system participants in a collaborative, cloud-based solution that automatically creates the modules. Therefore, future research should concentrate on user-centric, easy-to-use design of tools.

As described above, we see the traditional service provider in the role of a service aggregator in service systems which is "different than the dyadic buyer and seller standard equilibrium neoclassical economic model" and needs according value propositions which "invite, shape, and potentially transform engagement in service" (Chandler and Lusch 2015). This role is even strengthened if services are aggregated over modular service architectures. While we have had a clear focus on the service provider of the service systems offering TMSs in the scope of this paper, we call for future research that systematically addresses all service system participants in greater detail, examining their roles and their transformations stemming from digitization and other developments.

Apart from the method itself, we have presented its usefulness, as well as modularization and reuse rates that demonstrate its effects. Future research should extend the examination of modularization effects for services; empirical studies are needed to examine how service modularization effects influence service efficiency and service quality directly. Also, these studies should collect and provide empirical proof for leveraged service modularization benefits, such as module-wide innovation, faster development cycles, etc.

Many research studies dealing with modular structures of organizations have already been conducted (Baldwin 2008). The interconnection of service modularity and modular service architectures spanning service systems with the modularity of institutional structures needs to be investigated further. Here, the modularization principle of loose coupling is "a fundamental promise of services orientation properties to support organizational dynamism" (Bardhan, Demirkan et al. 2010).

This is especially important when it comes to innovation capabilities of institutions or predefined modular institutional structures as the so-called modularity trap (Chesbrough and Kusunoki 2001) needs to be avoided. We are confident that service modularization integrating ideas of agile, service-oriented architectures from IT domains can assist in coping with these challenges in the health domain, but future research does need to prove this.

Most business model frameworks, such as the business model canvas by Osterwalder et al. (2010), also follow a modular structure. Here, interesting interconnections between service and business model research need to be approached, taking a dedicated perspective on modularity to examine whether and how service modularity and business model modularity influence each other.

The modularization of whole service portfolios should strengthen the shown modularization benefits. This holds especially true for the reuse of modules over a TMS provider's portfolio which also requires corresponding strategies (Bardhan, Demirkan et al. 2010). In this context, one can also think of creating completely modularized service architectures with Service Oriented Architecture (SOA)-like and TMS-specific service repositories that integrate not only IT services but also non-IT, person-oriented services. These modular service repositories also foster the module-by-module evolution of services. In this context, potential transferability, especially to other smart interactive services (Wünderlich, Wangenheim et al. 2012), opens up an interesting area of future research. In this context, the role of the SMART method for service research and for research on information systems development as well as for new product and new service development needs to be assessed.

Within such SOA-like structures, many topics that have not yet been examined in this context need to be considered , e.g., the pervasive impact of the sociocultural context (e.g., family, community) on individual experiences and preferences or questions such as "What aspects of a patient's sociocultural context have the most impact on their health?" (Anderson, Ostrom et al. 2013) need to be addressed when it comes to coping with the challenges of transformative service research. As TMSs also contain IT services, further research should elicit "how technological advances may influence the levels of connectivity in service systems when yet unimagined types of ICT emerge in the future" (Breidbach, Kolb et al. 2013).

As a final potential field, we want to call on future research to deal with the challenge almost all domains face today: digitization. For developments in the health sector, digitization has enormous potential, and service modularization can be a key enabler of successful digitization strategies as it allows getting the best of both worlds: the traditional health settings and the new world. The former are based on several important factors for value creation and service quality: the excellence of medical experts, the legislations on medical products or long-lasting medical studies to guarantee safe medical service provision, ethical rules and standards, the trust-creating face-to-face momenta between patients and physicians or others, etc. These factors have been important and they remain important in all digital settings.

New possibilities for providing health services have nevertheless emerged due to digitization. Some of these new possibilities might simply make traditional health service provisioning easier or more efficient, e.g., the digital documentation of patient records with its many advantages. Others enable completely new services or service levels, e.g., the monitoring of chronically ill patients' vital data in a 24/7 manner, a service that in traditional, non-digital settings can only be realized by means of intensive or in-patient care. Service modularization allows for the combination of the digital and the non-digital world. It can also cope with highly varying development cycles between health developments that might require studies lasting many years and the development of apps facilitating new ways of service provision lasting only a few weeks per development cycle.

