A Capability-based Context Modelling Method to Enhance Digital Service Flexibility

DISSERTATION
to obtain the academic degree of

Doktor-Ingenieur (Dr.Ing.)

of the Faculty of Computer Science and Electrical Engineering
at the University of Rostock

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Universität Rostock
Traditio et Innovatio

Rostock, 15.12.2016

https://doi.org/10.18453/rosdok_id00002538

ABSTRACT

Today's economy is characterised by rapid change and digitalization. The technological advances and the increasing globalisation of the economy require in many areas high adaptability of enterprises. In order to improve their chances of success, enterprises need to cope with the challenges caused by dynamic markets, regulations, customer demands, novel technologies, etc. This requires a constant adaptation and flexible design of service/ product offerings to gain competitiveness. Due to the strong paradigm shift towards service economy and aforementioned digitalization trend, this thesis tackles the flexibility problem from the perspective of enterprises offering *digital services*. The central question tackled throughout the work is hence "from the methodological perspective, how can the design of digital services adaptable to changing requirements of the environment be supported?".

In this respect, the thesis argues that the enterprises need to understand their application context to be able to offer flexible digital services. Furthermore, after analysing the state of research in Services Science, it concludes that different roles with varying backgrounds participate to design and implementation of digital services, which adds the need for alignment between those as a further challenge for flexibility. To fulfil this, the thesis suggests that capabilities can be used as an overarching term and a communication vehicle.

The thesis has two main contributions to the scientific body of knowledge. First and foremost, by following Design Science Research (DSR) guidelines, it proposes Digital Enterprise Context Modelling Method (deCOM), a capability-based context modelling method that aims to increase digital service flexibility by means of conceptual modelling. Second, it combines the capability and service research streams, which is rarely found in the literature. Evaluated via different methods in a total of six evaluation episodes, the method has been iteratively developed in line with the feedback collected from various audiences. The results show that, although requiring an effort to learn, deCOM is a comprehensible, useful and well-documented method to elicit, identify and model the context of a digital service.

KURZFASSUNG

Die heutige Situation der Weltwirtschaft zeichnet sich durch schnellen Wandel und Digitalisierung aus. Ein dynamisches Marktumfeld mit stetiger Veränderung von Wettbewerbs- und Partnerstrukturen sowie kürzeren Innovationszyklen durch immer neue technologische Entwicklungen erfordert eine hohe Anpassungsfähigkeit von Unternehmen. Anpassungen betreffen dabei selten nur die eigentlichen Produkte oder Dienstleistungen, sondern meistens auch die organisatorischen oder technischen Aspekte eines Unternehmens, wie z. B. die Geschäftsprozesse oder die eingesetzten Informationssysteme.

Dienstleistungen nehmen im heutigen Wirtschaftsgeschehen einen immer größeren Stellenwert ein. Aufgrund des starken Paradigmenwechsels zur Dienstleistungsökonomie und dem oben erwähnten digitalen Wandel richtet diese Arbeit ihren Fokus auf die Anpassbarkeit und Flexibilität von *Digital Services*. Demzufolge lautet die zentrale Forschungsfrage, mit der sich diese Arbeit beschäftigt „Wie kann aus methodischer Perspektive die Gestaltung von Digital Services, die sich an veränderte Anforderungen der Umwelt anpassen müssen, unterstützt werden?".

In dieser Hinsicht wird argumentiert, dass für die schnelle Anpassbarkeit entscheidend ist, die Auswirkungen von veränderten Anwendungskontexten an die zu erbringende Dienstleistung genau zu verstehen und die möglichen Effekte vorab bestimmen zu können. Darüber hinaus wird nach der Analyse des Standes der Technik in Services Science festgestellt, dass unterschiedliche Rollen in der Gestaltung und Umsetzung von Digital Services beteiligt sind, was die Notwendigkeit der Abstimmung zwischen diesen Rollen als eine weitere Herausforderung an die Flexibilität stellt. Um ein solches Alignment zu erreichen, schlägt dieser Beitrag vor, *Capabilities* als übergreifenden Begriff zu verwenden.

Im wesentlichen leistet diese Arbeit seinen Beitrag mit zwei zentralen Erkenntnissen. In erster Linie entwickelt sie deCOM, eine Kontextmodellierungsmethode, die basierend auf die Capabilities den Grad der Flexibilität und die Anpassungsfähigkeit von Digital Services durch konzeptionelle Modellierung steigert. Zweitens kombiniert die Arbeit Ansätze aus den Gebieten *Capability* und *Services*; zwei Forschungsschwerpunkte, die in der Literatur nicht oft zusammengebracht werden. Die Methode wurde mit unterschiedlichen Instrumenten in insgesamt sechs Zyklen evaluiert und iterativ entwickelt. Jede Iteration bercksichtigte die von verschiedenen Zielgruppen gesammelten Rückmeldungen. Die Ergebnisse zeigen, dass deCOM zwar eine Einarbeitungsaufwand erfordert, aber eine verständliche,

nützliche und gut dokumentierte Methode ist, um den Kontext vom Digital Services zu identifizieren und zu modellieren.

ACKNOWLEDGEMENTS

I would like to express my special appreciation and thanks to my advisor Professor Dr. Kurt Sandkuhl, you have been a tremendous mentor for me. I would like to thank you for encouraging my research and for allowing me to grow as a research scientist. Your advice on both research as well as on my career have been invaluable and I will look back on each and every one of our meetings with fond memories. I would also like to thank Professor Jānis Grabis and Professor Jānis Stirna for serving as my referees at hardship.

I would also like to thank the experts, scholars and students, who were involved in the evaluation of the artefact proposed in this research project; in particular Dr. Jan-Christian Kuhr, Dr. Sergio España, Dr. Marcela Ruiz, Felix Timm, Tania Cardona González and Benjamin Siegler. Without their passionate participation and input, the evaluation could not have been successfully conducted.

Finally, I must express my very profound gratitude to my family for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without them. I would also like to thank all of my friends who supported me in writing, and incented me to strive towards my goal. At the end I would like express appreciation to my beloved wife Julya and son Yekta, who spent sleepless nights with and were always my support in the moments when there was no one to answer my queries. Thank you.

Author

[Hasan Koç]

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ACRONYMS

4em For Enterprise Modelling

acm Adaptive Case Management

api Application Programming Interface

aop Aspect-oriented Programming

ar Action Research

bam Business Activity Monitor

bcg Business Context Graph

bpo Business Process Outsourcing

bpm Business Process Management

bpmn Business Process Model and Notation

bsp Business Service Provider

bsr Behavioural Science Research

bnetza Bundesnetzagentur

caas Capability as a Service

ccp Capability Context Platform

cda Capability Delivery Application

cdd Capability-driven Development

cdt Capability Development Tool

cna Capability Navigation Application

cim Computation Independent Model

cml Context Modeling Language

cxg Contextual-Graph

decom Digital Enterprise Context Modelling Method

dsl Domain Specific Language

dsr Design Science Research

dss Decision Support Systems

ea Enterprise Architectures

eam Enterprise Architecture Management

edifact Electronic Data Interchange For Administration, Commerce and Transport

em Enterprise Modelling

epc Event-driven Process Chain

c-epc Configurable Event-driven Process Chain

er Entity-relationship Model

erp Enterprise Resource Planning

eucm Enhanced Unified Context Model

feds Framework for Evaluation in Design Science Research

ict Information Communication Technology

ida Input Data Association

is Information Systems

isr Information Systems Research

isv Independent Software Vendor

it Information Technology

iot Internet of Things

isv Independent Software Vendor

kbso Knowledge Based Services Organization

kpi Key Performance Indicator

mc Model Component

mda Model-Driven Architecture

mdd Model-Driven Development

mde Model-Driven Engineering

meds A Methodology for Evaluation in Design Science

mem Method Evaluation Model

mis Management Information Systems

mscons Metered Service Consumption

pmo Project Management Office

rbv Resource-based View

re Requirements Engineering

sdl Service Dominant Logic

se Service Enhancer

sebok Systems Engineering Body of Knowledge

sla Service Level Agreement

slr Systematic Literature Review

sme Small and Medium Enterprise

soa Service-Oriented Architecture

sos System of Systems

tam Technology Acceptance Model

tar Technical Action Research

swrl Semantic Web Rule Language

om Organizational Memory

omg Object Management Group

orm Object-role Modeling

owl Web Ontology Language

pim Platform Independent Model

psm Platform Specific Model

rbv Resource-based View

ucm Unified Context Model

uml Unified Modeling Language

un/cefact United Nations Centre for Trade Facilitation and Electronic Business

utilmd Utilities Master Data

wfms Workflow Management System

xml Extensible Markup Language

Part I

PROBLEM INVESTIGATION

1

INTRODUCTION

Economy of change

We are living in an economy which is characterised by rapid change and digitalization. The technological advances and the increasing globalisation of the economy require in many areas high adaptability of enterprises. In order to improve their chances of success, enterprises need to cope with the challenges caused by today's dynamic markets, regulations, customer demands, novel technologies, etc. This requires a constant adaptation of service/ product offerings to gain competitiveness.

Information Systems (IS) can be defined as "an information processing system, together with the associated organisational resources such as human, technical, and financial resources, that provides and distributes information" [1]. Enterprises adopt IS to improve their effectiveness in achieving goals, and are computerised with the purpose of increasing the efficiency of the work practice [2]. [3] indicates that IS should be seen as a dynamic entity that is able to support ever-changing organisation. There is an intrinsic relationship between an enterprise, its ecosystems, and its Information Technology (IT) systems to the extent that changes in one affect the others [4]. As such, organisations need to be flexible, not only in terms of their organisational structures but also regarding the IT supporting their service/ product design and delivery.

Flexibility in IS Design

The change of the global business environment implies unforeseen requirements that the enterprises could not take into account during system design. Necessarily, this poses new problems for IS Design, which cannot provide the required agility to cope with changing requirements. One challenge in this respect is the lacking support of the information systems in changing situations during the service provision, which is termed as *poor flexibility* [3, 5, 6, 7]. Al Kalbani and Nguyen report in their work that 65"%" of system modification costs base on adapting the system after it has been delivered in consequence of changes in the requirements [8]. As a result, business requires flexible systems which can be easily customised to meet changing demands and are easier to modify and maintain [9, p. 93]. Two short examples reflecting this notion of flexibility can be illustrated as follows.

Example 1: In Services literature, the customer is always interpreted as a co-creator of value. In this respect, airlines integrate the customers in the value chain activities and support them digitally with the required applications from checking in to flight status updates and baggage tracking. Currently such *digital services* do not provide the user with the contextual information, e.g. check-in process and passport screening process can be completed, even if there is a risk of a huge delay or flight cancellation due to bad weather, strike or accident on the flight day or the day before. Processing and monitoring such contextual information would allow for the passenger to show up at the airport just in time and at the same time might save the airline huge amounts of costs, which otherwise might be paid to the customer in connection with the Regulation (EC) 261/2004, air passenger rights in the event of denied boarding and of cancellation or long delay of flights[1].

Example 2: A world famous furniture retailer offers great possibilities on how to design your flat - even if it is a small one with 30m^2, having only one room with an open kitchen. Providing the customers with a web application, the company engages them in the participation of product customization, offers combinations of various product parts such as interior organizers, sliding doors, sliding frames knobs and handles of a wardrobe in a way that the customer himself assembles the desired product. Studies verify that perceived enjoyment of self-designing a product and participating to the value co-creation leads to a higher willingness to pay by a customer [10]. To allow for a high degree of flexibility in the customization of the products with the help of such *digital services*, the company had to adopt the ability of managing product variations as well as the relation between the different parts of the products.

Narrowing the focus

Since it is not possible to tackle the flexibility problem for all types of enterprises and sectors as well as for the whole IS Design, the investigation in this work has been limited to the enterprises and organisations offering **digital services**. A digital service represents *an activity or benefit that one party can give to another (...) through a digital transaction (information, software modules, or consumer goods) over Internet Protocol (IP).* [11, pp. 506]. Digital services are *specializations*

1 It is a very complex procedure to exit the airport after the passport control. Hence, in case of longer delays, travellers usually prefer to use airport services, e.g. restaurants and hotels once they are inside secure areas. Due to higher operational costs compared to their regular counterparts, such services are subject to inflated prices. Airlines are also obliged to reimburse the travellers' additional expenses related to delays or cancellations. The regulation can be retrieved from http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32004R0261.

of business services that are provided based on digital assets[2]. Two main reasons for the aforementioned limitation in the scope of this work is motivated in the following.

- **The importance of the digital economy & transformation**: As reported in the European Commission growth anaylsis, the digital economy is growing worldwide and seen as an important driver of innovation and competitiveness [12]. The report indicates that businesses, which fail to get digitally connected, will become excluded from the global market and calls for an exploitation of the potential of the digital economy. This fact is underlined by the digitization of our everyday life or the *digital transformation* to seize the opportunities provided by the current paradigms, such as Internet of Things (IoT), Sensing Enterprises, Social Media and Industry 4.0 [13].

  To address these concerns, the term *digital enterprise* is coined. In this work, a digital enterprise is interpreted as an organization (or its units), which possesses digital resources to provide (an important share of its) services digitally. By using digital assets, it improves the delivery of the existing digital services. The digital assets include digitized information possessed by the enterprise such as software components and services, digitized enterprise knowledge, best practices, and enterprise models.

- **Paradigm Shift - Service Dominant Logic**: The shift in the relative role of operant resources caused a shift from Goods Dominant Logic to Service Dominant Logic (SDL), in which intangibility and exchange processes are central [14]. The growth of the service economy caused by this paradigm shift impacts the business processes and culture of the organisations and makes it even more important for enterprises to adapt themselves to changes. Specifically, in many sectors, efficient and effective value creation and service delivery processes are considered as the key factor to competitiveness in a globalised market environment. As shown in the example of the world famous furniture taken from the industrial sector, the added value lies not only within the management of process variability to offer services but also in their flexible adjustment to customer situations.

  The role of Information Communication Technology (ICT) in the rise of the service economy is emphasized in [15]. The work states *"while the first services were certainly delivered by humans to humans, the advances in computer systems over the past 60 years allowed computers to deliver services to humans. ICT has significantly contributed to the evolution of services. Over the years, each wave*

2 The term *digital services* is also used in the literature as *e-services* or *online services*. A detailed discussion about the related terms such as business service, web service, e-service etc. are also provided in section 4.2.

of innovation has created solutions to automatically execute activities that were once done by human beings". By using the ICT as a strategic partner [16], the digital services should adapt to changing market needs, requirements, user needs [11], [17] and be designed context-adaptive [13].

Service Science

Due to the above-mentioned paradigm shift, *Service Science* gained attention amongst scholars in the last years. Service Science is "*the study of the application of the resources of one or more systems for the benefit of another system in economic exchange*" and as such built on top of the SDL world-view [14]. Service Science field is a relatively young discipline and investigates different facets of services [18]. Alter approves this and states "*Although it is less than ten years old, service science has already become the focus of substantial research and attention*" [19]. The very same work proposes three main directions that are covered by Service Science:

1. Things ranging from totally automated computer-to-computer interactions to personal services provided to customers through direct person-to-person interaction.
2. Things ranging from locally suited service activities through gigantic service systems such as entire governments.
3. Things ranging from the classification of industrial enterprises (as service, industrial or agriculture) through the operational details of specific service systems within organizations that produce services and/or industrial or agricultural products.

Focus of the work

The problems analysed in the course of this thesis and the proposed solution pertain to the third direction. Before tackling the problem at hand, the thesis gathers practical evidence from two enterprises offering digital services as well as theoretical foundations from the literature to challenge flexibility issues regarding the service provision, which are mentioned in section 1.1.1 shortly and in Chapter 3 in detail. At its core, the work proposes a solution approach to support flexible digital service provision from the conceptual modelling point of view in digital enterprises. But why to focus on conceptual modelling? Following paragraph taken from Krogstie's preface to his book "Model-Based Development and Evolution of Information Systems: A Quality Approach" provides the most satisfactory answer [20, p. v].

> One can argue that the main reason why humans have excelled as species is our ability to represent, reuse and transfer knowledge across time and space. Whereas in most areas of human conduct, one-dimensional natural language is used to express and share knowledge, we see

> the need for and use of two and many-dimensional representational forms to be on the rise. One such representational form is called *conceptual modelling*. A *conceptual model* is traditionally defined as a description of the phenomena in a domain at some level of abstraction[3], which is expressed in a semiformal or formal diagrammatical language. Modelling is an important part of both information systems development and evolution, and organisational development in general (e.g. used in enterprise modelling/enterprise architecture). The field includes numerous evolving modelling methods, notations and approaches.

The proposed solution approach is mainly based on a number of assumptions, all of which are to be shown in the course of the thesis. First, digital services are modelled *process-based*, i.e. there is an underlying business process that is modelled and implemented during the service delivery. Second, understanding and modelling of the service delivery context may help the digital enterprises to enhance the flexibility of their service provision. Last but not least, capability notion is useful to address the further refinement of digital services by adding context awareness and bridge the gap between the design of digital services and their actual implementation. Capabilities are *context-aware digital services that are related to the enterprise goals and implemented by the business processes*. As a result, after applying the solution proposed in this thesis, it is not the *digital services*, but the *capabilities* that the enterprises offer. Section 1.1 details and discusses the assumptions.

`Aim of the thesis`

Summarized, the thesis aims to **improve the flexibility** of digital services that are provided in **changing environments** by developing a **context modelling method** based on enterprise capabilities. The method is developed following the guidelines of DSR [21] (cf. section 2) and went through numerous evaluation cycles before maturing to its most current form (cf. section 6).

1.1 MOTIVATION

`What is a Service?`

Over the last decade SDL has become a dominant way of thinking about goods and services [22]. The transition to a service-dominant economy has lead academics and practitioners to reconsider traditional means of IT in order to facilitate and enable service provisioning in a more flexible manner [23].

3 To reach this abstraction level, one requires to know what to capture, i.e. what is relevant for the problem at hand. Consequently, when the term "modelling" is used in this thesis, it does not only concern representing certain facets, but also consists of the identification and elicitation of the relevant phenomena that needs to be represented.

Since it is applied in a number of disciplines, such as Economics, Computer Science and Information Science, the notion of service is subject to different interpretations, as studied in section 4.2.1. The work at hand interprets services as a socio-technical aspect of an organization rather than a purely technical aspect. Digital services encompass the IT-based design and provision of usual business services, mainly focusing on the related business processes and enterprise objectives to exchange value. In this sense, digital services require involvement and cooperation of different experts to its design and implementation on various layers [24]. This view has three important implications for this work [25, 26]:

i. Services are high-level implementation components that operationalize the organization's strategy.

ii. Modelling of services in changing environments should not only cover the technical aspects. It should also include the business context (e.g. different implementation scenarios) and enterprise goals to ensure Business-IT alignment.

iii. Certain aspects of services (e.g. how they relate to strategies and enterprise objectives) should be designed in an understandable way for the stakeholders, who do not necessarily have a deep IT knowledge.

Notion of capability

From the digital services point of view, all three implications share common characteristics and they address the subject of Business-IT alignment. Due to changes in regulations, globalization, time-to-market pressures and technological advances, the alignment of business strategy and IT becomes a serious challenge. Enterprises thus require the agility to adjust their offerings for a sustainable competitive advantage. One way to tackle these challenges is the management and design of the capabilities [27, 1, 28, 23]. Hence we use the term ***capability*** and show in the following how it specifically relates to the aforementioned implications[4].

1. Capabilities help to design digital services and are related to organizational strategies

Capabilities are used as fundamental abstraction instruments in business service design [29]. The linkage between capabilities and services is given in the seminal work by Vargo & Lusch, who define services as "*capabilities or competencies that one person, organization, enterprise or system provides for another*" [14] (cited from [30]). Capabilities are strongly related with enterprise strategies and stakeholder goals for a company to deliver value [31, 32, 33].

4 Instead further specifying capability as "IT Capability, Dynamic Capability or Operational Capability, the work adopts the more general term "Capability".

2. *Capabilities support flexible digital service design by taking the business context into consideration*

Flexibility is simply defined as "the adaptability to change" [34]. A requirement to offer flexible services, which necessarily reduces the adjustment efforts for different scenarios and situations, is taking the application context of the service into consideration. Usually, the configuration of the service delivery is strongly related to the various application situations of the service.

The notion of capability has been proposed as an instrument for context-dependent design and delivery of digital services [35, 36, 37] and in a recent EU-FP7 Research Project CaaS[5] the term **capability** has been elaborated for such purposes. In CaaS, capability is defined as *the ability and capacity that enables an enterprise to achieve a business goal in a certain context* [38]. Ability refers to the level of available competence, where competence is understood as talent, intelligence and disposition, of a subject or enterprise to accomplish a goal; capacity means availability of resources, e.g. money, time, personnel, tools. Amongst other definitions and approaches detailed in section 4.5.1, this definition was selected and refined due to its strong emphasis on the notion of context. In this work, capabilities are defined as *context-aware digital services that are related to the enterprise goals and implemented by the business processes*.

3. *For business stakeholders, capabilities provide an abstraction from technical concepts*

In line with the SDL, service-oriented paradigm in IT field gained importance among enterprises and found practical applications, mainly based on Service-Oriented Architecture (SOA). A capability is related to a specific digital service, a defined application context for this service and goals of the enterprise to be reached, which needs to be systematically modelled. Due to their roots in strategic management, capabilities are less technical-oriented concepts and take a business point of view. On the other side, services may refer to technical concepts (cf. Figure 4.3) and be concerned about the implementation aspects[6] [39]. Unlike services, capabilities are perceived to be easier to link to the drivers and goals of the business and they are becoming a useful concept to business stakeholders [1]. This relates to the fact that it is still not clear how service science should address the managerial aspects of service-oriented technologies, whereas capabilities provide an abstraction for business stakeholders on technical and IT-Services perspectives [23, 40]. As such, capability can be used as an "embracing" term to have a shared understanding between the ex-

5 www.caas-project.eu
6 Please refer to section 4.2 for a detailed discussion.

perts that cooperate to design a digital service (cf. Figure 3.1 and Figure 4.3.

Ethos of the thesis

The ethos of the thesis is proposing an approach to enhance the design, development and analysis of IS components supporting the digital service provision in changing environments of digital enterprises. In order to do so, the approach uses the capability notion and explicates the enterprise goals that have to be reached. Moreover, business processes required to implement digital services are identified, the delivery context of the digital service is captured and modelled. The relevance of the problem from the theoretical and practical point of views is demonstrated in the upcoming section shortly and in Chapter 3 in detail.

1.1.1 *Problem Relevance*

Problem from the theoretical point of view: Why do enterprises need to offer flexible digital services?

Enterprises offer business services to satisfy customer needs and to support the exchange of business values across their network [41]. Due to the achievements in ICT, business services can also be offered digitally, which require the infrastructure of an IT-based Internet for service creation, request or delivery [42]. Especially in the domain of e-services actors exchange information based on IT Systems [43]. In accordance with its definition provided in this work, such business services qualify as *digital services* [15, 44].

One of the main characteristics of all types of services is that they are customer centric, i.e. customers are co-producers of services [42]. Although digital services are developed for a specific customer group, they need to be **configured** before being delivered to the customer in line with the application context. In an environment where the organizations are in a constant seek of balance facing up to more and more constraints of the competitive environment; the **flexibility** of service provision gains importance. The need stems both from external constraints, such as changes in customer requirements, regulations, digitalization or service deployment environment and from internal constraints, such as priorities changes, delay constraints and staff schedule [45]. This observation is particularly valid in the digital world, where the enterprises have to react to the external environment and develop new solutions to survive [46]. A commonly used approach for composing digital services into business applications is business process modelling [24, 15, 44]. The business processes constitue the "how" part of the service provision, as stated in [47], who also analyses the duality between the business processes and business services extensively. As a result, enterprises need to offer flexible digital services to improve their chances of survival [23, 48, 17] and adapt their business processes to the changing context.

Industrial setting for the problem investigation

In order to support theoretical observations from the literature, the problem was also analysed from the practical point of view. For this purposes, the *problem explication step* of [49] is applied, which first defines the problem, then clarifies that it exists in the practice and finally analyses the root causes, which should be treated by a purposeful artefact. The problem is generalized as *digital enterprises struggle in offering flexible digital services, which should be adapted to the changing requirements of the environment*. Following that, the problem is shown based on the investigation of two organizations offering digital services within two distinct domains, Business Process Outsourcing (BPO) (cf. section 3.3) and e-Government (cf. section 3.4), both of which are highly influenced from such changing requirements. Finally, the root causes are analysed in the last activity to achieve better results when treating the problems. A detailed explanation of the problem explication step as well as the root causes are given in chapter 3.

Solution approach

Essentially, organizations investigated in this work possess necessary knowledge on different application contexts of the digital services influenced by various drivers, such as the changes in type of services offered, Service Level Agreement (SLA)s and regulations. However, a methodological support on how to capture, model and communicate such application context is missing. A way to contribute to the solution of the problem is engineering an artefact, a **a capability-based component-oriented method for context modelling**, which can be adopted by the organizations envisioning flexible provision of digital services and derives value from models to deal with complexity. The design process of the developed artefact must be defined rigorously and show relevancy to the motivated problem. Due to its socio-technical structure, IS Development is a wicked problem. Among other characteristics, wicked problems do not have a definitive formulation, they are unique and solutions to them are good-or-bad and not true-or false [50]. Based on these characteristics, we apply the DSR approach to tackle the problems, i.e. we follow the DSR guidelines proposed by Hevner and collegues [21]. Different organizations have different ways of working, in a context where the organizations are in a constant seek of balance work methods should be organized flexible and support various application scenarios [45]. Thus, we use a modular approach to methodology engineering by dividing the methodology into several method components. In doing so the method user could focus on those parts of the method that are needed and select the components relevant for a specific task "on demand" from a repository. For this, the method conceptualization framework is slightly extended in its operationalization, which is introduced in section 5.1 [51].

Which lines of work exist to solve the problem?

Although we did not directly find proposals that concern flexibility enhancement in digital services, it is possible to relate different lines of work in the literature to the investigated problem in the thesis. Among these lines of work, proposals have been identified in the area of Business Process Management (BPM), particularly in process variant management and context-aware business processes . As they do not entirely cover the relevant aspects of the solution approach proposed above, these lines of work have either shortcomings or cannot be implemented off the shelf to support digital service flexibility. Please note that in the following the reader is provided with a short summary of the lines of work, whereas the approaches are detailed in chapter 4.

- The solution approaches have shortcomings when it comes to reduce the gap between business requirements and technical implementations, which necessarily has a negative influence on the communication between various stakeholders and experts that collaborate during the design and implementation of digital services.
- The solution approaches do not derive value from existing enterprise models, on the contrary, they overcomplicate the models which have been developed for specific purposes.
- The proposals are very domain specific. It is challenging to produce consistent results when they are applied to different domains or platforms with correct transformation rules and other formalities.

`Research goal`

Given the problems and possible solution approaches above, the main research goal of this thesis is to **improve the flexibility**[7] of digital services provided in **changing environments** by developing a **context modelling method** based on enterprise capabilities. The method is situational **adaptable** and aims to support typical stakeholder roles (such as business analysts, solution engineers and (knowledge) workers /operators, cf. Figure 3.1) in order to reduce resources required to adjust and configure services.

1.1.2 *Research Questions*

The work at hand aims to answer the following research questions[8]

7 Note that we use the term *flexibility* instead adaptability, since the latter one implies the runtime aspects of the business service provision, whereas the former one connotes rather design time aspects and is more suitable from the capability point of view.

8 Detailed answers are provided in the respective chapters and sections

RQ 1 From the **methodological** perspective, how can the design of digital services adaptable to changing requirements of the environment be supported?

- **RQ 1.1** What are the current problems of the organizations offering digital services in changing environments? (cf. Chapter 3)
  - The digital services are offered for a specific customer group, yet they need to be **customized** and **adjusted** to fulfil specific requirements. The requirements are strongly related to the **application context** of the service. There is enough knowledge about what these contexts are in enterprises, but missing is how to **capture and model** this type of knowledge.
- **RQ 1.2** How are the terms **services** and **digital services** defined in the literature?
  - Service notion has been analysed in Information Science, Business Science and Computer Science [24]. One of the most cited definition of the term service is from [14], which states that *"service is the application of competence for the benefit of another"*. The same work details services as capabilities or competencies that one person, organization, enterprise or system provides for another. The term digital service is described as the IT-based design and provision of (business) services (or solutions), mainly focusing on the related business processes and enterprise objectives to exchange value (cf. section 4.2).
- **RQ 1.3** Which approaches exist that improve the flexibility in the design and configuration of digital services?
  - In the literature, we did not identify direct proposals that aim to enhance the flexibility of digital service design or provision. Instead, the contributions focused on the role of BPM in making organisations or services more flexible. In particular, context-aware design of business processes and developments in the process variant management seem to relate to the problem at hand. The proposals and their shortcomings are investigated in Chapter 4 in detail.
- **RQ 1.4** How should the method support for increasing digital service flexibility look like? (cf. Chapter 5, section 3.6)
  - A method can be developed, which states how the context is explicated, captured and designed, or in short how the context can be *modelled*. The method should benefit from the enterprise models in general and business process models in particular (cf. section 3.6.1). The method

should be adaptable and engineered component oriented (cf. section 3.6.2). As the main problem is the lack of support in the identification of contextual factors, the method should inform its user concerning the context elicitation procedure, document the inputs needed and outputs produced.

- **RQ 1.5** Is the method applicable in enterprises offering digital services? Does the method use lead to an improvement in the provision of flexible digital services?
  - To answer the **RQ 1.5** and ensure the rigour of the design artefact, the method was evaluated by following FEDS approach [52]. By applying various research methods (survey, interview, action research etc.) the artefact was evaluated in a total of six different episodes. Each episode provided a feedback, based on which the design artefact was improved. The results are documented in Chapter 6.

1.1.3 *Contributions*

C1. In order to offer flexible digital services, enterprises need to understand their application context. The analysed context modelling approaches (methods, techniques, frameworks, procedures) assume that contextual information is already known [53] and fail to show how to elicit contextual information in a systematic way. Moreover, they lack important elements, such as notation, tools required to model the context, the prerequisites to use the method etc., which would enhance their practical applicability. This work closes the gap by providing a method to identify and model the contextual factors, which influence design and delivery of a digital service.

C2. The combination of capability and service research streams are rarely found in the literature [17]. However, when the notion of "Service" is analysed, we observed that several disciplines related to IS had diverse perceptions, all of which are relevant in the context of digital services. In this work, the term capability is proposed as a "glue", in other words, as a communication vehicle between those disciplines that study Service Science, such as Information Science, Business Science and Computer Science. This requires a refinement in the traditional interpretation of the capability notion, which is described as *context-aware digital services that are related to the enterprise goals and implemented by the business processes* and used as an instrument to bridge the gap between the design of digital services and their actual implementation.

1.2 OVERALL APPROACH

A component-oriented context modelling method

In order to answer the research questions formulated in Section 1.1.2, the work proposes to develop a *component-oriented method for context modelling*. The approach aims designing digital services based on their application context and enterprise goals systematically, which we call capability. The contribution of the work is a method as a DSR artefact, which should be applied by the organizations following the objective of offering flexible digital services.

The research process is conducted design-science oriented and is mainly based on three cycles. *Relevance cycle* is assured by the application cases taken from two CaaS industrial partners. In *rigour cycle* we use the applicable knowledge in the literature by investigating frameworks, models and methods that might solve or help in solving the problem. Finally, in *design cycle* we develop the artefact in line with the inputs from both cycles, observe how the developed artefact behaves in these scenarios and refine the artefact after the gathered feedback in the evaluation.

Structure of the thesis

After detailing the research methods used in this thesis in Chapter 2, Chapter 3 takes a closer look at the problem and investigates the application cases from utility and e-Government sectors. Following that, Chapter 4 presents the state of the art in related areas such as context modelling, capability modelling and Services Science. Chapter 5 introduces the core proposal of this thesis *deCOM*, the context modelling method and Chapter 6 documents its evaluation process as well as the gained feedback. Following that, Chapter 7 discusses the findings, reports the threats to validity, communicates the limitations and concludes the work.

1.3 OVERVIEW OF PUBLICATIONS

Journal Publications

1. S. Berzisa, G. Bravos, T. C. González, U. Czubayko, S. España, J. Grabis, M. Henkel, L. Jokste, J. Kampars, H. Koç, J.-C. Kuhr, C. Llorca, P. Loucopoulos, R. J. Pascual, O. Pastor, K. Sandkuhl, H. Simic, J. Stirna, F. G. Valverde, and J. Zdravkovic, "Capability Driven Development: An Approach to Designing Digital Enterprises," *Business & Information Systems Engineering*, vol. 57, no. 1, pp. 15-25, 2015. [Online]. Available: http://dx.doi.org/10.1007/s12599-014-0362-0

2. K. Sandkuhl, J.-C. Kuhr, H. Koç, and U. Czubayko, "Capability Management im Geschäftsprozess-Outsourcing," *Controlling*, vol. 27, no. 12, pp. 693-702, 2015. [Online]. Available: http://dx.doi.org/10.15358/0935-0381-2015-12-693

Book Chapters

3. H. Koç, J.-C. Kuhr, K. Sandkuhl, and F. Timm, "Capability- Driven Development - A Novel Approach to Design Enterprise Capabilities," in *Emerging Trends in the Evolution of Service-Oriented and Enterprise Architectures*, ser. Intelligent Systems Reference Library, E. El-Sheikh, A. Zimmermann, and L. C. Jain, Eds., 2016, vol. 111, pp. 151-177. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-40564-3_9

Conference and Workshop Publications

4. H. Koç, F. Timm, S. España, T. González, and K. Sandkuhl, "A Method for Context Modelling in Capability Management," in *24th European Conference on Information Systems, ECIS 2016, Istanbul, Turkey, June 12-15, 2016*, 2016, p. Research Paper 43. [Online]. Available: http://aisel.aisnet.org/ecis2016_rp/43/

5. H. Koç, "A Context Modelling Method to Enhance Business Service Flexibility in Organisations," in *Proceedings of Short and Doctoral Consortium Papers Presented at the 8th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modelling (PoEM 2015), Valencia, Spain, November 10-12, 2015*, ser. CEUR Workshop Proceedings, S. España, J. Ralyté, P. Soffer, J. Zdravkovic, and O. Pastor, Eds., vol. 1497. CEUR-WS.org, 2015, pp. 91-98. [Online]. Available: http://ceur-ws.org/Vol-1497/PoEM2015_DCPaper1.pdf

6. H. Koç, "Methods in Designing and Developing Capabilities: A Systematic Mapping Study," in *The Practice of Enterprise Modeling - 8th IFIP WG 8.1. Working Conference, PoEM 2015, Valencia, Spain, November 10-12, 2015, Proceedings*, ser. Lecture Notes in Business Information Processing, J. Ralyté, S. España, and O. Pastor, Eds., vol. 235. Springer, 2015, pp. 209-222. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-25897-3_14

7. H. Koç, E. Hennig, S. Jastram, and C. Starke, "State of the Art in Context Modelling - A Systematic Literature Review," in *Advanced Information Systems Engineering Workshops - CAiSE 2014 International Workshops, Thessaloniki, Greece, June 16-20, 2014. Proceedings*, ser. Lecture Notes in Business Information Processing, L. S. Iliadis, M. P. Papazoglou, and K. Pohl, Eds., vol. 178. Springer, 2014, pp. 53-64. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-07869-4_5

8. H. Koç, M. Ruiz, and S. España, "LightCDD: A Lightweight Capability-Driven Development Method for Start-Ups," in *Advanced Information Systems Engineering Workshops - CAiSE 2016 International Workshops, Ljubljana, Slovenia, June 13-17, 2016, Proceedings*, ser. Lecture Notes in Business Information Processing, J. Krogstie, H. Mouratidis, and J. Su, Eds., vol. 249. Springer, 2016, pp. 15-26. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-39564-7_2

9. H. Koç and K. Sandkuhl, "A Business Process Based Method for Capability Modelling," in *Perspectives in Business Informatics Research - 14th International Conference, BIR 2015, Tartu, Estonia, August 26-28, 2015, Proceedings*, ser. Lecture Notes in Business Information Processing, R. Matulevicius and M. Dumas, Eds., vol. 229. Springer, 2015, pp. 257-264. [Online]. Available: http://dx.doi.org/10.1007/978-3-319-21915-8_17

10. H. Koç and K. Sandkuhl, "From Business Process Models to Capability Models," in *45. Jahrestagung der Gesellschaft für Informatik, Informatik 2015, Informatik, Energie und Umwelt, 28. September - 2. Oktober 2015 in Cottbus, Deutschland*, ser. LNI, D. W. Cunningham, P. Hofstedt, K. Meer, and I. Schmitt, Eds., vol. 246. GI, 2015, pp. 979-992. [Online]. Available: http://subs.emis.de/LNI/Proceedings/Proceedings246/article99.html

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19. K. Sandkuhl, H. Koç, and J. Stirna, "Context-Aware Business Services: Technological Support for Business and IT-Alignment," in *Business Information Systems Workshops - BIS 2014 International Workshops, Larnaca, Cyprus, May 22-23, 2014, Revised Papers*, ser. Lecture Notes in Business Information Processing, W. Abramowicz and A. I. Kokkinaki, Eds., vol. 183. Springer, 2014, pp. 190-201. [Online]. http://dx.doi.org/10.1007/978-3-319-11460-6_17

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21. J. Zdravkovic, J. Stirna, J.-C. Kuhr, and H. Koç, "Requirements Engineering for Capability Driven Development," in *The Practice of Enterprise Modeling - 7th IFIP WG 8.1 Working Conference, PoEM 2014, Manchester, UK, November 12-13, 2014. Proceedings*, ser. Lecture Notes in Business Information Processing, U. Frank, P. Loucopoulos, O.