Future research should focus on how modular health services and TMSs should be designed by combining traditional and digital modules – not only from a provider or service system aggregator but also from a patient as well as a service system and market perspective.

13.8 Contribution, Conclusion, and Managerial Implications

This paper has dealt with service modularization and following the DSRM, has presented the design and three-fold evaluation of the five-phase modularization method SMART. We have presented these phases in detail and have shown their application by using an in-depth case study performed at the site of a TMS provider. After outlining how we addressed the first five DSRM activities, we emphasize on the last activity "communication" in this section as we present theoretical and practical contributions as well as managerial implications from the SMART method.

This paper makes substantial contributions to service research and service modularization in particular. As its main contribution, it presents the design, evaluation, and applicability of the SMART method capable of modularizing service modules. This method comprises five phases. Starting from the analysis and status capturing of a service, it decomposes it into its service processes before modularizing it based on modularization parameters. It then specifies interfaces and runs tests, before it elicits the effects of the service modularization. By doing so, we present a systematic approach for service modularization in the field of telemedicine. We have demonstrated how to modularized 20 services with a total of 235 service processes and created more than 40 modules, thus realizing modularization rates of up to 93% and service module reuse rates of up to 23%. Thereby, we clearly confirm the applicability and usefulness of the method and present the way TMSs should be built: as modular.

We extend the body of knowledge in regard to method engineering and support practitioners in providing individually tailored service offerings to their steadily growing customer base. We also contribute by presenting the created TMS modules themselves, thus providing insights into TMSs and their related parts. This should help in leveraging the potential for efficient and customer-centric service provisioning in this highly promising field.

Another contribution is the application of the modeling technique BTPM used in the second phase of the SMART method. This technique allows for the interdisciplinary modeling in multi-stakeholder settings that deal with services comprising combinations of IT and non-IT, highly person-oriented services. Thus, we contribute to the needed innovative assembly of ICT as well as non-ICT resources (Srivastava and Shainesh 2015). The method thereby also helps to understand stakeholders better and allocate resources accordingly. This is because it creates relationships which "not only explore the visible and evident aspects of customer behavior but should also identify and learn about the existence and the influence of hidden, unshared, and subjective factors" (Wägar, Roos et al. 2012). The presented contributions also respond to the call for the design of novel artifacts facilitating the engineering and management of service systems (Böhmann, Leimeister et al. 2014). When reflecting on the twelve research priorities that have been previously defined, i.e., stimulating service innovation, facilitating servitization, service infusion, and solutions, understanding organization and employee issues relevant to successful service, developing service networks and systems, leveraging service design, using big data to advance service, understanding value creation, enhancing the service experience, improving well-being through transformative service, measuring and optimizing service performance and impact, understanding service in a global context, and leveraging technology to advance service (Ostrom, Parasuraman et al. 2015), we are confident to say that our contributions and discussions might assist in leveraging all of them.

As for managerial implications, the SMART method with its integrated modularization mechanisms lays the foundation for the two main pillars of efficient and user-centered service provision in the digital age.

First, it is a good starting point for all scope-extending and future attempts of more modularization of TMSs and similar classes of services that integrate combinations of highly person-oriented services and IT services. Such attempts might extend the scope to method-driven modularization of all participants of the service systems. Both the architecture and management of service portfolios as well as service repositories play a key role. A key challenge is the transfer of principles already present in SOAs. Here, interfaces and corresponding interface specifications within person-oriented services need to be addressed, as they are much more difficult to handle than the IT services of existing SOAs with clearly specified protocols and standards. While these topics are being realized, service providers transform from a value co-creating entity into the orchestrator of value-creating service systems with underlying architectures that leverage modularization potentials that could be interpreted as the consequent development of Vargo and Lusch (2004) thoughts on service-dominant logic. In all these areas, accompanying research is needed with regards to tool support that facilitates such modularization endeavors.

Second, the SMART method is the basis for many interesting ideas that revolutionize the way in which services are created in the future and for which clear modular structures are needed since huge agglomerations of service processes are not manageable in efficient ways. This is especially valid for new forms of digital work, e.g., in the field of crowdsourcing, where service providers enable company-internal or external crowds to deliver a specified part of the service as an integral part of the overall service offering afterwards. Future successful service providers that want to crowdsource such specified parts of their services – the modules – need to learn how to size their modules, how typical types of modules are structured that qualify to be crowdsourced, how the service quality or integrated quality-enhancing structures can be checked, and how these modules can then be integrated into their service portfolios.