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Journal Submissions (Under review)

22. K. Sandkuhl, H. Koç and J. Stirna, "Capability as a Service: Method and Tool Support for Context-Aware Business Services," *International Journal of Information Systems in the Service Sector (IJISSS)*, Under Review

23. H. Koç, M. Ruiz, and S. España, "LightCDD method: an application of capability-driven development methods for start-ups development," *Complex Systems Informatics and Modeling Quarterly (CSIMQ)*, Under Review

24. O. Pastor, M. Ruiz, H. Koç, and F. Valverde, "Capability-based Communication Analysis for Enterprise Modelling," *Enterprise Modelling and Information Systems Architectures (EMISA)*, Under Review

2

RESEARCH METHOD

The set of activities used by a research community to contribute to the understanding of a phenomenon is called *research method* [54]. Research communities are classified as *paradigmatic* and *multi-paradigmatic* depending on the variety of applied methods. Paradigmatic communities have a nearly common understandings of what should be investigated and by which means. As opposed to that, multi-paradigmatic communities benefit from an overlap in sets of phenomena of what should be investigated. Since the subjects under study are associated with different disciplines, the methods on how to investigate them are also manifold. Information Systems Research (ISR) is a multi-paradigmatic area with possibilities to apply various approaches during the investigation of subjects under study. Among this approaches, it is possible to distinguish between Behavioural Science Research (BSR) and DSR on a higher abstraction level [55]. This chapter focuses on the selected research paradigm as well as the applied research methods and frameworks in the thesis.

2.1 DESIGN SCIENCE RESEARCH

DSR is fundamentally a problem-solving paradigm[1], which at its core is directed towards understanding and improving the search in order to construct an artefact[2] [56]. A (practical) problem is understood as "a gap between the current state and a desirable state as perceived by the participants (in practice)" [49, p. 2]. To solve a problem, i.e. to close this gap, DSR seeks to create *artefacts* through which the anal-

1 There is an ongoing discussion about the classification of DSR in ISR. [56] states in his article that DSR is not design, not a research method and not a research strategy. Adressing the positivist and interpretivist paradigms as the most important research paradigms in IS, [49] extends the list with "DSR is not a research paradigm". Notwitstanding the fact that the thesis does not aim at searching what DSR is, it posits DSR as a *research paradigm* [56, 57]. Interestingly, Johannesson & Perjon's description of research paradigm, "a set of commonly held beliefs and assumptions within a research community about ontological, epistemological and methodological concerns" [49, p. 167] satisfies the classification of DSR as a research paradigm, given that its application does not exclude interpretivist and positivist approaches [54, 58].

2 "Artefacts" are objects made by humans with an intention to support the solution of an encountered problem [49]. They are used when designing, developing, maintaining, and using information systems [59]. Artefacts in DSR are discussed in section 2.1.2.

ysis, design, implementation, and use of information systems can be effectively and efficiently accomplished [60, p. 118]. Such artefacts should improve and help to understand the behaviour of the IS aspects [54]. Consequently, DSR aims at "utility", i.e. the construction and evaluation of generic means-ends relations rather than "truth", which distinguishes it from BSR [61].

2.1.1 *History of Design Science Research*

Having a history over nearly 50 years - Design Science Research Society was founded in 1966 - it is fair to argue that the DSR is not a new paradigm. Three years after the foundation of DSR Society, Simon's first book was published, which is considered to be a seminal work in this field [56]. Although having its roots in in engineering and other applied sciences, the DSR paradigm was introduced to the Management Information Systems (MIS) field at the late 80's [55] This was the result of the strong criticism due to the application of empirical research paradigms inherited from the parent field, Management Systems, and thus neglecting the design criteria as addressed in [62]. As the adaptation of information systems in global organisations swelled, the call for professors in the MIS field also increased. Academics from related disciplines such as computer science and engineering were introduced to MIS to overcome the shortage of professors in this field, which gave rise to the application of their original research tradition that considers design as a central part [63].

Design means "to create, fashion, execute, or construct according to plan"[3]. Hence design is about bringing new artefacts into being, which is a distinguishing attribute between DSR and behavioural research. As March and Smith express, "A natural science is a body of knowledge about some class of things - objects or phenomenon - in the world (nature or society) that describes and explains how they behave and interact with each other. A science of the artificial (design science), on the other hand, is a body of knowledge about the design of artificial (man-made) objects and phenomena - artifacts - designed to meet certain desired goals" [64]. Simply expressed, behavioural research aims at truth to explore and validate generic cause-effect relations, whereas DSR aims at utility and deals with how to construct and evaluate generic means-ends relations. Consequently DSR involves "the creation of new knowledge through design of novel or innovative artefacts (things or processes that have or can have material existence) and analysis of the use and/or performance of such artefacts along with reflection and abstractionto improve and understand the behaviour of aspects of Information Systems" [54].

Currently, different aspects and sub-areas of DSR are being investigated in the literature, which are beyond the scope of this work.

3 http://www.merriam-webster.com/dictionary/design, Last Retrieved 09.03.2015

Detailed information about DSR and recent discussed areas can be found in [63], [61], [56], [54], [59] and [21].

2.1.2 *Artefacts in Design Science Research*

In DSR community there is a common agreement on the types of artefacts produced [61, p. 471]. Based on March and Smith's classifications [64], the DSR artefacts are constructs, models, methods and instantiations. *Constructs* are the languages to specify solutions to problems and constitute a conceptual vocabulary of a domain. Modelling primitives implemented by modelling tools are an example of this artefact type. *Models* use this language to represent problems and solutions. They are a set of propositions or statements expressing relationships between constructs [54], such as business process models or goal models. *Methods* describe steps for solving the problems and provide guidance. *Instantiations* are aggregations of the aforementioned three types that are specific to a problem and operationalise constructs, models and methods [64, 61]. The list of artefacts produced by DSR endeavours are extended by [65] with a fifth output, *better theories*. DSR can contribute to theory building in two ways. First, the construction phase of the aforementioned artefacts are natural objects for theorizing in many communities (e.g. how to build a context-aware system). Second distinct way is relates to the nature of the artefact, i.e. the relationships between the elements of the artefact can be studied to increase their understanding (e.g. the context-aware system operates in certain conditions due to a number of reasons). The discussion in the resarch communities is still on-going, whether theories (or design theories, as stated in [66]) are outcomes of DSR[4]. Table 1 shortly summarizes the DSR artefacts and their descriptions.

Table 1.: Outputs of a DSR project [54]

	Output	**Description**
1	Constructs	The conceptual vocabulary of a domain
2	Models	A set of propositions or statements expressing relationships between constructs
3	Methods	A set of steps used to perform a task - how to knowledge
4	Instantiations	The operationalization of constructs, models and methods
5	Better theories	Artifact construction as analogous to experimental natural science, coupled with reflection and abstraction

4 As it does not further add value to the work at hand, the discussions among the scholars related to that topic and our position is not included in the thesis. Yet, interested readers are referred to [66] for more detail.

The artefact types are directly related to the knowledge contribution of the researcher. To classify this, [67] proposes a framework which is illustrated in Figure 2.1. The x-axis represents the maturity of the problem space, where the developed artefact is applied and y-axis defines the level of solution maturity. In each quadrant, information flows between two relevant information types in DSR is required, namely *descriptive* and *prescriptive* knowledge. Descriptive knowledge is the knowledge about the phenomena and the laws and regularities among the phenomena [67, p. 343]. Prescriptive knowledge is the knowledge about how the phenomena should be constructed, modelled or instantiated. In DSR descriptive knowledge stems from the research activities that concern observations, classifications, principles, laws and theories about the artefact. The prescriptive knowledge on the other side results from the research activities about semantics, syntax, algorithms, techniques, concepts and symbols of the phenomena [64].

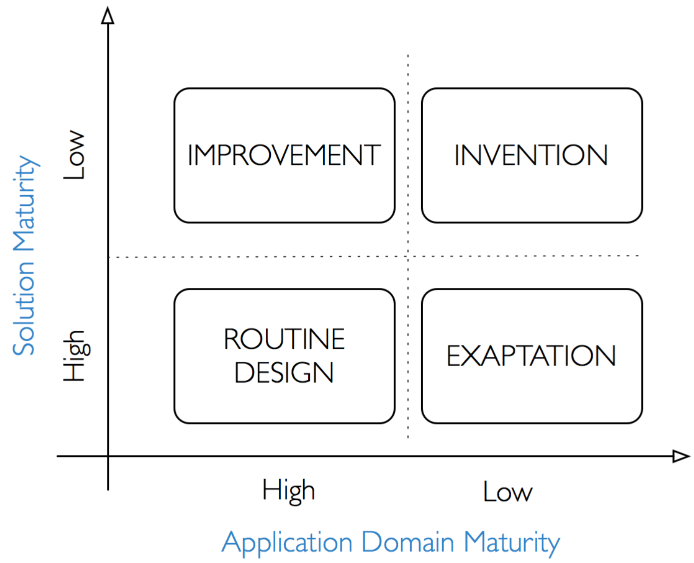

Figure 2.1.: Knowledge contribution framework in [67, p. 345]

In the following the quadrants are described:

- Invention: The field under study is new and there is a little understanding about problems. This leads to a lack of formulated research questions. The researcher is guided by interestingness. His contributions are amongst others a novel artefact and the conceptualization of a problem that has never been or only to some extent mentioned before[5]. The knowledge flow in the in-

5 Most of the DSR procedures start with "problem definition" step. Obviously, a recognized problem may not exist when inventing a novel artefact. Consequently, this quadrant interestingly contradicts some of the DSR processes, which is also acknowledged by [67]. Hence interest is as equally as important as showing the relevance of a problem and justifying the value of a possible solution.

vention quadrant is from prescriptive to descriptive, since there is no theory, law, pattern etc. about the artefact to be developed. An invention is very rare and requires a departure from the traditional way of thinking. An example of invention in IT field is the vision of a Decision Support Systems (DSS) by Scott-Morton in 1967 [67, p. 343].

- Improvement: In this quadrant new solutions are proposed for known problems that are better than the existing ones as they assist the user of an artefact to create products, services, process, technologies, ideas etc. more efficiently. The researcher should in this case prove that the developed solution advances on existing solutions and thus it is possible to speak of an improvement. This can be achieved by rigorously validating/ evaluating the developed artefact as well as communicating its new aspects with experts, researchers and audiences, which are both management and technology oriented. In general the improvement quadrant contributes to the body of prescriptive knowledge by proposing methods, concepts, models or design principles, which can be demonstrated in terms of positive changes in efficiency, productivity, quality, competitiveness, market share or other quality measures. An example of the DSR artefacts produced in the improvement quadrant is a tool providing a graphical user interface to design schemas for context models to ease the task of modelling and management of complex context information [68] or a method for developing context-aware systems in line with unified process [69].

- Exaptation: In this quadrant known solutions in a field are extended and applied to the fields with new problems. This is the case when a solution already exists in a related problem area from a different discipline, which may be transferred and adapted to the field under study. The main task of the researcher is demonstrating the non-triviality of knowledge contribution in the problem area. Similar to the improvement quadrant, the efforts in exaptation quadrant contributes both to descriptive and prescriptive body of knowledge. An example of exaptation in IS field is the introduction of Action Research (AR) in 1981 by Checkland, which has been originally developed in the social psychology field after World War II to investigate psychological and social disorders caused by war [70].

- Routine Design: In this quadrant known solutions are applied to known problems, which demonstrates no major contribution to the body of knowledge. The routine work may lead to surprising results, yet as research opportunities are scarce, this will probably require to move to another quadrant.

Table 2 illustrates the relationship between knowledge contribution and example artefacts. From Level 1 to Level 3, the maturity of knowledge and completeness of the artefact is expected to increase.

Table 2.: Knowledge contribution and artefact types in DSR, [67, p. 342]

Contribution Types	Example Artefacts
Level 3. Well-developed design theory about embedded phenomena	Design theories
Level 2. Nascent design theory-knowledge as operational principles/architecture	Constructs, methods, models, design principles, technological rules
Level 1. Situated implementation of artifact	Instantiations (software products or implemented processes)

The aim of this thesis is to develop a context modelling method to enhance digital service flexibility, which supports enterprises operating in dynamically changing environments. The method as a main DSR artefact is positioned in the *improvement* quadrant based on the following reasons:

- As introduced in Chapter 1 the problem of flexibility in the area of IS design in general and digital service design in particular is known. The application domain as such is mature, which will be discussed in Chapter 3 and Chapter 4 in detail.
- Certain solution proposals also exist to overcome the flexibility problem in the design of digital services. Yet, the proposals lack certain qualities (e.g. benefiting from Enterprise Modelling, considering the tasks and perspectives of various stakeholders participating to service design, providing a systematic support for context elicitation). Chapter 4 discusses the shortcomings extensively.

The objective of the artefact is enhancing the flexible design of digital services by engineering deCOM, a capability-based context modelling method. Considering the contribution levels by [67, p. 342] the designed artefact is classified on Level 2.

2.1.3 *Procedures in Design Science Research*

Various methods are proposed about performing within the design science framework. Although the approaches differ on their nomenclature, such as *design science research*, *design science research methodology*, *design cycle and design research* [71], the procedures are basically made up of two phases, **build** and **evaluate**. The building phase includes the activities of constructing an artefact for a specific purpose and evaluation phase studies how good this artefact performs in the context that it has been designed for [64]. In this thesis the term *design science research procedure* is used to refer to the research method based on design science.

Irrespective of the type of research procedure applied, [21] proposes seven guidelines on how to conduct DSR which are described as follows:

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

A comparison of different DSR procedures proposed in the literature would reach beyond the boundaries of this work. Nevertheless, Table 3 illustrates the comparison of the methods, which are detailed in [71].

This work applies the DSR process model by [72], which is developed by synthesizing the common process elements, upon which the representative DSR papers agree (see Figure 2.2). The *problem identification & motivation* activity defines the research problem and justifies value of the solution. Then, the *objectives of the solution* are explicated, which are inferred form the problem specification. The objectives can be both qualitative (solution to not addressed problems) and quantitative (solutions which are better than current ones). After that the *design & develop artefact* steps is conducted, where the artefact is created

Table 3.: Comparison of different methods, taken from [71]

Authors	Main steps of the method							
	Problem definition	Literature review or search for existing theories	Suggestions for possible solutions	Development	Evaluation	Decision about the best solution	Reflection and learning	Communication of results
Bunge	X		X	X	X			
Takeda et al.	X		X	X	X	X		
Eekels and Roozemburg	X		X	X	X	X		
Nunamaker et al.	X		X	X	X			
Walls et al.	X	X	X	X	X			
van Aken et al.	X		X	X	X		X	
Vaishnavi and Kuechler	X		X	X	X	X		
Cole et al.	X		X	X	X		X	
Manson	X		X	X	X	X		
Peffers et al.	X		X	X	X			X
Gregor and Jones	X	X	X	X	X			
Baskerville et al.	X		X	X	X			
Alturki et al.	X	X	X	X	X			X

that should solve the stated problem in the first activity. Whether the initial version of the artefact solves the problem or not is investigated in *demonstration* activity. The *evaluation* activity makes measurements in order to define how well the artefact supports a solution by comparing the objectives of the solution with the demonstration. Finally the research process, the artefact and its utility are published to the scientific community and to the practitioners in the *communication* activity [72, pp. 52-56]. DSR creates the purposeful artefact with multiple iterations, each iteration aiming to increase artefact maturity.

The process model and the alignment with the DSR guidelines are illustrated in Figure 2.2. Two slight adaptations of the procedure should be mentioned here. First, the iterations in the procedure proposed by [72] exclude the problem identification step (activity 1), i.e. the problem motivating the design artefact is identified once and remains stable over the course. Taking the time frame, in which the thesis and the artefact was developed, this activity was revisited a number of times. This is mainly due to the reason that the stakeholders who will benefit from the purposeful artefact had a more sharpened view of the problems; the more workshops and in-depth analysis were performed, the clearer was the problem, even after demonstrating the artefact (see also section 2.1.3.1). Second, the work at hand aligned the DSR guidelines with the activities. Associating the guidelines helped to focus on certain ”instructions” and proceed without deviating from the objectives of the activities. The activities performed in each task are briefly mentioned in the following sections, which are then detailed in respective chapters.

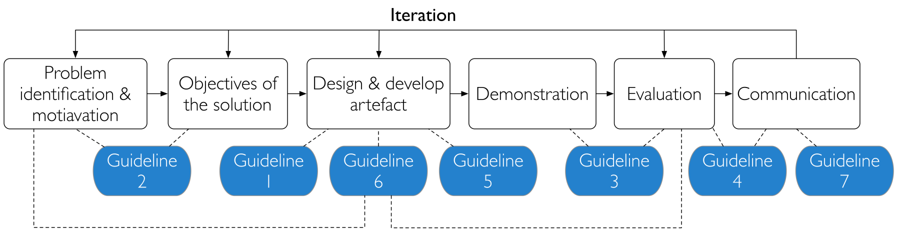

Figure 2.2.: DSR procedures and DSR guidelines following [72]

2.1.3.1 *Problem Identification*

The first step of the DSR procedure followed in this thesis is the ”problem identification and motivation”, as illustrated in Figure 2.2. To coordinate the steps, the ”explicate problem activity” of the DSR method framework proposed in [49] is used (see Figure 2.3).

In the first sub-activity, *define precisely*, the aim is raising the comprehensibility of the problem by iterating on the problem definition. Here, the researcher finds a balance between overly narrow problem definitions and less precise problem definitions. To define the problem precisely, related work in the literature in form of the unstructured literature analysis was investigated first, which is then enriched with the application studies from the industries offering digital services (see sections 3.3 and 3.4). In the earlier steps, the problem was defined as "enterprises need process flexibility to offer business services", but this would be too narrow and reduce the number of potential solutions. The process flexibility would positively influence the business service offerings of the enterprises under study, thus the problem was altered as *business services are not flexible enough to meet the demands of the business environment*. Finally, based on the application cases and the observations, the scope was narrowed down to the *digital services* and the business environment was limited to the *changing environments*. Hence, the definition of the problem was finally expressed as *"enterprises struggle in offering flexible digital services, which should be adapted to the changing requirements of the environment"*.

Following that, in the *position and justify* activity, the practical aspects of the domain under study is investigated. To do so, surveys and interviews with stakeholders from industry are conducted to ensure that the problem is of general interest [73]. In addition to that, action research and observation methods are used to give a depth to the problem. Finally, in the *find root causes* sub-activity, the causes are analysed to reach a detailed understanding of the problem (cf. section 3.5). The sub-activities are not purely sequential, they are rather incremental and iterative, i.e. the knowledge gained during the second sub-activity may feed back into the first sub-activity to express the problem precisely. The outputs of the problem identification activity are detailed in Chapter 3.

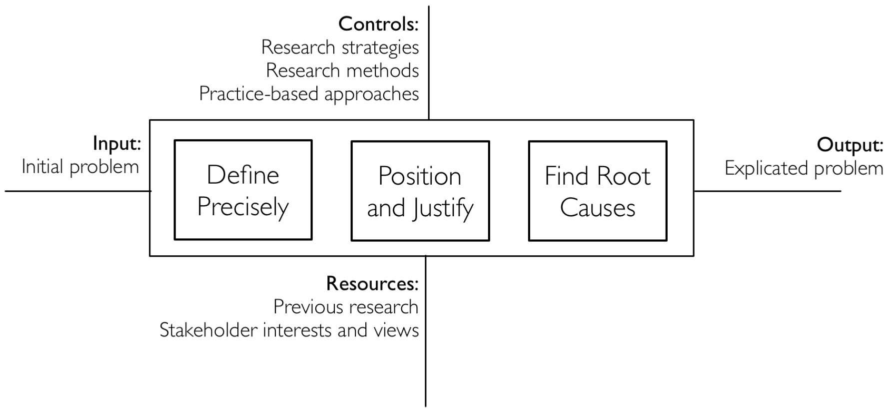

Figure 2.3.: The problem explication activity, following [49]

2.1.3.2 *Objectives of the Solution*

The second step in the DSR procedure is defining the properties of the design artefact (cf. Figure 2.2) and eliciting the requirements to solve the problems addressed in the prior step. A requirement is defined as "property of the treatment desired by some stakeholder, who has committed resources to realize the property" [59, p. 51].

The activities and guidelines recommended in [49] are adapted in the frame of this work. As various artefacts can be designed to enhance the digital service flexibility (cf. section 2.1.2), *method* was selected as the most appropriate artefact type to solve the explicated problem (cf. section 3.6.1). Considering the aforementioned requirement definition by Wieringa, the treatment here corresponds to the designed artefact, i.e. the context modelling method developed in the thesis. Following techniques were used to derive requirements that the method should fulfil, which are detailed in section 3.6.2.1 [49, 74].

Survey techniques: In the beginning of the EU-FP7 research project CaaS, an industry survey has been designed to gather industrial requirements for the CDD methodology, which uses certain parts of the context modelling method developed in this thesis as an integral method component. The questionnaire included closed and open-ended questions, the prior providing a list of acceptable responses and the latter allowing for a free form [73]. The target group of the survey was European companies involved in various kinds of digital business and e-business activities, such as IT service development, IT service provider and companies using advanced IT solutions.

Observation techniques: This technique is recommended when the domain specialists are unable to share their expertise with the requirements engineer due to time limitations. Thus, between 11.2013-02.2014 the author spent three days a week in the premises of SIV.AG[6], a CaaS industrial project partner offering digital services, which are highly influenced from changing environments.

Support techniques: The properties of the design artefact must fulfil the stakeholder objectives. Stakeholders are defined as any person or organisation that has an opinion, a responsibility for, or who may be influenced or affected by the proposed system [75]. Hence, during the elicitation of the properties, a close communication and collaboration between the researcher and the stakeholders are beneficial. In the context of this work, the relevant stakeholders were enterprise architects, software product managers, solution engineers, knowledge workers and business analysts in the CaaS project. The support techniques such as focus groups, workshops and case studies can be used to study the artefact properties. To mitigate the risk that one person dominates such groups, participative approaches were used, upon which the requirements were derived from the enterprise goals regarding a context-aware service delivery.

6 More details about SIV.AG is provided in section 3.3.

Document-centric techniques: Relates to the extensive secondary data[7] analysis between early 2014 and mid 2015 in SIV.AG. The information from the documents were extracted with a certain perspective, i.e. flexibility & context modelling support in mind.

The resulting properties are then grouped into *functional* and *non-functional* requirements, which are detailed in section 3.6.2.2.

2.1.3.3 *Design and Develop Artefact*

In this step the purposeful artefact should be designed and developed. Here, two important criteria are important. First, the artefact to be designed should address the explicated problem in Step 1. Second, it should fulfil the requirements defined Step 2. [49] proposes four sub-activities when designing and developing the artefact, all of which are performed in parallel and iteratively. In the *imagine and brainstorm* sub-activity, initial ideas are generated and documented collectively or as individuals. The authors propose a number of instruments that enhance the creativity and hinder social loafing during participative sessions. In the *assess and select* sub-activity, the generated ideas will be evaluated to narrow the focus on a possible solution. The artefact is constructed in *sketch and build* sub-activity, followed by the *justify and reflect* sub-activity, in which the design rationale is documented and discussed with the stakeholders that participate to the design process.

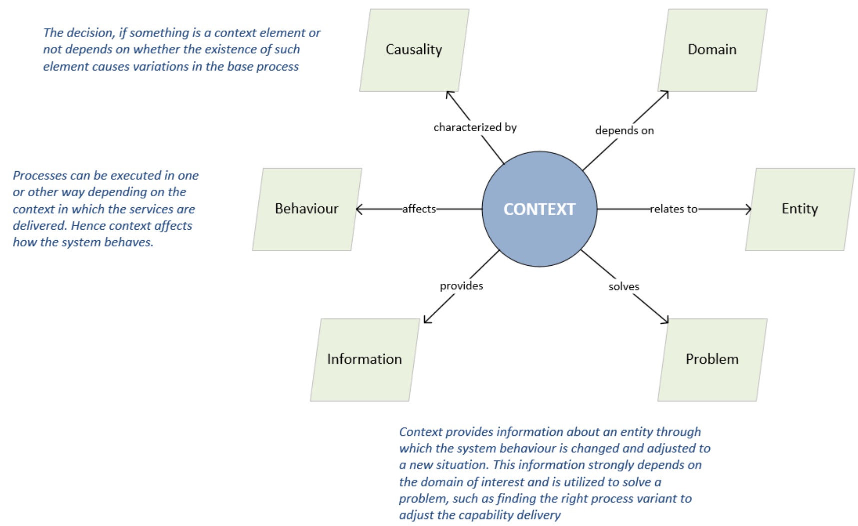

Figure 2.4.: Main components of the concept "context"

Although providing useful guidelines, authors acknowledge the complexity of systematically describing the process of artefact design

7 Customer specifications, policies, guidelines, service level agreements, documents explaining the organizational processes, the structures, roles, task allocations, handling instructions, best practices etc.

and state "(this step) differs from other design science activities in that it does not primarily aim to answer questions by producing descriptive or explanatory knowledge. Instead, its main purpose is to produce prescriptive knowledge by creating an artefact" [49, p. 125]. Consequently, it is recommended to adopt any research approach which may help to generate solutions that work. The design artefact developed in this thesis was defined as *a method to capture and elicit context*, but two important questions remained yet unanswered. The first question was related to *engineering* aspects, i.e. which frameworks and tools exist that help to design and develop a method. Second question concerned the *content* of the method, i.e. how the method should look like, which areas should it cover etc. To answer the former question, we opted using Goldkuhl's method engineering framework (cf. section 5.1), mainly based on the reason that this framework was applied in CaaS project. This inevitably would lead to the other benefits. First, compared to the other frameworks (e.g. (ISO/IEC 2007)) the effort to cover the industrial requirements with Goldkuhl's framework was considered to be lower. Second, during the artefact evaluation episodes, the author could benefit from engineering-related know how of enterprise modelling experts in CaaS project, who have extensive knowledge and experience with the framework.

Desining an artefact is a creative process. It requires inveting new and innovative elements to solve an adressed problem. Nevertheless, in most cases, parts of the existing solutions must be integrated into the constructed elements. Therefore, for answering the second question, the author of the thesis conducted a literature search on the notion of context and ways to capture and document it (cf. section 4.3 and section 4.4). The results were refined to a point, where the boundaries of the "context" notion was created based on the 6 main components, i.e. behaviour, causality, domain, entity, problem and information [76, 77, 78]. These are depicted in Figure 2.4 and detailed in section 4.3. The concepts are used to prepare the questions to be asked, which the method is supposed to answer (see Figure 2.5).

The aforementioned concepts and questions as well as the elicited problems and requirements served the basis for engineering deCOM. The first method version was sketched and introduced to the supervisor of the thesis during the meetings, where the design decisions and their rationale were justified. The output of the first iteration in the design and develop artefact step, i.e. the first version of the method is shown in Figure 2.6. In fact, as a DSR artefact, the engineering process of deCOM is iterative, i.e. in each cycle a new method version is designed, which is then evaluated in a respective setting. The evaluation results are then used as an input for the following cycle, which ensure that method addresses the explicated problem and fulfils the identified requirements. Chapter 5 documents the final version of

1) What is the scope of the business service offered that is subject to context modelling?
2) Which business goals are required for capabilities?
3) What are the relevant business services for this capability?
4) Which processes are required in this domain to offer capabilities? Which of them are standardized, i.e. always executed in a way that remains same?
5) What are the variations of these processes? Under which circumstances do these variations occur?
6) Can the cause of variation be parameterised?
7) What are the attributes of the factors that cause variations
8) What are the properties of these attributes? How can their properties be measured?
9) Which value ranges are possible for attributes?
10) Are there any rules that specify the possible relationships between different context elements ?
11) What are the quality indicators of the context information? How can the ambiguous context information be avoided?
12) Which context element(s) is (are) of importance for which process variation? How are they linked to the patterns?
13) How do the measurable properties relate to the changes in context?
14) How can the context information be stored and queried in the run-time?
15) How does the context platform behave when there are changes in the context?
16) Who should be notified when context changes and how?
17) In which way should the rules be applied to the context elements? Which activities do these rules trigger?
18) How can the business delivery be adjusted using context information?

Figure 2.5.: Idea generation: Questions that the method should answer

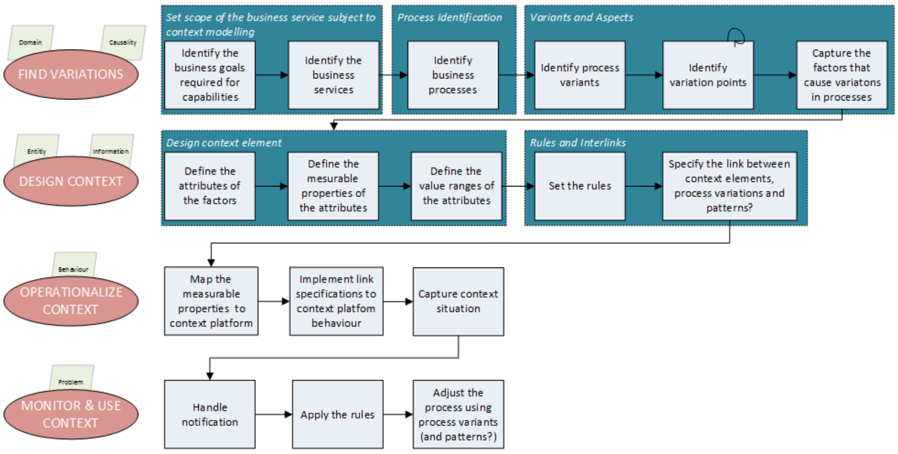

Figure 2.6.: First version of the design artefact

deCOM and Chapter 6 reflects the evaluation activities, gained feedback and version changes in detail.

2.1.3.4 *Demonstration*

In this step, the researcher aims to test the feasibility of the artefact in a selected case that represents the explicated problem. As [72, 71] observe, the demonstration step is usually not part of a DSR procedure. It is not quite easy to distinguish between *demonstration* and *evaluation* steps, whereas it may suffice to argue that demonstration is a weak evaluation, which allows the researcher to present the purposeful artefact even in its initial stages and thus to tolerate false starts.

Figure 2.7.: Technical meeting in CaaS project, where the method has been demonstrated

To demonstrate the artefact, [72] recommends to find a suitable context first. To do so, concrete objectives of artefact demonstration were defined as follows:

- Is it possible to find the concepts proposed by the method in the organizations providing the use cases?
- Is it possible to reduce the problem at hand by applying the method?
- Considering the method solves the investigated problem, to what extent is it possible to adopt the method for use in practice?
- From an engineering point of view, to what extent does the first version adopt the principles of Goldkuhl's framework?

Answering such questions during demonstration requires the participation of experts, who are not only knowledgeable about the realistic problem context and requirements, but also experienced in method engineering. Thus, the research method *expert opinion* is adopted [59], and the first version of deCOM was introduced to the CaaS project stakeholders during a technical project meeting (see Figure 2.7). The meeting included scholars as well as practitioners that are expected to adopt the method in the future to solve the addressed problems. The discussions and expert opinions led to reflections which were to use for improving the method in the future versions. The 1st evaluation episode documented in Chapter 6 details the answers to the aforementioned questions.

2.1.3.5 *Evaluation*

DSR is the process of designing a purposeful artefact, which solves a problem by contributing to and profiting from the scientific body of knowledge. The problem should be relevant in theory and practice, its solutions should be of interest to particular stakeholders. The artefact proposing possible solution should be constructed rigorously, i.e. the design process should appropriately apply existing foundations and methodologies. The evaluation step investigates to what extent the artefact solves the expressed problem and the rigorousness of the artefact development phases. As such, it is a crucial component in any DSR procedure, as illustrated in Table 3. Against this background, this work devotes a separate section to the evaluation aspects and details the theoretical background concerning the artefact evaluation in section 2.4. Likewise, the evaluation results and their incorporation to the respective method versions are discussed in Chapter 6.

2.1.3.6 *Communication*

As mentioned in Guideline 7 of DSR, the research results must be presented effectively to both technology-oriented and management-oriented audiences. [79] names this step as *reflection and learning* and interprets it as a basis for knowledge generation, both in practice and theory. Regarding the communities, [49] distinguishes between research and practitioner communities, which may include both technology-oriented and management oriented audiences. The authors slightly revise the well-established IMRAD (Introduction-Methods-Results-Discussion) structure, which is used in the scientific community to report the results of a research activity. For documenting the results of a DSR project, the *Introduction - Methods* and *Discussion* parts remain. To emphasize the artefact's role, the beginning sections are followed by the *Problem and Requirements-Artefact-Evaluation* sections, which lead into the *Discussion* and *Conclusion* parts. Similarly, [67] modifies the IMRAD structure and recommends a publication schema for a DSR study. Here, *the Literature Review* is placed between the *Introduction* and *Methods* sections to report the relevant work from the knowledge base. Subsequently, *Artefact Description* summarizes the DSR artefact and *Evaluation* documents the gathered evidence concerning the usefulness of the artefact. The structure is completed with the *Discussion* and *Conclusions* sections.

When compared, the structure of this work may remind the former proposal. However, in a way, it is a combination of both. This thesis aimed to demonstrate the need for designing an artefact by extensively analysing both the practical and theoretical aspects. As such the structure extended Johannesson & Perjon's proposal by adding the chapter *State of the Art in Related Areas*, which corresponds to the *Literature Review* in Gregor & Hevner's proposal (cf. Chapter 4).

Concerning the gained knowledge, the results documented in this work has been presented in conferences, workshops, journals and in a book (cf. section 1.3). Fortunately, each submission to the aforementioned channels led to greater feedback from the scholars, all of which have been used to develop the method. Furthermore, especially in the context of conferences and workshops, the author of the thesis received interesting questions which helped him to improve the method qualities. The focus of scientific dissemination lies on the rigour and the contribution on the knowledge base, which necessarily differs from the focus of practical dissemination. The practitioners have also been informed, particularly in form of method handbooks and posters. Still, much attention needs to be given to the management-oriented audiences in the future, mainly by demonstrating the benefits of method use in the practice.

2.2 SYSTEMATIC LITERATURE REVIEW

The literature review is a research method and research genre that critically evaluates what has been published on a chosen research topic. The purpose of a literature review is "to assist in the development of a framework, to summarize prior research, to critically examine contributions of past research, to explain the results of prior research and to clarify alternative views of past research" [80, p. 35].

The literature reviews help to develop new ideas by identifying the gaps in the research and justify the uniqueness and relevance of them [81]. Therefore, literature reviews are crucial in any academic field. Drawing on the purposes of the literature review, [82, p. 287] distinguishes between four types of literature reviews.

1. A literature review can be a part of a scientific research paper reporting from a study. In that case, the review is usually a smaller part of the paper and it comes before the research method as well as the result presentation. The section comprising of the literature review is named mostly as "related work", "state of the art", "theoretical background" or similar.

2. A literature review can be a *standalone review*, i.e. "a (...) type of publication in its own right [80]. Examples of this type can be found in [83, 84, 85, 86, 87], to name a few.

3. A literature review can be a part of a thesis (cf. section 4.3.3 and 4.5.1). Similar to the 1st item, the review is positioned before the main proposal and its discussion.

4. A literature review can be applied when proposing a project. In that case they are precisely described and thus longer than a scientific research paper (1st item). If the project is accepted, the results can be published in form of task reports or deliverables.

Writing a literature review is a huge challenge, especially when countless of thousands of studies are printed each year in various forms [88]. To address this, [81] use the metaphor of *standing on the shoulders of giants*. Clearly, regardless of its type, if a literature review is not transparent, through and fair, it cannot deliver scientific value [89, 90]. Hence IS authors develop guidelines and methods on how to conduct literature reviews.

Kitchenham's procedure

Kitchenham proposes a procedure for performing SLR [89]. The author defines SLR as "a means of identifying, evaluating and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest". To ensure the rigour of the review process, a SLR has to be transparent and replicable. For this, [89] recommends the following three phases:

1. Plan Review: This phase formulates the problem at hand and specifies the research questions, which help to motivate the literature analysis and justifies the need for performing them (Step 1). Following that, an initial plan that is used throughout the review process is documented as a *review protocol*. The initial plan includes the literature sources (databases, certain conferences or journals, books) to investigate, the search term(s) to apply, the part of the primary study to query (abstract, keyword, full-text, title) as well as the definition of the time frame. The review protocols may be submitted to peer review (Step 2).

2. Conduct Review: After agreeing upon the review protocol, the search starts by applying the terms that are identified earlier. Depending on the results, the search terms can be populated (Step 3). Then, the resulting set is studied to find out whether they help in answering the research questions and they will be excluded/ included appropriately. To ensure the rigour of the selection process, the criteria for inclusion/ exclusion should be defined clearly (Step 4). In a larger context, it is also recommended to assess the study quality (Step 5). This is followed by *data extraction*, which has the objective of designing data extraction forms to accurately record the obtained information (Step 6). The extracted data is synthesized, i.e. the researcher summarises the results of the included primary studies (Step 7).

3. Document Review: The last phase interprets and documents the results for communication purposes (Step 8). The selected instrument for such communication can be a journal paper, a conference paper, a technical report or a section of a Ph.D. thesis, the latter of which applies to the work at hand.

According to the available resources and purpose of the research, the above-mentioned procedure can be adapted. To exemplify, [91] extends each phase by adding a validation step. This work adjusted the procedure of [89] in a sense that the initial plan (Step 2) was documented, though not reviewed by peers. Moreover, the *assess study quality step* was not performed, since the inclusion and exclusion criteria of primary studies is elaborated in the *study selection* step in detail.

Snowballing procedure

Webster and Watson propose the *snowballing* approach to perform SLRs in IS discipline [92]. The snowballing procedure can be summarized as follows:

1. Start with major journals; scan the journal's table of content in addition to keyword searching and create a starting set of papers,

2. Go backward by reviewing the reference lists of the articles identified in step 1 and step 2; iterate until no new papers are found (backward snowballing),

3. Go forward by identifying articles that cite the articles found in step 1 and 2 (forward snowballing).

[93] compares Webster and Watson's guidelines to Kitchenham's approach. The main focus of the comparison is how different entry points may affect the results. The results can be summarized as:

- Time and effort required in Kitchenham's approach is higher than Webster's. This is based on two reasons. First, snowballing does not require search string formulation in various databases, it is done only once. Second, the authors identified 4.9 times more initial papers with Kitchenham's method, which points out to a greater time to extract the relevant articles.

- The noise (the number of irrelevant papers) in snowballing research seem to be more reasonable, compared to the papers found by Kitchenham's approach (32% to 85%).

- When including/ excluding studies, snowballing might miss the articles with no relevant keywords in the title, since the judgement is mostly based on the title of the paper. On the other hand, papers using different keywords might not be found in Kitchenham's method.

- Snowballing approach is found to be more understandable and easy to follow, in particular for novice researchers.

- Authors cite often their earlier work. Consequently, in snowballing approach, it is possible to have a bias to overrepresent the results of specific authors. This risk is eliminated in Kitchenham's method.