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14 Theoretical Contribution

Following a design science research approach, this thesis presents a modularization method for TMSs and confirms its usefulness. Thereby, it answers the three overarching RQs presented in chapter 1. In this chapter, I want to outline the thesis's theoretical contributions according to the distinction by Gregor and Hevner (2013) into contributions of prescriptive and descriptive knowledge.

Prescriptive knowledge "concerns artifacts designed by humans to improve the natural world" (Gregor and Hevner 2013), which is coined "sciences of the artificial" by Simon (1996). The thesis provides the following artifacts representing this kind of knowledge:

- The modularization method for TMSs, i.e., the SMART method and TM³ which can be considered an earlier instantiation of the first
- The BTPM technique

These contributions also respond to the call for the design of novel artifacts facilitating the engineering and management of service systems (Böhmann, Leimeister et al. 2014).

The thesis obviously builds on descriptive knowledge representing the body of knowledge (Gregor and Hevner 2013), but also extends it in the following ways:

- The conceptualization of service modules and its interdependencies to services and service processes
- Modularization parameters for TMSs
- New metrics for measuring service modularization
- The role of service providers in telemedicine service systems

14.1 The Modularization Method

The modularization method is the core contribution of the thesis. This artifact is the result of several "build-and-evaluate" cycles as outlined in chapters 10 and 13, and represents a theory of design and action according to Gregor (2006). I hereby present a systematic and repeatable approach which contributes to service modularization for TMSs in particular and for all services comprising a combination of person-oriented and IT services in general. It is based on the extensive analysis of existing modularization methods. The method is capable of modularizing and reengineering non-modular services, while also enabling the engineering of modular services from scratch. It comprises five phases. Starting from the analysis and status capturing of a service, it decomposes the service of consideration into its service processes before modularizing it based on modularization parameters. It then specifies interfaces and runs tests, before it elicits the effects of the service modularization. By doing so, a systematic approach for service modularization in the field of telemedicine is presented. It has to be stated that this main contribution aggregates other contributions that could be made while answering the RQs of this thesis, e.g., the BTPM technique. These contributions also informed the design of the SMART method. As the method can be applied to all services in a portfolio, it fosters holistic service modularization in multi-stakeholder environments such as telemedicine. It has the potential to play a useful role in the operationalization of digital transformations in all fields that are based on person-oriented services.

14.2 The BTPM Technique

Another contribution is the modeling technique BTPM used in the second phase of the SMART method as presented in chapter 11. This technique allows for the interdisciplinary modeling in multi-stakeholder settings that deal with services comprising combinations of IT and non-IT, highly person-oriented services. Thus, it contributes to the needed innovative assembly of ICT as well as non-ICT resources (Srivastava and Shainesh 2015). As it combines elements of BPMN, e.g., pools and lanes, and service blueprinting, e.g., lines of interaction and visibility, it can be extended by additional stakeholders and is able to represent different interaction levels. For the latter, three lanes are used in every pool for this purpose, i.e., for every stakeholder. The frontstage lane contains interactions with other stakeholders. It is separated from the backstage lane by the line of visibility as in the backstage part, all service processes invisible to other stakeholders are modeled. The lane for technical infrastructure comprises all service processes that are part of IT systems or devices. This also responds to new sensor-driven services and allows for the representation of "actions" which are located at a specific stakeholder, but might be processed automatically, e.g., a telemonitoring device from a patient might not require a conscious action by the patient, but still causes the transfer of data from the patient to a monitoring center. This feature is relevant and transferable to many other digitized services. The technique thereby also helps to understand stakeholders better and allocate resources accordingly.

14.3 Conceptualization of Service Modules

As outlined in the chapter "Theoretical Foundations" in detail, this thesis also contributes by providing a clear conceptualization of service modules as well as insights on how they should be positioned in contrast to services and service processes. All services can be decomposed into a set of service processes representing all activities for the conduction of the according service. Using systematic modularization and according modularization parameters, such a decomposed service can be used to create service modules that comprise service processes. For successful service modularization, these service modules are used to build modular services. This conceptualization is a key contribution of this thesis and should be used for future service modularization attempts.