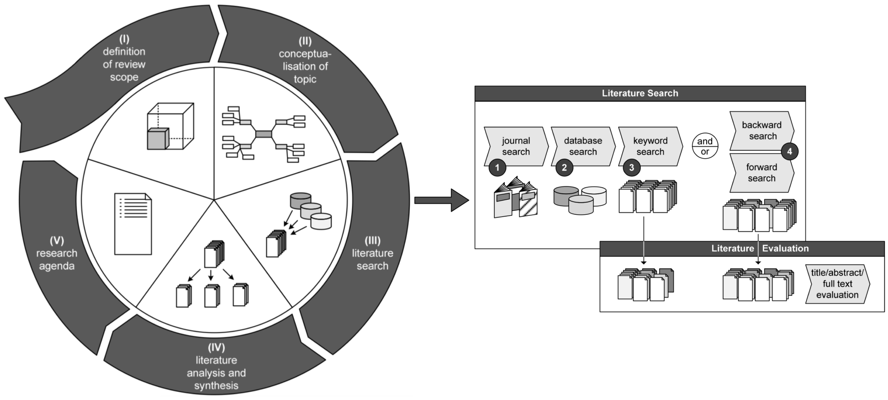

Figure 2.8.: Framework provided by vom Brocke et al., adapted from [81, pp. 8]

Framework by vom Brocke et al.

vom Brocke and colleagues present a framework for performing SLRs. They motivate this need by stating "IS researchers cannot refer to established guidelines for documenting the literature search process and (...) are not fully aware of the importance of rigorously documenting the literature search" [94, pp. 7]. The framework is illustrated in Figure 2.8. Phase I defines the scope of the review study. For this, the authors introduce a taxonomy, focusing on the characteristics and categories of a SLR. For instance, a review study may have the *focus* (characteristic) on *research outcomes* (category) and select *general scholars* (category) as the *audience* (characteristic). Phase II elaborates on the conceptualization of the research topic, i.e. what is already known in the area and where is this knowledge useful. It is recommended to acquire such knowledge from the resources that are likely to provide an overview or summary of the related subject, such as seminal textbooks or encyclopaedias. Phase III concerns the literature search process, involving database, keyword, backward, and forward search. As the framework values circularity when performing an SLR, this phase includes also an ongoing evaluation of sources. There are three ways to perform phase III. The first option follows Kitchenham's procedure and identifies prominent journals and the databases that include them. Then, a keyword search is conducted, which is followed by an evaluation of the results. Second option opts applying the snowballing approach, i.e. based on backward and forward research, relevant articles are extracted. Third option is basically the combination of the first and second approaches. After collecting sufficient evidence, the results are analysed and synthesised in phase IV. The authors recommend applying the concept matrix of Webster and Watson [92]. Finally, in phase V, the researcher puts together a research agenda, which provides the basis for extending the review or its findings for further research.

Mapping reviews

A special form of an SLR is the *(systematic) mapping review*. Mapping studies are characterized by their wider scope of the study and the generalization of research questions in a broader field [86]. After getting an overview of the research area by for instance defining the research methods, research designs and research topics, detailed information can be extracted from a set of publications. This work applies unstructured literature reviews (cf. section 4.2, section 4.3.3), snowballing-based systematic literature reviews (cf. section 4.4) and mapping reviews as research methods to investigate the body of knowledge in the literature (cf. section 4.5.3).

2.3 (TECHNICAL) ACTION RESEARCH

AR is a research into a social setting, where the researcher intervenes to the situation in order to improve it collaboratively and learn from it [95]. Aim of the action research is the search for a change in the client-organisation, i.e. to ensure the applicability of results, the researcher looks for a solution that works in at least one organisation [96].

AR has its origins in social sciences and was initiated by Lewin [97] "as a method to apply the results of social research to practice and learn from it" [59, p. 292]. Application of AR strengthened qualitative research in IS as it is performed very close to the empirical field [96]. The researchers work together with practitioners to develop some operational practice. In line with the dual purpose of the AR, practitioners collaborate with the researchers in the process of practical problem solving [98]. In this respect, Goldkuhl addresses an important demand in AR which is "... the search for a workable change in the client-organisation. To have a solution that works in at least one organisation is a way to ensure some applicability of results" [96, p. 63]. This requires a close cooperation with practitioners on a long-term basis, which in this work is demonstrated via two enterprises, SIV and everis (cf. Chapter 3).

Role of AR in DSR

In the scientific community, there is a debate concerning the similarities between AR and DSR as both approaches are interventional, involve problem-solving and evaluation [56, 96, 98, 99, 100]. Comparing AR and DSR, Baskerville argues that AR is "focused on problem solving through social and organizational change" whereas the latter "is focused on problem solving by creating and positioning an artefact in a natural setting" [56, p. 442]. Furthermore, he points out that the **discover-through-action** is the core of the AR, which does not necessarily involve design activities as opposed to the DSR. In other words, DSR follows the **discover-through-design** approach. As such, the work concludes that AR "is a methodology" and DSR "... is a paradigm" [56, p. 442]. Iivari and Venable share this view by stating "AR is a research method while DSR is more a research orientation" [98, p. 5]. In the context of this DSR-oriented thesis, we opt this view and argue that AR helps the researcher to ensure the practical relevance and observe artefact characteristics in client organisations.

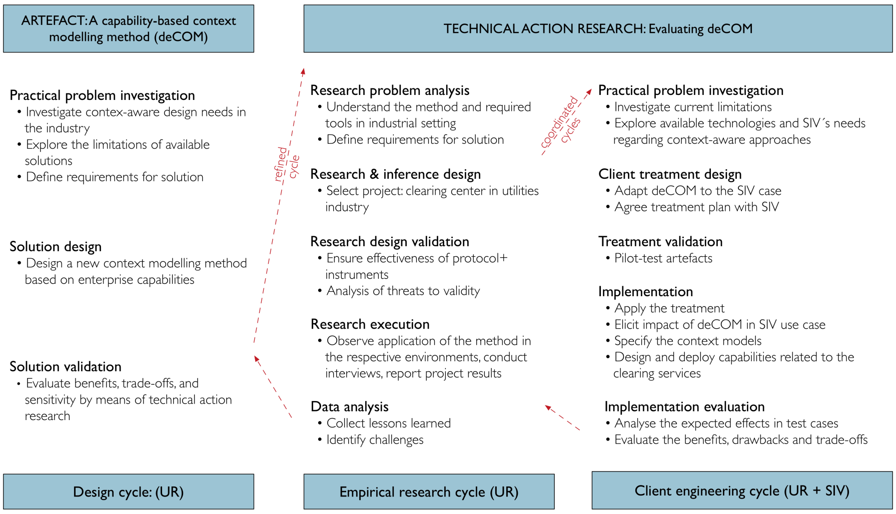

Figure 2.9.: The structure of the research method used in an evaluation cycle

TAR and Artefact Evaluation

AR studies are categorised in three classes. Technical Action Research (TAR) focuses on ”improving effectiveness and efficiency in a practice”. Practical action research aims ”to improve practitioners' understanding of themselves and their work”. Emancipatory action research concerns the questioning and improving of the goals that are related to the organizational and social context of practitioners [49, p. 50]. Supported by the above-documented view and as proposed in [98], we use in this thesis TAR as a method to evaluate the DSR outcome, i.e. deCOM, as detailed in section 6.2.5.1. The research in TAR is artefact-driven, i.e. the goal is the validation and improvement of an experimental artefact, whereby the validated artefact is still under development and yet not transferred to the original problem context [59]. In the following, we briefly show how TAR is used to structure and evaluate deCOM, an example of which is given in Figure 2.9.

In TAR, the researchers play three roles [59]:

- *Technical researcher*, who designs a treatment to solve a problem. The author of this thesis develops the purposeful artefact and as such plays the role of the technical researcher in the design cycle.
- *Empirical researcher*, who answers questions regarding the evaluation of the artefact, which are also termed as *knowledge questions*[8]. To empirically validate the artefact, the researcher himself acted in this cycle.
- *Helper*, who conducts a client-specific iteration to apply the treatment to help the client. Here, the selected client is SIV.

8 Knowledge questions ask for information about something that exists, such as ”is deCOM easy to use? Is the user interface of the required tools understandable?”.

The *design cycle* aims at the development, design, engineering of treatments for a problem. The activities performed in the design cycle are equivalent of the first three activities of the selected DSR procedure in this thesis. Therefore, they will not be mentioned here. Evaluation aspects concern both the *empirical research cycle* and *client engineering cycle*. The aim of these cycles is helping a client by applying the artefacts in the client's industrial setting and improving the experimental artefact based on the gained results. In TAR, the empirical research cycle and client engineering cycle interact with each other. Hence, in Figure 2.9, the arrow reads "coordinated cycle".

To evaluate deCOM by means of TAR, a collaborative working week in Zagreb including , SIV, UR and CROZ[9] was organised. The method have been applied in the respective tool environment in close collaboration with the client (SIV). To do this, we enacted a rational problem-solving cycle. The structuring of the evaluation in line with TAR and evaluation results are documented in section 6.2.5.1.

2.4 FEDS: FRAMEWORK FOR EVALUATING DSR

At its core, DSR concerns the iteration of two main activities, *build* and *evaluate*, latter of which is "development of criteria and the assessment of artifact performance against those criteria." [64, p. 258]. Noticeably, all procedures compared by [71] in Table 3 include evaluation step, emphasizing its importance in DSR. This is reflected in [101] as well, which assesses that evaluation is the biggest weakness in DSR and called for a "convincing form of evaluation." Concerning the methods as DSR artefacts, the possibilities of evaluating them are even more limited. This is explained with the fact that "there is typically no theory, no hypotheses, no experimental design and no data analysis to which traditional evaluation criteria can be applied to IS design methods" [102].

To assure a rigorous design and evaluation process, quality and benefits of the developed artefact has to be evaluated by appropriated research methods. For evaluating the method versions, we applied the FEDS[10] by [52], which is a strategy that considers *why, when, how, and what* to evaluate in a DSR project. In this respect, the design

9 CROZ is an industrial project partner in CaaS project, which is responsible for the development of the CDD environment.

10 By the time of writing, the FEDS approach was being extended to A Methodology for Evaluation in Design Science (MEDS). The author of this work attended to the MEDS workshop conducted during European Conference on Information Systems (ECIS) in Istanbul in 2016 to compare the substantial changes between FEDS and MEDS. Citing from the developers of both approaches, the main contribution of MEDS is *packaging FEDS in a method-wise aspect, rather than a framework*. As such, at its core, MEDS continues to use the evaluation strategies and steps, which are explicated in FEDS and applied in this work. Consequently, it is the author's belief that updating to MEDS from FEDS during the thesis should not bring any specific benefits. Moreover, unlike FEDS, since MEDS have not been published and evalu-

process of deCOM was iterative, i.e. in each cycle a version of the method was designed, which was then evaluated in a given setting. In line with the *build-evaluate* core of DSR, the evaluation results provided feedback for further development of the artefact, as such they were used as an input in the following cycle.

2.4.1 *Evaluation Dimensions in FEDS*

FEDS distinguishes between two types of dimensions to evaluate an artefact. *Functional purpose* of the evaluation concerns "why to evaluate" and explicates the goal of an evaluation process. Venable and colleges point out six different purposes that may emerge when evaluating an artefact:

- to investigate how well an artefact achieves its main purpose,
- to find out whether design theory leads to a developed artefact,
- to compare the new artefact with others,
- to measure the utility, where the utility is understood as a complex and composite concept and thus require rigorous demonstration of "functionality, completeness, consistency, accuracy, performance, reliability, usability, fit with the organization, and other relevant quality attributes" [21],
- to identify the undesirable impacts or side effects, and
- to elaborate the knowledge outcomes, i.e. why an artefact works or not [52, p. 3].

Functional dimension can be measured by performing *formative* and *summative* evaluations. The formative evaluations aim to improve the outcomes of the process under evaluation, e.g. develops characteristics of a design artefact. Summative evaluations are performed to measure whether the outcomes match expectations, e.g. if the design artefact works in its real environment [103]. Formative and summative evaluations are distinguished by their functional purpose rather than any difference in the nature of the content of their evaluations. The former aims at improving the characteristics or performance of the evaluand, whereas the latter provides a basis for creating shared meanings about the evaluand in the face of different contexts.

The other dimension studied in FEDS is the *paradigm of the evaluation*, i.e. "how to evaluate". In this respect, FEDS distinguishes between *artificial* and *naturalistic* evaluations. As the name may imply, artificial evaluations concern the non-real measurements of the

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ated, upgrading to the latter may even initiate problems in terms of a rigour artefact evaluation.

design artefact by adopting research methods such as laboratory experiments, field experiments or simulations. In contrast, naturalistic evaluations require measuring the artefact in its real environment (e.g. organizational setting), for which the artefact was designed to provide utility [104, p. 186]. Naturalistic evaluation adopt research methods, such as case studies, field studies, field experiments, surveys, and action research [66]. Compared to artificial evaluations, naturalistic evaluations are harder to perform as they are affected by confounding variables, which are hard to eliminate. Artificial evaluations are straightforward, less costly and its findings are easier to understand due to the reduced number of variables. However, the results of artificial evaluations involve a certain abstraction from the real context, i.e. the users, the systems and the problems are unreal and thus the results do not reflect the reality, or concern only a certain extent of it.

2.4.2 *Evaluation Strategies in FEDS*

FEDS proposes four different evaluation strategies, each of which aims to balance the disadvantages of the aforementioned dimensions and allow for the most appropriate evaluation path, considering the needs and resources available to the DSR project. The strategies are briefly introduced in the following and depicted in Figure 2.10[11].

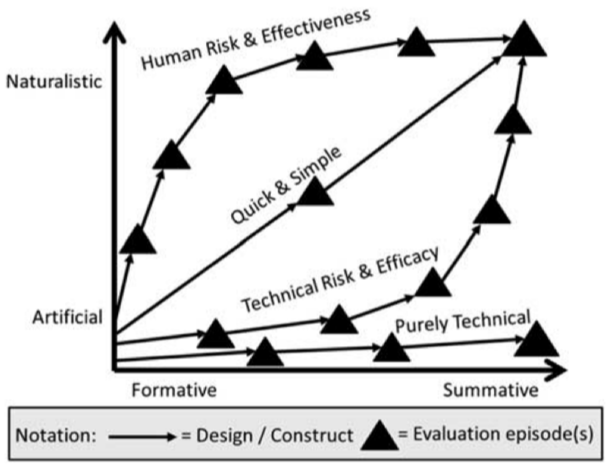

Figure 2.10.: Four strategies in FEDS [52, pp. 4]

Quick & Simple. Performs relatively little formative evaluation and progresses rather quickly to summative and more naturalistic evaluations. The quick and simple strategy is characterized by its inclusion of few evaluation episodes. Such a strategy is preferable

11 Venable and colleges note that any given strategy may be revised during the course of a particular project. Hence, the triangles representing the evaluation episodes in Figure 2.10 serve only illustration purposes.

when the researcher has a very limited budget or when project conclusions are expected rather soon [52, p. 5].

The Human Risk & Effectiveness. Focuses on the formative and artificial evaluations, which develop the artefact characteristics. Hence this strategy allows for false starts, for instance when little is known about the artefact or the domain under study. The strategy is characterized by its rather fast progression towards naturalistic formative evaluations. Naturalistic summative evaluations are performed towards the end to ensure that the artefact is ready to deliver its utilities, even when used in a real organisational situation. The researchers should opt for this strategy, if "the major design risk is social or user oriented and/or if it is relatively cheap to evaluate with real users in their real context". In addition to that, this path is recommended, if the researcher aims to demonstrate that the utility/benefit gained by the artefact use will continue in real situations and over the long run" [52, p. 6].

Technical Risk & Efficacy. Focuses on the artificial formative evaluations early in the process, but progressively moves towards summative artificial evaluations. In this strategy, more naturalistic evaluations are performed towards the end. As opposed to the Human Risk & Effectiveness strategy, the researcher should prefer this path when the risk is technically oriented and the costs are high to design an evaluation in a real environment with real users. The strategy is useful to establish the efficacy, i.e. the utility/benefit gained by using the artefact is due to the artefact, not something else [52, p. 6].

Purely Technical Artefact. Applies for evaluating the artefacts that are purely technical and do not involve human users. As for a technical artefact the naturalistic settings are not relevant, this strategy requires the design of artificial environments, in which the artefact should be evaluated. As such, the strategy should be chosen if artefact does not have any social aspects or will be used in future rather than today [52, p. 6].

2.4.3 *Evaluation Design Process*

FEDS proposes four steps, which should help to develop an appropriate evaluation strategy for the DSR artefact to be developed [52, pp. 6-8]. This section briefly mentions the steps, whereas Chapter 6 shows how they are used to evaluate the context modelling method.

Step 1: Explicate the goals. In this step, the objectives and constraints of the evaluation is defined. Roughly, the evaluands (artefacts to be evaluated) and their nature (socio-technical or purely technical) are determined, the uncertainties in the development are estimated, goals are explicated and prioritized. Authors identified four competing goals when evaluating a DSR artefact:

1. *Rigour*: Evaluating rigour is interpreted in two senses. First is that the outcome caused by the artefact is only due to artefact itself, and not any other confounding variable (efficacy). Second is that the instantiation of the artefact works in a real situation despite organizational complications (effectiveness). To reach the rigour in the first sense, artificial evaluation should be used. Rigorously evaluating effectiveness would require naturalistic evaluation.

2. *Uncertainty and risk reduction*: Instantiating an artefact may carry social (e.g. the artefact may not fit well into the social environment of the user) and technical risks, which the researcher should identify and hinder as early as possible.

3. *Ethics*: The evaluation of safety critical artefacts should not put animals, people, organisations, or the public at risk during or after evaluation.

4. *Efficiency*: Concerns balancing the above-mentioned goals against the available resources and ensures that the evaluation works within resource constraints. Formative evaluation is more beneficial to reduce costs by evaluating before incurring the costs of instantiation.

As detailed in section 2.1.2, various artefacts may be produced in a DSR project. In terms of evaluating the *methods* as a DSR artefact, different understandings of the term *effectiveness* and *efficacy* was identified in the literature. As a method does not describe any external reality, *truth value* of a method cannot be shown; it is only possible to demonstrate its pragmatic value or, in DSR terminology, its *utility*[12]. In this respect, Moody develops MEM, a framework for validating IS design methods [102]. The author states that ”the objective of validation should not be to demonstrate that the method is ’correct’ but that it is rational practice to adopt the method based on its pragmatic success”, where pragmatic success is defined as ”the efficiency and effectiveness with which a method achieves its objectives”. In that regard, the methods are instruments to either improve the efficiency (e.g. by reducing the time required to complete a task) or effectiveness (e.g. by improving the quality of the result), as depicted in Figure 2.11 [102].

Unlike Venable and colleges, Moody refers to *(actual) efficacy* in MEM as a phenomenon related to the pragmatic success, i.e. ”whether the method improves performance of the task”. As such,

12 On the other hand, Sonnenberger and vom Brocke opt the view that ”the prescriptive knowledge that emerges throughout a DSR process has a truth-like value”. The same work argues that statements of truth in DSR relate to the fact whether an artifact is actually useful for solving a given class of practical problems [105]. Hence, we conclude that the main aim is demonstrating the *utility* of the artefact. The discussion whether this has a truth-like value is beyond the limitations of this work.

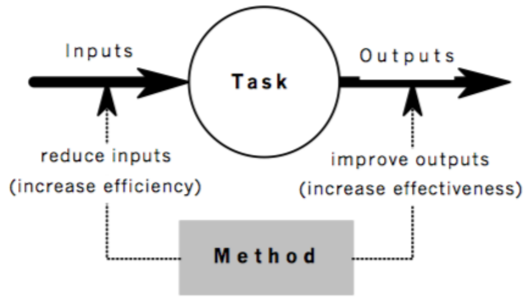

Figure 2.11.: Two ways of task improvement, taken from [102]

actual effectiveness and actual efficiency together determine in MEM the actual efficacy. On the other hand, the *effectiveness* in FEDS corresponds to the *adoption in practice* in MEM, which is derived from the Technology Acceptance Model (TAM) [106]. The primary contracts of TAM are *perceived ease of use*, i.e. "the degree to which a person believes that using a particular system would be free of effort", *perceived usefulness*, i.e. "the degree to which a person believes that using a particular system would enhance his or her job performance" and *intention to use*, i.e. "the extent to which a person intends to use a particular system" [106, p. 985][13]. Hence, effectiveness in terms of FEDS can be interpreted as *perceived efficacy* plus *intention to use* in MEM. Against this background, we propose a conceptual mapping between the two frameworks as shown with the red up-down arrows in Figure 2.12. The black arrows connecting the circles in the figure illustrate law of interaction in MEM (e.g. perceived ease of use is determined by actual efficiency).

Step 2: Choose a strategy or strategies for evaluation. Based on the identified goals, one or more strategies to evaluate the artefact should be selected. For instance, if the artefact is purely technical and the budget for its construction is limited, then the researcher should probably select the Quick & Simple strategy.

Step 3: Determine the properties to evaluate. Depending on the goals and expected outcomes, various artefact properties can be subject to evaluation[14]. Numerous works addressing the important properties[15] to evaluate an IS artefact have been performed in the IS and Software Engineering literature. However, the scholars do not seem

13 Note that [102] modified the definitions and used the term "method" instead "system" to reflect the change of domain. Also the definition of *perceived usefulness* is changed as "the degree to which a person believes that a particular method will be effective in achieving its intended objectives".

14 Please note that the work does not analyse the approaches that are applied to measure software quality, such as the ISO standard 9126 or SQUID approach [107].

15 Also other terms are used in the literature, such as "characteristic, criteria, subcriteria, attribute, utility property". This work adapts the term "evaluation property".

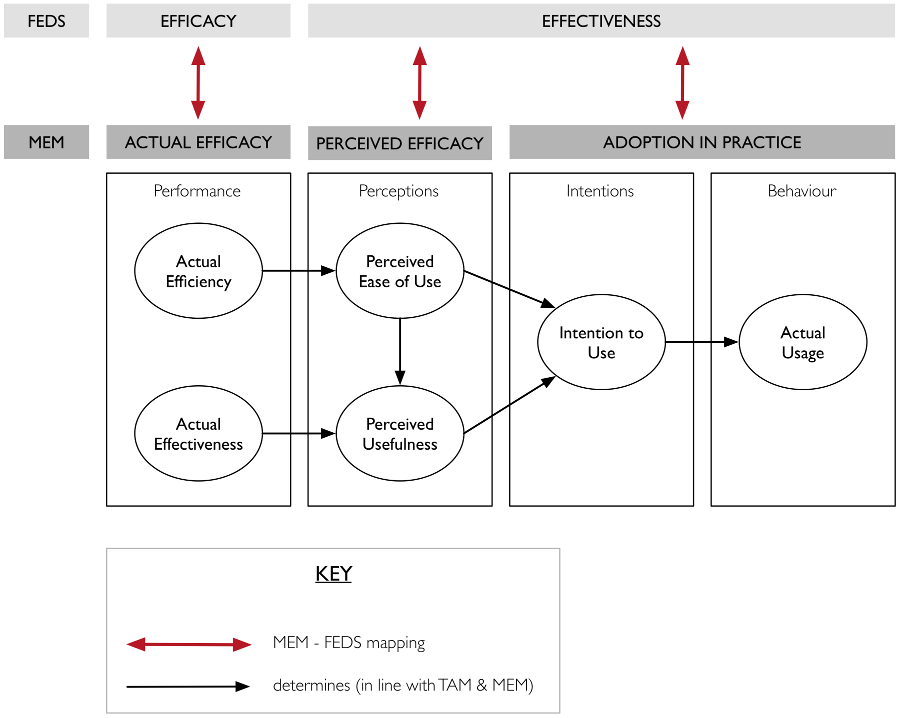

Figure 2.12.: Aligning MEM with FEDS, based on [102]

to have reached an agreement upon the taxonomy, structure or hierarchy of the evaluation criteria.

One of the earliest attempts to identify evaluation criteria can be found in [64]. The authors propose considering *ease of use*, *efficiency*, *generality* and *operationality* as relevant criteria to evaluate a method as a DSR artefact. The criteria are artefact type dependent, i.e. if the researcher aims to design a model, then completeness, fidelity, level of detail and robustness properties need to be evaluated.

Based on the assumption that artefacts in IS are systems [108], Prat and colleges define another hierarchy of evaluation criteria, each classified to the system dimensions *goal*, *environment*, *structure*, *activity* and *evolution* [109]. Goals are characterized by the evaluation criteria **efficacy** (as defined in FEDS, i.e. "the degree to which the artefact achieves its goals"), **validity** ("the degree to which an artefact works correctly") and **generality**. Environment dimension includes **consistency** as the main criteria, which is further divided into the sub-criteria **understandability, utility, ease of use, fit with the organisation** and **ethicality**. The structure of the artefacts are assessed by measuring a number of criteria, such as the **completeness, simplicity, level of detail** and **consistency**. Activity dimension is evaluated by the criteria **efficiency, completeness, consistency, accuracy and performance**. Here, the authors describe efficiency as "ratio between the outputs and inputs of the activity", which is in line with MEM. The final dimension concerns evaluating the evolution dimension, which includes the criteria **robustness** and **learning capability**.

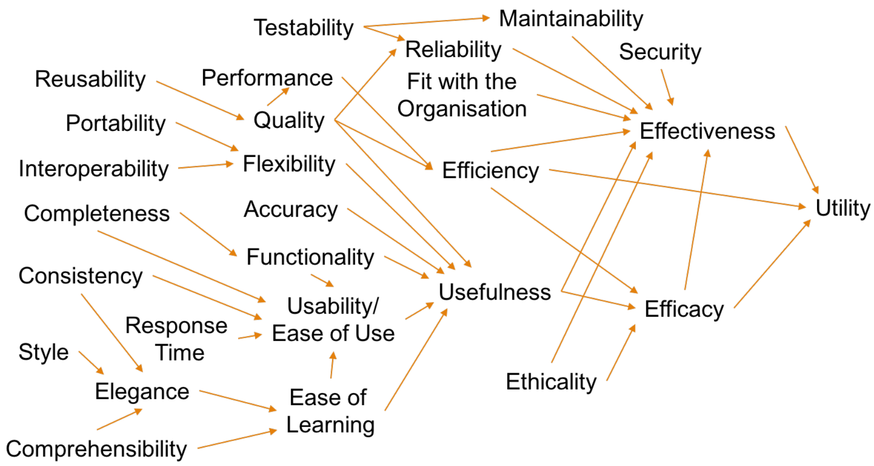

Figure 2.13.: The relationship between utility properties in FEDS

FEDS associates the property dependencies as depicted in Figure 2.13[16]. The relationships are conceptual ones and are based on the definitions of terms and conceptual understanding, yet it is possible to test them empirically. One of the changes in MEDS is that compared to the FEDS, it distinguishes between of *properties*, *constructs* and *measures*. Properties are conceptual-level concepts, such as efficacy and usefulness. Constructs are perceptual-level concepts representing properties, (e.g. training costs to measure usefulness). Measures are very specific and material-level concepts that reflect constructs (e.g. time in training).

Step 4: Design the individual evaluation episodes. This step specifies the episodes, which are represented as triangles on Figure 2.10. For each episode, the risks (social or technical) and property uncertainties (response time, usability etc.) should be listed. Then, depending on the resources, the researcher prioritizes the properties to evaluate and plans the individual evaluation episodes, i.e. when particular episodes will be conducted, in what way and by whom. It is possible and even recommended to evaluate many properties in any given episode.

Chapter 6 follows the above-mentioned four-step evaluation design process and uses this theoretical background for evaluating deCOM.

2.5 SUMMARY

Design science research

This chapter documented the selected research paradigm, applied research methods and frameworks in the thesis. The research paradigm

16 The illustration is taken from the slides of the workshop *FEDS2 DSR Evaluation Design Tutorial* by John Venable at CAiSE 2015, Stockholm Sweden and used with

adopted during the whole project is DSR. DSR is a problem-solving paradigm. It seeks to create *artefacts* through which the analysis, design, implementation, and use of IS can be effectively and efficiently accomplished [60, p. 118]. In DSR, produced artefact types can be constructs, models, methods, instantiations or better theories (cf. Table 1). A number of procedures have been proposed to perform DSR. In this thesis, the selected artefact type is a method and the applied procedure is the one from Peffers et al. [72]. An essential activity in any DSR project is the artefact evaluation (cf. Table 3. For this purposes, this thesis uses FEDS, an evaluation framework developed by Venable et al. [52].

`Systematic literature review`

Two important research methods applied extensively during this research is SLR and AR. SLR critically evaluates what has been published on a chosen research topic. Based on gained evidence, the literature reviews describe and analyse the knowledge that exists and the gaps occur in research related to the field of interest. As such, the literature reviews reveal similarities and differences, consistencies and inconsistencies and controversies in previous research. A special type of an SLR is a *(systematic) mapping review*. Different techniques to perform SLRs were mentioned in section 2.2. This work adopts unstructured SLR (cf. section 4.2, section 4.3.3), snowballing-based SLR (cf. section 4.4) and mapping reviews as research methods to investigate the body of knowledge in the literature (cf. section 4.5.3).

`Action research`

AR is a problem-driven approach. The researcher works in a close collaboration with the client to solve a certain problem or class of problems. It is distinguished from other research methods in a sense that the researcher intervenes to the situation in order to improve it collaboratively and learn from it [95]. Three types of AR have been identified, amongst which TAR seemed most appropriate for the aim of this thesis. TAR focuses on improving effectiveness and efficiency in a practice. TAR has been used in this thesis as a research method to evaluate the artefact, as detailed in section 6.2.5.1.

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3

PROBLEM RELEVANCE

In line with the DSR procedure explained in section 2.1.3, this chapter documents the findings from the *problem identification & motivation* step. The theoretical evidence collected from the knowledge base by unstructured literature analysis is reflected in section 3.1. To position the problem in the practice and to understand and define it more precisely, sections 3.2, 3.3 and 3.4 elaborate on the application cases from the digital enterprises offering services, which are referred to as "digital services". After performing a root cause analysis and explicating problems in section 3.5, initial solution with the derived requirements are outlined in section 3.6. Section 3.7 summarizes this chapter.

3.1 KNOWLEDGE BASE ANALYSIS

Organisations operate in ever-changing environments. There is an intrinsic relationship between an enterprise, its ecosystems, and its IT systems to the extent that changes in one affect the others [4]. Based on such rapid changes and uncertainties in the future that are not predictable, organisations need to be flexible, not only in terms of their organizational structures but also regarding the IT supporting their service/ product design and delivery. The change of the global business environment and digitalization imply unforeseen requirements that the enterprises did not take into account during system design.

The shift towards a digitalized and services-oriented economy makes it even more important for enterprises to adapt themselves to changes [110]. In this work, the focus is on organisations offering digital services. A distinctive feature of the services[1] is that they are customer centric, i.e. customers are co-producers of them [42]. Although digital services are developed for a specific customer group, they need to be configured before being delivered to the customer in line with the application context. In a market where the organizations are in a constant seek of balance facing up to more and more constraints of the competitive environment the flexibility of service provision gains importance. The need stems both from external constraints, such as changes in customer requirements, regulations or service deployment environment and from internal constraints, such

1 A detailed discussion about services is provided in section 4.2.

as priorities changes, delay constraints and staff schedule [45]. [11, p. 510] state that "the ability to be malleable or to be able to adapt to changing market needs or requirements" is the most important quality attribute of digital services. Hence, in the context of digital services, flexibility is described as means to cope with the uncertainties in dynamic business environments and the capability to seamlessly adapt to changes [48, pp. 414].

A commonly used approach for composing digital services into business applications is business process modelling [24, 15, 44] (see section 4.2.3 for a detailed discussion). The business processes constitue the "how" part of the service provision, as stated in [47], who also analyses the duality between the business processes and business services extensively. This is supported in [111] who also intreprets BPM as a *value-switch for digitalization*. [48] takes the role of business processes one step further and states that the overall flexibility of a digital service is determined by the flexibility of the underlying processes. As a result, enterprises need to offer flexible digital services to improve their chances of survival [17, 23, 48] and adapt their business processes to the changing context. The challange for flexible digital service provision stems from the need for support in less structured (or ill-defined, [112]) processes. As stated in [113] "Experiences with workflow technology show that it is relatively easy to support structured processes. However, processes involving people and organisations tend to be less structured. Often, the process is not stable and changes continuously or there are many cases that require people to deviate from the predefined process". Our observations from the following application cases also confirm this finding, since the analysed organizations deal with processes that require involvement of the knowledge workers and service consumers. In the services literature, the term Knowledge Based Services Organization (KBSO) is used for such cases. Flexibility, i.e. the ability to cope with changing needs and preferences of the clients, is coined as a fundamental dimension of the quality of service in a KBSO [114].

The following subsections support the theoretical relevance with the examples from the industry based on the application cases[2].

3.2 BACKGROUND FOR THE APPLICATION CASES

By tackling many challenges, such as changes in the economic climate, novel technologies and regulations, enterprises need to be flexible to improve their chances of survival. Operating in the modern digital business world increases the importance of business agility, for example, in terms of customisation, availability and scalability.

2 Please note that the cases are to a large extent taken from the industrial partners of CaaS Project, in particular from [73] [115], [116] and [38]. Additional citations are added to the text, when needed.

Consequently, organizations face the need to adapt their business services according to various situations in which their applications are used. In this regard the EU-FP7 research project CaaS aims to facilitate a shift from the prevailing service-oriented paradigm to a capability delivery paradigm[3]. To this end the CaaS project introduces CDD, an approach that includes a methodology, modelling languages and a number of tools for designing and delivering enterprise-grade capabilities. CDD enables organizations to design, execute and continuously improve their business capabilities and the way they are supported by information systems. In order to ascertain a general, cross-industry applicability of the new paradigm, the CaaS project follows a use case driven approach. The application cases analysed in the CaaS project are related to the digital enterprises offering digital services. In line with the DSR procedure, the following part briefly explains the characteristics of the selected digital enterprises to identify, position and justify the problem.

- **SIV group** is based in Rostock, Germany and serves the utility sector by developing and distributing the industry-specify Enterprise Resource Planning (ERP) system kVASy® as well as acting as a BSP (cf. Figure 3.2). The principal target group of SIV group (or simply, SIV) are medium-sized public utilities, predominantly in Germany, but also in several other European countries. As a BSP, SIV deals with inter-company business processes between partners in the utility market that requires exchange of bulky messages about energy consumption data. Currently, if an exception occurs in validating or processing the message, the BSP acts as a clearing center involving the manual interaction of a human agent, which causes extra costs on the side of the utility as well as operational efforts.

- **everis** is a multinational consulting firm providing business and strategy solutions, application development, maintenance, and outsourcing services. The everis application case is based on the public sector and the main emphasis is put on digital services provided to municipalities, which are then used by citizens and companies. The company provides in a SOA platform a service catalogue with up to 200 e-services in 250 municipalities (cf. Figure 3.9). Different factors and actors involved has to be taken into account when offering the services, such as Small and Medium Enterprise (SME)s, multinational corporations which provides services, diverse public administration's laws, regulations, administrative consortia and calendars, as well as various technological tools.

Cooperation of different roles

Service provision requires involvement and cooperation of differ-

3 http://caas-project.eu/

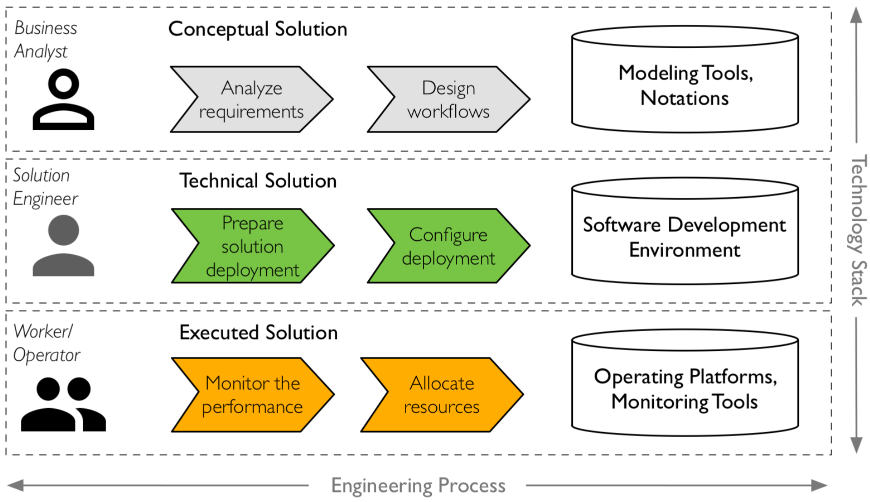


Figure 3.1.: Roles, processes and technology stack, adapted from [27]

ent experts to its design and implementation [24]. This can be observed in the established development and operating processes, technology stacks, and roles of the aforementioned enterprises, as shown in Figure 3.1. The horizontal line represents the **engineering process** encompassing the steps for designing, developing and operating digital services whereas the vertical line, **technology stack**, addresses all IT-tools, notations, languages, workflow engines, software development environments required in the engineering process. The engineering process consists of three steps [27]:

- In the *conceptual solution* phase digital services are developed to meet strategic objectives. Focus is here on the business logic and not on the technical implementation.
- *Technical solution* phase prepares the conceptual solution for execution, i.e. refines or enhances the conceptual solution when adapting it for a specific technical platform.
- *Executable solution* represents the deployment of the technical solution, i.e. a running system used by the service consumer.

Different stakeholder roles with varying backgrounds and perspectives participate to the engineering process. *Business analyst* is developing conceptual solutions by analysing business needs and processes, designing future workflows and expressing them in appropriate models. *Solution engineer* is developing executable solutions based on the conceptual solution delivered by the business analyst. This includes preparing the solution for deployment within the organization or other deployment contexts. *(Knowledge) Worker* uses the solution for activities and work tasks within the business processes of the organization and *operator* manages the deployed solution during runtime, which might include performance monitoring, resource allocation, incident management and other systems management tasks. Obviously, a shared understanding and alignment at the different levels is a prerequisite to enhance the flexibility of digital services, which can be realized by means of enterprise modelling.