14.4 Modularization Parameters

As interdependencies between modules reflect the basic principles of modularization, i.e., cohesion and loose coupling, they need to be elicited. These interdependencies are based on attributes of the underlying service processes that make up the to-be-modularized service and are captured in detailed service process maps. Also, these attributes represent candidates for modularization parameters. In chapter 12, this thesis presents such a set of modularization parameters and thereby contributes to service modularization research by providing the ingredients (modularization parameters) for the recipe (the overall modularization method) for systematic service modularization of TMSs.

Publication 6 suggests that the right choice of modularization parameters is based on existing parameters which should serve as the starting set for all modularization attempts for complex services, and a further step in which extra or obsolete parameters are included or excluded according to the setting. These parameters are, and have to be, distinct. They are dichotomous, i.e., the pair-wise assessment of the service processes either results in a dependency or an independency. Thus, the assessed interdependencies can be directly integrated in the matrix generation within the SMART method.

14.5 Metrics for Service Modularization

One part of the three-fold evaluation of the SMART method is based on the effects that could be measured in regards to the method's application. In this context, the method's usefulness could be demonstrated by confirming strong modularization rates and service module reuse rates. With the help of these metrics, the actual result and potential success of service modularization attempts can be measured. Also, these metrics allow benchmarking with other classes of services and give indications regarding which types of services allow for which modularization effects. Also, they might be used for estimating the benefits of service modularization attempts, as the effort of conducting can be compared to predictable effects. For reliable predictions, an implementation of further application settings for the according services is needed.

14.6 Service Providers in Service System Telemedicine

As outlined in the thesis, TMSs are provided in service systems and require co-creation. Typical provider-customer-only perspectives are not sufficient when implementing a service system perspective. Still, the thesis contributes by outlining that the service provider still plays an important role and cannot be substituted by a general system perspective that equally considers all service system participants. Instead, a perspective reflecting that the service provider manages the service system in order to co-create value and implement promised value propositions is crucial and introduced in the thesis. The service provider acts as the service aggregator and orchestrator in a complex network of co-creating entities and service system participants.

15 Practical Contribution

The thesis provides a number of contributions that are useful for practitioners, managers, and researchers in practice.

As the main contribution of this thesis, the SMART method with its integrated modularization mechanisms lays the foundation for efficient and user-centered service provision in the digital age. It enables the phase-by-phase service modularization of TMSs.

Thereby, it is also a good starting point for all scope-extending and future attempts in terms of modularization of TMSs and similar classes of services that integrate combinations of highly person-oriented services and IT services. Such attempts might extend the scope to method-driven modularization of all participants of the service systems. This is relevant for all stakeholders dealing with the architecture and management of service portfolios as well as service repositories. A key challenge is the transfer of principles already present in SOAs. Here, interfaces and corresponding interface specifications within person-oriented services need to be addressed, as they are much more difficult to handle than the IT services of existing SOAs with clearly specified protocols and standards.

While these topics are being realized, service providers transform from a value co-creating entity into the orchestrator of value-creating service systems with underlying architectures that leverage modularization potentials that could be interpreted as the consequent development of Vargo and Lusch's (2004) thoughts on service-dominant logic. The thesis presents a clear implementation of SDL as devices and IT systems of the considered TMSs are naturally integrated, and also outlines the changing roles of service system participants in a service-dominant and digital age. These insights are relevant for all participants of service systems in telemedicine.

The SMART method can also be the basis for many interesting ideas that revolutionize the way in which services are created in the future and for which clear modular structures are needed, since huge agglomerations of service processes are not manageable in efficient ways. This is especially valid for new forms of digital work, e.g., in the field of crowdsourcing and crowdwork, where service providers enable company-internal or external crowds to deliver a specified part of the service as an integral part of the overall service offering. Future successful service providers that want to crowdsource such specified parts of their services – the modules – need to learn how to size their modules, how typical types of modules are structured that qualify to be crowdsourced, how the service quality or integrated quality-enhancing structures can be checked, and how these modules can then be integrated into their service portfolios. The SMART method and the contributions of this thesis can foster such attempts.

Although the BTPM technique is an integral part of the SMART method, it provides a practical contribution on its own. This technique allows for the modeling of service processes. For many reasons, it should be a top priority for every company or institution to have a detailed and easy-to-understand picture of the provided services. One of these reasons is an increased shared understanding of all involved service system participants. BTPM helps here as it congregates the different terminologies used by different stakeholders in the jointly created process maps. BTPM's effectiveness and easy-to-apply characteristic could be proven in workshops with practitioners and led to quotes from the workshop participants such as: "Modeling the services and service processes totally pays off […] and now [after the workshop] I feel confident to model other services on my own." Also, it fosters awareness of the own service processes. Through its structure, BTPM also enables the modular extension to other stakeholders, makes interaction levels between stakeholders explicit, and enables the modeling of automatically processed actions, which becomes more and more important in sensor-driven environments.

As another practical contribution, the typology of TMSs assists in describing and classifying TMSs and enables a representation of the TMS domain that fosters understandability and systematic differentiation. The typology thereby congregates relevant TMS dimensions that are usually discussed separately and are dealt with differently in the various application fields and research domains. Thus, a basis of shared information and jointly used language and terminology for the very heterogeneous field of TMSs is created, which also facilitates interdisciplinary TMS developments and innovations. It can be considered as a useful navigation aid and entry point for practitioners that are new to the field of TMSs.

The presented set of modularization parameters as well as the modules that resulted from the SMART method's application further provide important insights for practice and thus represent a practical contribution of this thesis. By acquiring these insights, practitioners get the chance to inform themselves about what is needed for successful service modularization, but also what according outcomes might look like.

Some of the figures used in this thesis, e.g., Figure 3.1 illustrating the interdependencies between services, service processes, and service modules, also provide a practical contribution as they condense important aspects and conceptualizations of service modularization in one-page abstractions. These figures were constantly redeveloped and are the result of interesting discussions with top scientists and experts from practice at conferences, doctoral consortia, workshops, and other events.

16 Limitations

This thesis is subject to a number of limitations, which originate in the chosen research methods and evaluation settings, the complexity and interdisciplinarity of the studied domain, as well as format restrictions.

From a research methodology perspective, the design science approach of this paper builds on the build-evaluate cycles resulting in according artifacts. I will explain existing and potential limitations of my thesis in line with this build-evaluate perspective.

For the build-process, two main resources were used to inform the design: the existing body of literature which was examined in systematic literature reviews, and insights from practice which were elicited in case study settings using interviews, workshops, and other materials that also resulted in design criteria. The evaluate-process comprised criteria-based evaluation, evaluation by application, and evaluation demonstrating the designed artifacts' effects.

As typical for literature reviews, there is always the chance that important work is omitted for consideration. Still, I tried to reduce this risk by conducting the reviews in a systematic manner and by also updating them accordingly, e.g., the literature review on modularization methods was reworked and now includes relevant methods published until the beginning of this year. In regards to insights from practice and evaluation settings, one can always include more interviewees, collect more data from more companies, or apply the designed artifacts using more services. Still, I am confident that the chosen settings provided a very good fundament for the information of the build-process and the conduction of the evaluate-process as the chosen interviewees excel an exceptional level of expertise, the chosen companies are top-of-breed in terms of innovativeness and provided great sets of material, and the considered services represent a heterogeneous sample of services which I believe will increase in importance in the following years.

As telemedicine is a highly complex and interdisciplinary domain, there are particularities of this environment which were not studied in detail. As one example, data privacy issues for personal medical data are important for advancements in the TMS field, but were not addressed specifically. Still, I am convinced that modular service structures can help in creating TMSs that respond to these challenges, e.g., by developing modules that integrate data privacy considerations by design. Due to better manageability of the overall TMSs, modular structures of services allow to focus solely on such specific modules calling for the implementation of data privacy, e.g., the exchange of personal monitoring data of patients.

Also, the actual size of the created service process maps did neither allow for a holistic representation of one complete service process map in this thesis nor for the illustration of all service process maps that were modeled with BTPM in the course of the presented research.

17 Implications for Future Research

The findings and contributions as well as the limitations of this thesis provide a good starting point for interesting future research.