3.3 APPLICATION CASES FROM UTILITY SECTOR

Need for flexibility in utility sector

Energy distribution companies are facing a continuously changing business environment. Raising complexity, new opportunities, altered regulations and a growing competition lead to a demand for flexible solutions that are delivering business value in ever changing context situations in energy sector [117]. The application cases introduced in this section are fundamentally linked to the digital service provision by SIV group in energy sector. The underlying business scenario is based on the exchange of Metered Service Consumption (MSCONS) messages[4] between two standardized market roles, the grid access provider and the balance supplier (see section 3.3.2 and Figure 3.3) in utility industry.

- **Application Case 1 - Dynamic BSP Support:** This case elaborates on the digital services related to clearing a failed message, which was exchanged during the market communication process between two market partners[5]. During the message processing, exceptions can occur due to various reasons. To remedy such failures, SIV Utility Services GmBH acts as a BSP and offers clearing services. The failed process instance is forwarded to the BSP and based on a rather fixed contractual agreement with the client, the message is subsequently analysed to define whether the handling of the current case is to be carried out by the BSP or the market partner itself. The contractual agreement as such cannot respond to dynamic customer demands, particularly when certain deadlines must apply to the message that are specified by the regulatory authority. The company aims to design a more flexible solution related to the routing of the exceptional cases, which allows for on-demand configuration of decisive parameters (in some cases by the client itself) and thus adaptation of the clearing services. This solution is termed as "Dynamic BSP Support" and detailed in section 3.3.3.
- **Application Case 2 - Enhanced Exception Handling:** As defined earlier, depending on the contractual agreement between

4 MSCONS is used industry wide for the exchange of energy consumption data and a member of the Electronic Data Interchange For Administration, Commerce and Transport (EDIFACT) specification family, which is mandated by regulatory authorities in Germany.

5 Market partners that use SIV's industry-specific ERP platform kVASy® are reffered to as *clients*.

SIV group and the client, the faulty message might be cleared by the BSP, i.e. the client *outsources* his business process which needs to be cleared. If the case requires a manual interaction from the BSP, SIV Utility Services GmbH incorporates highly-trained experts, so-called *knowledge workers*, that handle complex cases by following best-practices. Here it is possible to speak of the paradigm Adaptive Case Management (ACM), since the problems that might hinder the processing of the messages are of unpredictable nature. Nevertheless there are certain parts of the clearing processes that reoccur, i.e. there is a potential to support the knowledge worker during the provision of the service and reduce the operative costs on SIV's side. One possible approach to enhance the exception handling processes is creating of flexible mechanisms that supports the knowledge worker on decision making. Section 3.3.4 details the Enhanced Exception Handling application case.

3.3.1 *Description of the Organisation*

Roles of the SIV group

The SIV group is a vertically integrated digital enterprise from Rostock, Germany that specifically serves the utility industry and has over more than 300 employees. The group acts in the market mainly in two different roles, namely as an Independent Software Vendor (ISV) and as a BSP (see Figure 3.2). As an ISV, the group has a long-standing market presence in developing and selling the industry-specific ERP platform kVASy®, a software product that provides support functions specifically for the utility services industry, for example, assets management, processing and examination of invoices, automatic billing initiated by meter readings, meter data evaluation, maintenance management, order management etc. [118]. The platform is widely used by public utilities in Germany, especially for the commodities electricity, natural gas, district heating and water.

Within the European Union the commodity markets are strictly regulated, which in turn leads to complex business relationships and rules between the players of the utility sector. Given the strict regulation and growing complexity, public utilities increasingly consider outsourcing of their business processes to external service providers. This is where the SIV group acts as a BSP. The subsidiary of the SIV group, *SIV Utility Services GmbH*, offers digital services to a variety of medium-sized utility providers and other market players of the energy sector running kVASy®. The SIV group has a vital interest in further developing kVASy® as well as offering flexible digital services adaptable to changing situations. The work and the application cases at hand focus on the BPO services, i.e. the resolution and clearing of conflicts in the exchanged data between two different market partners (market communication) [115].

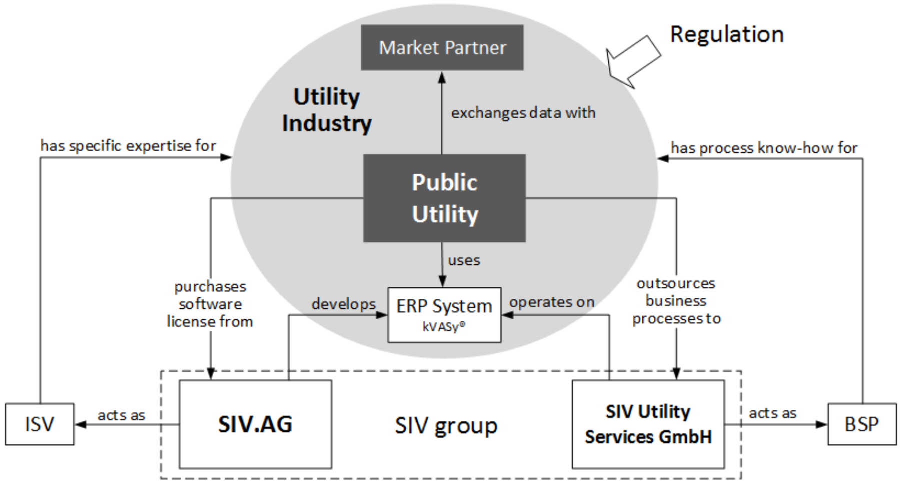


Figure 3.2.: Cross-enterprise relationships of the utility sector, taken from [115]

3.3.2 *Background and Motivation for the Application Cases*

Liberalization in the utility industry

In order to liberalize the utility industry within the single European market, the European Commission has enacted a number of directives. To assure a fair competition in the market, non-discriminatory access to the grid must be granted to any interested party. In German energy market, the Bundesnetzagentur (BNetzA)[6] is responsible to ensure that the practices directed by European Commission is implemented for the commodities *electricity* and *natural gas*. In order to efficiently regulate the utilities sector, the BNetzA has established a market role model, which is illustrated in Figure 3.3. Such regulation of the energy distribution market makes the separation of market roles mandatory, where each of them perform distinct business functions. The *balance supplier* is in charge of supplying the customer[7] with electricity (step 1) and *grid access provider* has interest in the meter readings of the customer, i.e. the amount of energy that has been consumed by the end user (step 2). The meter readings are forwarded to the balance supplier (step 3) that invoices the customer on the basis of the transmitted consumption data.

Common basis for the application cases

BPO has been proven to be an economically interesting way for companies to control their whole value chain by concentrating on their key business and leaving ancillary processes to highly-specialized service providers, thereby also securing a high level of overall quality [118]. [34] identifies two main outsourcing risks for a client's organisation; i) inflexible contracts and ii) poor supplier capability & service. Similarly, [119] states that ensuring sufficient contract knowledge, too inflexible outsourcing contracts and difficulties with

6 www.bundesnetzagentur.de
7 Please note that although the customer is not part of the market role model, it is included to enhance understanding of the relations between market players.

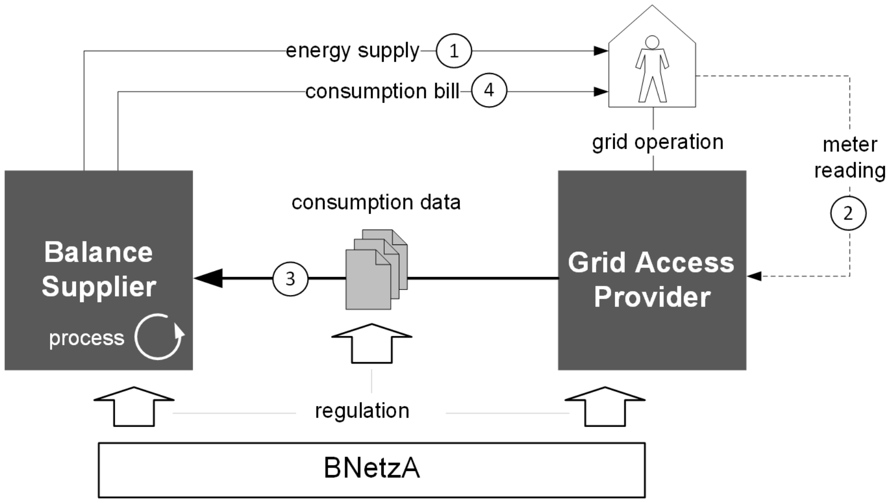


Figure 3.3.: Separation of market roles, taken from [115]

performance measurement are three most important challenges in an outsourcing firm. In the cases of the SIV group, the thesis will focus on the *SIV Utility Services GmbH*, which is a 100% subsidiary of SIV performing the role of BSP and offering digital services in market communication. More particular, we will focus on the clearing process of MSCONS messages that are carried out by the BSP, which is termed as **clearing services** in SIV's terminology. Another common denominator among the application cases is that they focus on the electronic transmission of meter readings from a grid access provider to a balance supplier. The interactions between both market roles are regulated strictly by BNetzA, which are subject to constant change. In Germany EDIFACT standard, a widely used cross-industry specification, is applied for exchanging the data. For the exchange of energy consumption data, the BNetzA has mandated the use of the MSCONS format, which is a member of the EDIFACT specification family [115]. The application cases introduced in the next subsections are based on the exchange of energy consumption data or shortly *MSCONS* between grid access provider and supplier. The shared basis for the cases are simply illustrated in Figure 3.4. In general, the activities performed by different roles when offering clearing services can be classified to four phases, namely *negotiation*, *preparation*, *operation* and *maintenance*, which are explained in Table 4 [120].

3.3.3 *Application Case 1: Dynamic BSP Support*

The Dynamic BSP Support will elaborate on *clearing services* of the BSP in market communication, which are provided IT-based. Therefore these are classified as digital services in line with the definition

Table 4.: Phases and involved activities for offering clearing services

Phase	Input	Activity	Output
Negotiation	Client contact or request	Initiation: Acquisition of potential clients by sales representative or client-initiated request for BSP support. Negotiation on BPO services, time frame, volume of transactions, pricing models, etc.	Quotation for selected BPO service[s] accepted by the client
	Accepted quotation; Sample handling instruction taken from similar clients	Creation of client-specific handling instruction[s] for the selected BPO service[s]. These specify the sequence of steps that are to be taken for any anticipated clearing scenario. The handling instructions also include, e.g., the utility's market role and the requested commodities (e.g. electricity, natural gas). The instructions may also include client-dependent process parameters that impact the control flow's execution path of individual clearing instances.	Handling instruction
	Selected BPO service; Client-specific handling instruction[s]	Send handling instruction[s] to client for approval	Approved handling instruction[s]
Preparation	Handling instruction	Obtain from client a formal permission that authorizes SIV.US to operate on client's ERP system. Configuration of the technical environment that enables SIV.US staff to securely access client's ERP system. Configuration also includes appropriate privileges on the ERP system to perform the required clearing steps.	Knowledge worker able to remotely access the client's ERP system and to perform the required clearing steps.
	Approved handling instruction	Study process description: go through the process description and required forms on client system	Study process description: go through the process description and required forms on client system
	Approved handling instruction	Study process description: go through the process description and required forms on client system	Knowledge worker permanently assigned to client
Operation	Instances of MSCONS market communication processes with non-processable EDIFACT messages	Decide on clearing: Go manually through the messages and decide whether they are covered by the agreement between client and SIV.US	EDIFACT messages for clearing by BPO service provider
	Messages to be cleared	For each non-processable message of any failed MSCONS process: Manually collect the required information from different forms of the client's ERP system and take appropriate corrective actions.	Cleared MSCONS business process
Maintenance	Change of regulation	Depending on the impact of the change: Adjustments of clearing procedures may be required, including control flow and process parameters.	For each client: Adapted clearing procedures. If appropriate also revised handling instruction.
	Client-requested change	Depending on the impact of the change request, adjustments of the handling instruction may be required, including the clearing procedure's control flow and process parameters.	Adapted treatment of clearing cases. If appropriate also revised handling instruction.

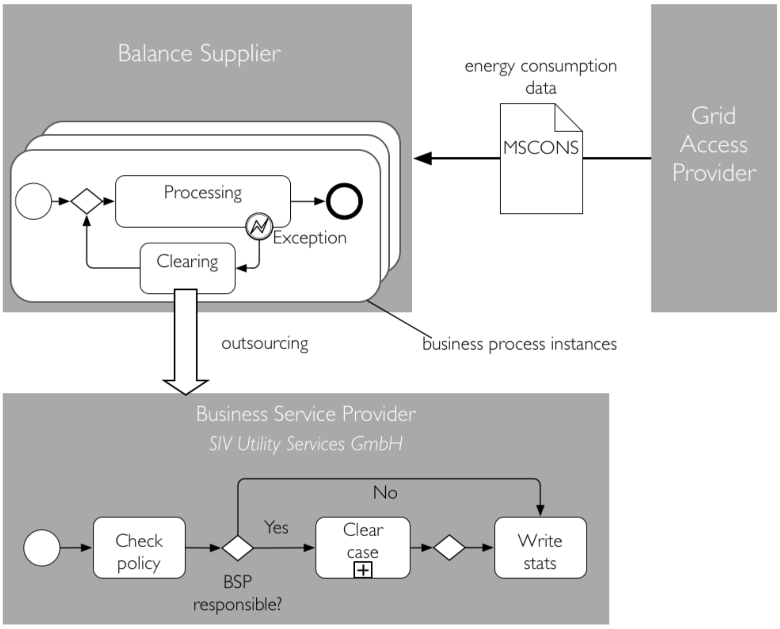


Figure 3.4.: Outsourcing of a business process from a market role to BSP, taken from [115]

given on page 26 and section 4.2[8]. SIV group faces the challenge of continuously changing business contexts affected by new regulations, bylaws and other circumstances. Change requirements may not only be driven by external regulations but also by business opportunities that may be related to technological advances (such as cloud computing) and changing customer preferences. This leads to a need for the context-aware solutions that deliver business value to an ever changing market in the provision of clearing services.

The purpose of this application case is the transmission of energy consumption data from one market role to another role. Messages received by the balance supplier are checked for correct syntax and then validated against an underlying informal data model. Upon reception of an MSCONS file from a market partner, the balance supplier imports the transmitted values into kVASy®. This is illustrated in Figure 3.5. This process includes a file-level check, a validation step and the processing of the individual meter readings. The exceptions in the former two steps can be remedied automatically by the ERP system.

However, the problems in the processing of the meter readings cannot be resolved without a manual intervention of the BSP or the client, as the conflicts are caused by the complex and dynamic nature of the market rules. For any occurring exception the BSP acts as a clearing

8 Ølnes and Jansen also state that a digital service can include a set of separate interactions including case handling [44, p. 198].

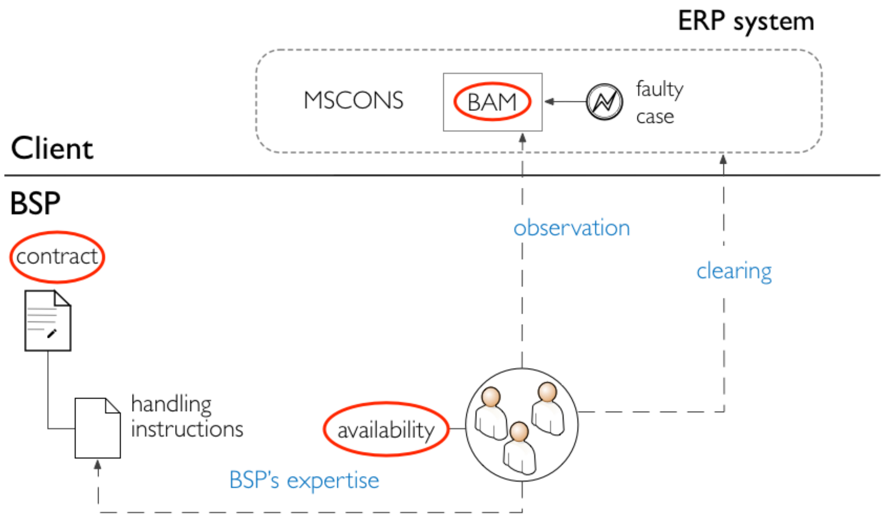


Figure 3.5.: The as is situation in BSP, adapted from [121, p. 13]

center with costly manual interaction, i.e. having a direct access to the client's environment, a knowledge worker regularly checks the client's Business Activity Monitor (BAM) for failed MSCONS import processes. This causes organizational efforts, such as the arrangement of BSP's human resources schedule. Then, based on the contractual agreement between the BSP and the client, the responsible party for the clearing of the message is defined. This decision depends on various factors such as the backlog size of the customer, message type that has thrown an exception or the type of the commodity, which are all necessarily captured in the contractual agreement. These are the major contextual factors and illustrated with a red oval in Figure 3.5 and detailed in Figure 3.6.

The contractual agreement as such cannot respond to customer demands, particularly when certain deadlines must apply to the message that are specified by the regulatory authority. The company aims to design a more flexible solution related to the routing of the exceptional cases, which is termed as "Dynamic BSP Support". The envisioned solution has to support a dynamic behaviour in order to decide whether or not an individual case has to be cleared by the client or by the BSP. The value proposition is an important component in digital services, where users pay for the perceived value [p.515][11]. We argue that SIV's clients tend to perceive higher value, when they are aware of this flexibility and when the clearing service provides them with the related statistics, e.g. the number of cases cleared for them.

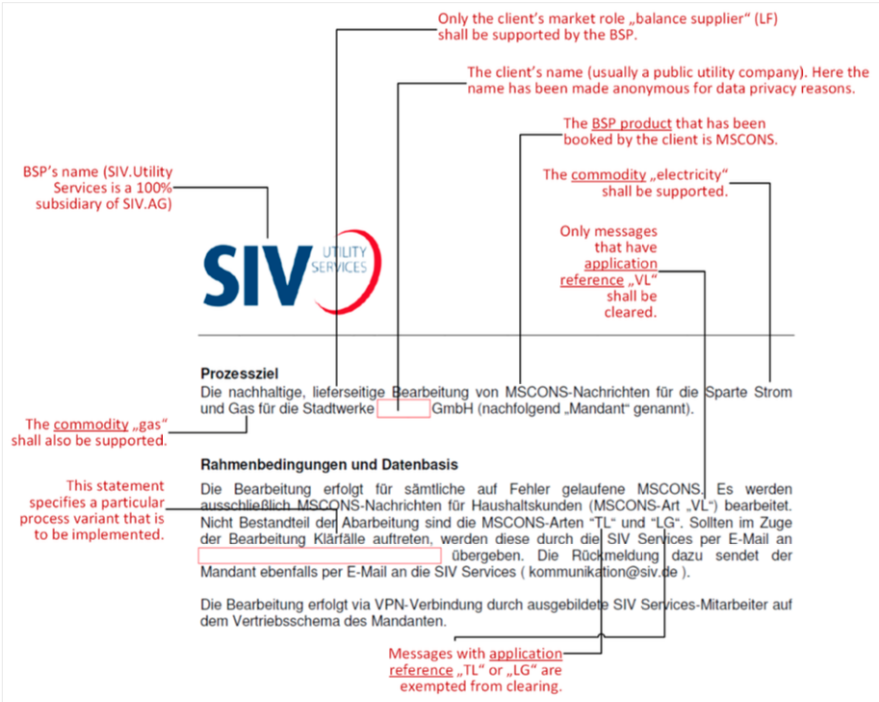


Figure 3.6.: An exemplary contract between the BSP and a client

3.3.4 *Application Case 2: Enhanced Exception Handling*

As described in the prior section, an invalid message causes an exception to be thrown, which might be cleared by the BSP. The routing decision is context dependent in the sense that the conditions, whether the BSP or the client itself clears the message may dynamically change.