I will structure them according to five key areas: the redevelopment and refinement of artifacts that represent key contributions of this thesis; the considerations of contexts in which modularization also plays an important role; perspectives on service systems, service portfolios, and architectures; telemedicine developments; and the interplay of digitization and services.

17.1 Redevelopment of Artifacts

One obvious implication originates from the scenarios and application fields that were used for the artifacts of this thesis. The SMART method, the BTPM technique and the typology would all benefit from a wider application to other TMSs and other classes of services that comprise combinations of person-oriented and IT services. In this context, future research should also consider particularities of different service and service system types and examine how they promote or impede the intended effects of the artifact's application.

Also, the tool support of the artifacts can be extended – at best, to a holistic, easy-accessible, intuitive tool that guides the users through the application of the SMART method while enabling interdisciplinary collaboration. Therefore, future research should concentrate on the user-centric, easy-to-use design of tools that are built in a web-based, responsive fashion.

Apart from the SMART method itself, I have confirmed its usefulness and presented modularization as well as reuse rates demonstrating its effects. Future research should extend the examination of modularization effects for services; empirical studies are needed to examine how service modularization effects influence service efficiency and service quality directly. Also, these studies should collect and provide empirical proof for leveraged service modularization benefits such as module-wide innovation, faster development cycles, etc. Such effects are also needed for a more profound understanding of the BTPM technique.

With regard to method engineering, this thesis provides an extensive background based on systematic literature reviews that in turn inform the design of the methods SMART and TM³. Here, future activities should concentrate on a wider scope of services where applicability is proven, e.g., for all digitized service offerings.

17.2 Modularization in other Contexts

Many research studies dealing with modular structures of organizations have already been conducted (Baldwin 2008). The interconnection of service modularity and modular service architectures spanning service systems with the modularity of institutional structures needs to be investigated further. Here, the modularization principle of loose coupling is "a fundamental promise of services orientation properties to support organizational dynamism" (Bardhan, Demirkan et al. 2010). Design science research for the engineering of such structures as well as empirical research on according effects of organizational changes needs to be conducted at this stage. This should – among others – also include the design and evaluation of motivation and incentive structures that foster such organizational transformations, so that the intended effects can be realized.

This is especially important when it comes to innovation capabilities of institutions or predefined modular institutional structures as the so-called modularity trap (Chesbrough and Kusunoki 2001) needs to be avoided. I am confident that service modularization integrating ideas of agile, service-oriented architectures from IT domains can assist in coping with these challenges in the health domain, but future research does need to prove this.

Most business model frameworks, such as the business model canvas by Osterwalder et al. (2010), also follow a modular structure. Here, interesting interconnections between service and business model research need to be approached, taking a dedicated perspective on modularity to examine whether and how service modularity and business model modularity influence each other.

17.3 Service Systems, Service Portfolios, and Architecture

This thesis considers the traditional service provider in the role of a service aggregator and orchestrator in service systems which is "different than the dyadic buyer and seller standard equilibrium neoclassical economic model" and needs according value propositions which "invite, shape, and potentially transform engagement in service" (Chandler and Lusch 2015). This role is even strengthened if services are aggregated over modular service architectures. While a clear focus was set on the service provider of the service system offering TMSs in the scope of this thesis, future research that systematically addresses all service system participants in greater detail, examining their roles and their transformations stemming from digitization and other developments needs to be conducted. In regard to the SMART method, the interactive participation for all stakeholder groups in the method's application could be a promising starting point.

The modularization of whole service portfolios should strengthen the shown modularization benefits. This holds especially true for the reuse of modules over a TMS provider's portfolio, which also requires corresponding strategies (Bardhan, Demirkan et al. 2010). In this context, one can also think of creating completely modularized service architectures with Service Oriented Architecture (SOA)-like and TMS-specific service repositories that integrate not only IT services but also non-IT, person-oriented services. A key challenge is the transfer of principles already present in SOAs. Here, interfaces and corresponding interface specifications within person-oriented services need to be addressed, as they are much more difficult to handle than the IT services of existing SOAs with clearly specified protocols and standards. This needs to be investigated on a scientific level. Also, such modular service repositories foster the module-by-module evolution of services. In this context, potential transferability, especially to other smart interactive services (Wünderlich, Wangenheim et al. 2012), opens up an interesting area of future research. In this context, the role of the SMART method for service research and research on information systems development as well as new product and new service development needs to be assessed.

Modular structures are also the basis for companies intending to perform digital work successfully, e.g., in the field of crowdsourcing and crowdwork. As service providers enable company-internal or external crowds to deliver a specified service module as an integral part of their overall service offering, future research needs to examine which requirements service modules need to fulfil in this context. Open questions concern the size of modules, how typical types of modules are structured that qualify to be crowdsourced, how the service quality or integrated quality-enhancing structures can be checked, and how these service modules can then be integrated into service portfolios.

17.4 Developments in the Field of Telemedicine

As outlined in the dedicated telemedicine chapter of this thesis, telemedicine is a very promising field and future developments for TMSs are of utmost importance for the health of our societies on a regional, a national, a European, and a global scale. One of the key challenges seems the required interdisciplinarity for successful TMS developments in the future. All means that enable a collaborative way of developing and provisioning services need to be examined. Also, current technological advancements should be assessed regarding their potential role for value-creating service configurations. This is in line with the identification of stakeholders that are new to medical and health environments, but might play an important role in the future service systems that co-create value herein. As the provision and showcasing of according paragons constitute one of the most promising ways of establishing TMSs for future healthcare scenarios, new "playgrounds" and pilot projects need to be created that allow for innovative scenarios. While national and European regulations might seem to be hindering, the precise observation of according success factors in these systems should be conducted and investigated further.

17.5 The Interplay of Digitization and Services

In addition to ageing societies and globalization, there is one mega trend which provides enormous challenges: digitization. Future research should embrace this trend and the opportunities it brings along for better quality of services and life in general.

In this context, I want to point out my understanding of the interconnectedness of services and digitization. It might sound simple, but – from a process perspective – digital transformations occur when existing services, products, or product service systems are enriched with a digital part, an IT service. That is why all findings and contributions of this thesis that consider the interplay of modules comprising non-IT and IT services are of fundamental importance for digital transformations. The potentials of digitization can only be realized when following a SDL perspective. This thesis contributes to leveraging according digitization potentials.

For developments in the health sector, digitization has enormous potential as well, and service modularization can be a key enabler of successful digitization strategies as it allows getting the best of both worlds: the traditional health settings and the new world.

The former are based on several important factors for value creation and service quality: the excellence of medical experts, the legislations on medical products or long-lasting medical studies to guarantee safe medical service provision, ethical rules and standards, the trust-creating face-to-face momenta between patients and physicians or others, etc. These factors have been important and they remain important in all digital settings. It is up to future service research to examine how these traditional qualities in healthcare can be retained while becoming digital.

In this endeavor, one distinction in regard to new digital scenarios is critical for future research. Some of the newly emerging possibilities might simply make traditional health service provisioning easier or more efficient, e.g., the digital documentation of patient records with its many advantages. On the contrary, others are real game changers and enable completely new services or service levels, e.g., the monitoring of chronically ill patients' vital data in a 24/7 manner, a service that in traditional, non-digital settings can only be realized by means of intensive or in-patient care. Service modularization allows for the combination of the digital and the non-digital world. It can also cope with highly varying development cycles between health developments that might require studies lasting many years and the development of apps facilitating new ways of service provision lasting only a few weeks per development cycle. That is why future research should focus on how modular health services and TMSs should be designed by combining traditional and digital modules – not only from a provider or service system aggregator, but also from a patient as well as from a service system and market perspective.

In times of digital transformation, the time for service research and service modularization considering combinations of non-IT, person-oriented services, and IT services is now.

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The design and provision of telemedical services which are both, efficient and customer-centric, constitute a huge challenge in the promising field of telemedicine. This dissertation presents an adequate solution. It outlines a systematic approach for the modularization of telemedical services: the SMART method.

Following a design science research approach, this method was iteratively designed and evaluated. Thereby, the three overarching research questions could be answered successfully. They address the requirements elicitation, the design, and the evaluation of the method.

The application of the SMART method confirms the intended effects, e.g., higher efficiencies due to reuse of service modules, and represents the key practical contribution of this thesis. Thus, service providers from the field of telemedicine are enabled to design and provide their services in an efficient and user-centric fashion.

This dissertation contributes to all person-oriented fields that face digital transformations.

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