The 2nd application case builds upon the 1st case and focuses on the scenarios, where the message is to be cleared by the BSP. The contractual agreements define the precise conditions upon which the BSP shall take care of the cases. In addition to that, for each exception type the exact sequence of procedural steps is specified. These sequences are to be followed whenever clearing a case whose failure has been caused by the exception type in question. The specification of the clearing procedure for a given exception type is illustrated in Figure 3.7.

The main idea behind this application case is simulating the steps that a domain expert would follow whenever such exceptions occur. The knowledge of the domain experts is implicit and it might not be possible to automatize the whole solution process simply by performing a series of machine-executable tasks due to fact that the parameters cannot be always predicted. Still the domain expert's implicit case handling knowledge can be formalized as an executable business process to some extent, i.e. clearing is nevertheless basically procedu-

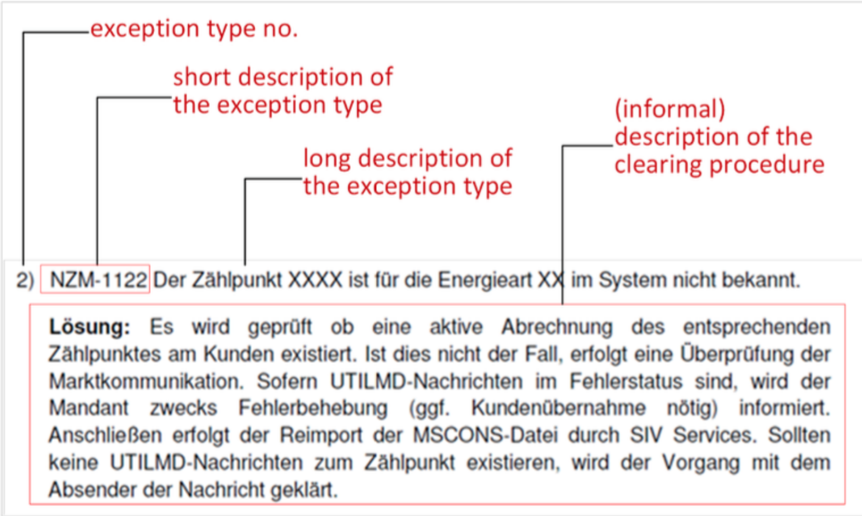


Figure 3.7.: The specification of the clearing procedure is part of the contractual agreement between SIV and the client

ral, calling for a process-centric solution that offers strong support for human interactions. As a result it is only possible to implement the enhanced exception handling capability for some exception classes.

There is an important difference between the first application case (Dynamic BSP Support) and Enhanced Exception Handling case. In the Enhanced Exception Handling scenario, faulty cases are not directly passed on to a human agent for clearing but rather checked if a predefined process variant exists that automatically remedies the case. Only if no such procedure can be found the case is subjected to manual treatment. Nevertheless, one can see automatic exception handling case as an extension of the dynamic BSP support case which provide the utmost business value to the customer when combined. Figure 3.8 illustrates the relationship between first (gateway A) and second application cases (gateways B, C).

In the course of a student project spanning over 3 months, an in-depth analysis of failure situations and exception types had been carried out. From this analysis it became clear that any given sequence of clearing steps are recurring patterns. However, we also observed that the handling instructions have previously been captured textually, i.e. no formal and executable specifications in terms of BPMN process models existed to date for the clearing activities.

3.4 APPLICATION CASES FROM E-GOVERNMENT SECTOR

e-Government is defined as "the relationships between governments, their customers (businesses, other governments, and citizens), and their suppliers by the use of electronic means" [122]. Due to the role of electronic means and the focus on interrelationship, e-Government

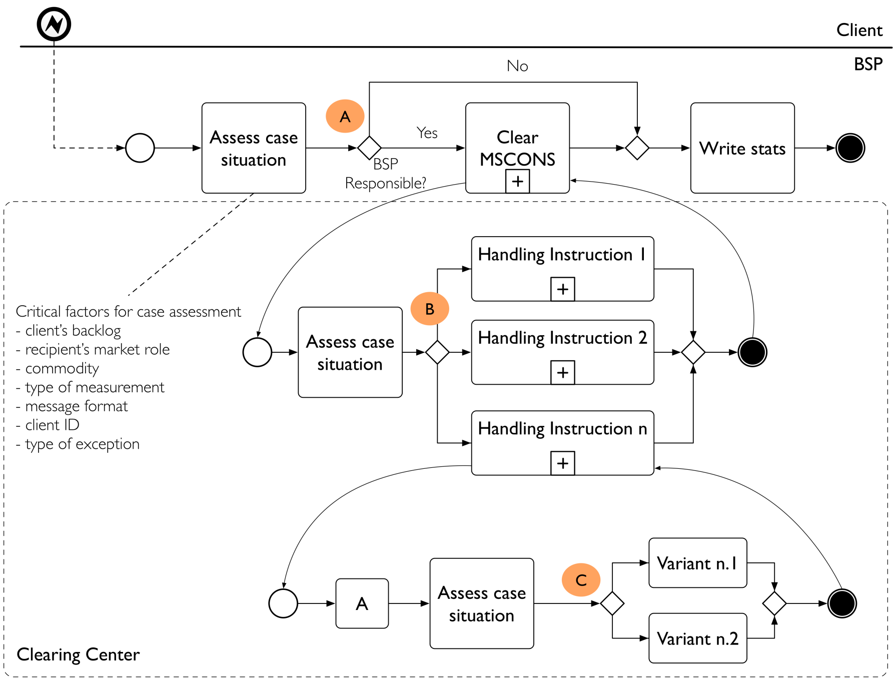


Figure 3.8.: Three levels of clearing. The application case two pertains to levels B and C

activities are interpreted as government-to-citizen (G2C) services in digital form [15].

Digital service is a key concept in today's e-Government development. The availability, flexibility and quality of such services are important indicators showing the maturity of an e-Government [44]. The main benefits of using the digital services are denoted as cost-efficiency, improvement of the citizen/business interaction with the government, reduction in the time (travelling to a government office, waiting in line) and paperwork spent, as well as 7/24 availability [123, 124]. Consequently, the pressure of reducing high costs makes designing successful e-Government services a priority for governors' major administrative plans [125].

Studies of Cardoso and Fromm show that there is a room for improvement regarding the adoption of digital services in e-Government field in Europe, since "…it is not yet at the levels of e-banking and e-commerce" [15, p. 47]. This is also reflected in the European Commission's "The Digital by Default or by Detour" report, which states "satisfaction with e-Government services is significantly lower than the satisfaction with eBanking services" [126, p. 16]. Results of the same report show that the shift towards a service-oriented thinking is not yet fully embraced in Europe. One way to reach higher levels of maturity would be increasing the number of automatically delivered services. [125] indicates the importance of understanding the user needs as they are the co-producers of the services. According to the

European Commission report, the ”time and flexibility gains are most important to users, followed by saving money and simplification of a delivery process”.

In this section, two application cases are introduced to show the problem relevance in practice. The application cases are taken from *everis*, a CaaS industrial project partner in e-Government domain.

- **Application Case 1 - Service Promotion:** This application case elaborates on the promotion of digital services in a municipality web page, which can be used by the citizen. Based on the municipality, the parameters for promoting a service may change, all of which are managed currently manually. To facilitate the access of the most important or used digital services to the citizens, everis envisions a flexible and automated solution that is applicable to all municipalities. Section 3.4.3 details the first application case in e-Government domain.

- **Application Case 2 - Registration Case:** *everis* provides a SOA platform including a service catalogue with up to 100 services, which are actively in use in 250 municipalities. These services may be fully, partly or non-automated. One frequently operated service in this context is the *registration service*. Registration services provide an electronic way for citizens to enrol and apply for different activities or procedures. Due to its complexity and the high number of process variants, the registration services are partly automated. By developing appropriate solutions, it is though possible to increase the extent, to which this digital service can be automated. Section 3.4.4 details the second case in e-Government domain.

3.4.1 *Description of the Organisation*

everis is a multinational operating consulting company that offers its clients comprehensive business solutions covering all aspects of the value chain from business strategy to systems implementation. It was founded in Spain in 1996 as DMR Consulting and became part of the NTT Data Group in January of 2014. The company is active in the sectors of banking, healthcare, insurance and the public sector.

Public sector is one of the most prominent fields, where adaptability and flexibility has an influence on the project success. Collaboration between different companies is common practice in such projects, where the aim is to provide better solutions to the citizens and internal management of the public administration itself. At the same time, the public administration is led by a strong policy and legislative aspects, in turn changing, and it is influenced by the context, such as: calendar, deadlines, guidelines from the government at various levels, procurement, accounting, etc. [116, pp. 15-16].

3.4.2 *Background and Motivation for the Application Cases*

everis has to comply with the bylaws and regulations. In this context, the Law 11/2007, of 22 June[9] ensures the right of citizens to communicate with all the administrations electronically to allow for a more efficient, effective and closer administration. The Law enforces the access of citizens to all public services electronically, anywhere and any time. For this purpose, the SOA platform was created in everis to comply with this law, which offers a common infrastructure for the whole network of councils to share common services to offer to the citizens. Benefits of such solution is shown in Table 5 [116, p. 21].

Table 5.: Benefits for the administrations and citizens

Benefits for the administrations	**Benefits for the citizens**
Improved service and therefore the image of the administration	Services availability 24x7
Improved internal process efficiency	Simplicity in the procedures involved with the Administration
Reducing the use of paper and the related costs of transportation and storage	Speed and agility in obtaining the required service.
Promoting widespread use of new technologies	Elimination of the need to physically move to the administration
Deep boost in the e-Government transformation (cf. [126])	Application of basic social principles such as inclusiveness or facilitate access to new technologies

The two application cases illustrated in this section are based on the public sector and the main emphasis is put on electronic services provided to municipalities, which are then used by citizens and companies. This above-mentioned SOA platform provides a service catalogue with up to 100 services, which are actively in use in 250 municipalities. These services can be of threefold nature; automated, semi-automated or non-automated services. Automated services can be consumed completely online, semi-automated services provide only partial functionality through the SOA platform, while non-automated services require complete face-to-face actions in the municipality's offices. The application case demonstrates the potential of the digital service flexibility within the SOA platform in a scenario with various factors and actors involved: multinational corporations, small and medium-sized enterprises, diverse public regulations and laws.

Each municipality is responsible for deciding which services are offered through their web pages by configuring the SOA platform. This is termed as *service promotion*. Companies can access their *electronic municipality headquarter* and citizens their *virtual office*, from where

9 http://boe.es/buscar/act.php?id=BOE-A-2007-12352 Last retrieved 09.08.2016

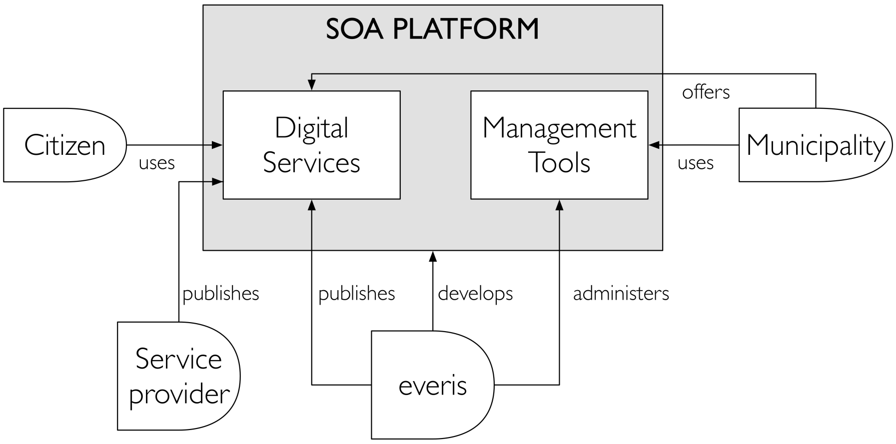


Figure 3.9.: The roles and relationships in everis case, simplified view

they engage in or see the offered services. Service provider companies directly expose them in the integration bus. Thus these services are shared and accessible through the SOA platform. Public servants of the municipalities access directly to the back office applications to manage and customize all the services. The roles and their relationships are illustrated in Figure 3.9.

The current limitations of the SOA digital service delivery is summarized as follows [116]:

- Each time the municipality wants to promote a service, it has to be done manually by a technician from the municipality. Due to this manual action, the costs for selecting and exposing the right service is usually high and the current solution is not agile enough to cope with the environmental factors.
- The registration services provide an electronic way for citizens to enrol and apply for different activities or procedures. Currently, due to missing mechanisms to manage contextual information, not all of the registration services are offered automatically. In this work, the focus will be on swimming pool registration process, which basically allows the citizen to book a swimming pool 24 hours a day, 7 days per week online.
- As in the SIV case, the e-services in everis case also need adaptation every time the platform is deployed in a new municipality and whenever the context changes. For the time being, service customisation is done at code level, which causes additional costs on the service provision and delivery. The aforementioned limitations are detailed and discussed in section 3.4.3 and section 3.4.4.

3.4.3 *Application Case 1: Service Promotion*

The Service Promotion scenario focuses on the ability to automatically promote the most interesting and used services of a municipality's service catalogue in its home page. Currently, each time the municipality wants to promote a service, it has to be done manually by a public servant from the municipality. Due to this manual action, under-exploitation of services can occur. By automating the process, which necessarily requires to assess and calculate the runtime context information, *everis* aims to reduce the time that is used by the public servants to highlight a service as well as to allow the citizens to access relevant services more easily (see Figure 3.10).

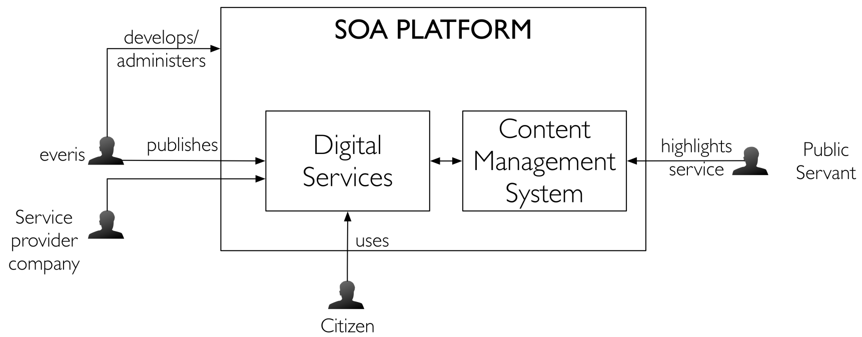


Figure 3.10.: Participating roles in service promotion case

The business process of the service promotion case is illustrated in Figure 3.11. As a first step, the public servant of the municipality identifies the service to promote. This decision is closely related with the current events in the municipality and time of the year. Then, the public servant needs to decide whether to highlight the service immediately or schedule it for a further date. In each case, a suitability check is performed, i.e. whether there is enough room for an additional service in the municipality page. If the web page is not full, then the service is promoted (either instantly or at the scheduled time). The public servant has to reassess the situation, if the web content does not allow adding another service. In such cases, she can either drop an older service and substitute it with the new service that needs a promotion or withdraw her promotion decision.

Once the service is highlighted at municipality's home page, the public servants will decide if they want to inform other similar municipalities or not. There are two ways of informing other municipalities; by sending an email to other municipalities with a similar profile or contact the Project Management Office (PMO) who will inform them. If the public servant decides that there is no need to inform other municipalities, the process is terminated.

The above-mentioned service promotion case is performed manually. The procedures how to highlight a service depends on the

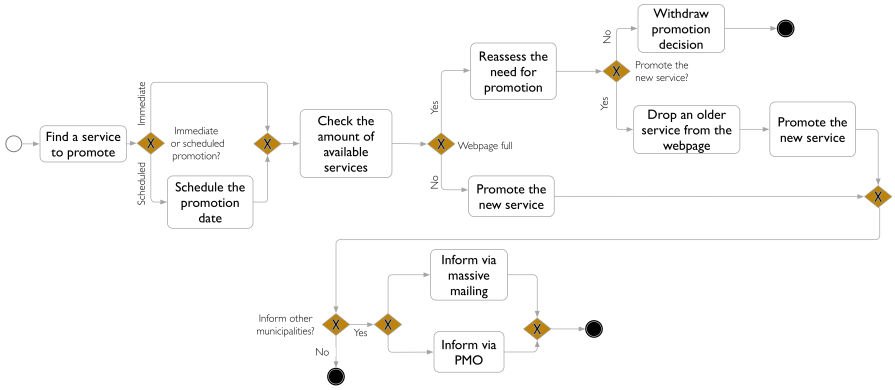


Figure 3.11.: Service promotion manual process model, adapted from [116]

decision of the public servant and as such they most likely differ for each municipality and for each public servant. Similar to SIV's 2nd application case *automated exception handling*, the main idea behind this scenario is simulating the steps that a domain expert would follow whenever a service needs to be promoted. The knowledge of the public servants is implicit and it might not be possible to automatize the whole highlighting process simply by performing a series of machine-executable tasks due to fact that the parameters cannot be always predicted. Still this implicit knowledge can be formalized as an executable business process to some extent, i.e. promotion is performed basically procedural. Once this is done, the parameters that affect the decision of a public servant can be understood and captured systematically. To fulfil this goal across all municipalities, everis envisions implementing a context-aware solution that provides ways to document and configure the factors that may influence the public servants' decision whether to promote a service or not. As such, the service promotion should allow the municipalities to reach an enhanced flexibility, where flexibility means taking the *current situation* of the respective municipality into account (e.g. current weather, service highlighting ability) during service promotion and adapting it faster to a changing environment. everis can also exploit this *automatic service promotion capability* to assure the promotion of the most important or used services., i.e. in every specified period of time, services can be automatically highlighted on the cover of the clients' (in this case, municipalities) page without the direct involvement of the public servants.

3.4.4 *Application Case 2: Registration Case*

The registration case focuses on the registration module of the e-Government SOA platform. This module offers citizens of a municipality to enrol online for public activities (e.g. cooking or language courses) and to register for other public services (e.g. marriage registration or swimming pool reservation). Generally, there is a defined procedure on how to design a registration process, though depending on the context, the business process that describes the registration service can change its behaviour. For instance, the marriage registration service might require the execution of additional activities, such as checking the staff availability and number of applications, which depend on the calendar of events and type of the day. Likewise, in order to execute the swimming pool registration service, various factors have to be taken into account such as the location of the user, temperature, precipitation, municipality size and registration capacity. If the number of the applications is higher than the capacity of the municipality, the services cannot be provided. In contrast, if the service is not yet fully booked, it can be promoted in the municipality service catalogue. These are the typical parameters that need to be configured each time the platform is deployed in a new municipality or the regulations change.

A registration case is triggered by the citizen which selects a service that requires registration, e.g. marriage or swimming pool registration. Once the relevant service is selected, the citizen is asked whether to continue with an online registration or they wish to register face-to-face in the town hall, latter of which redirects the client to a new page to print out a template. In case of an online registration, the citizen needs to introduce himself to the system. This is done in two ways. First is via a certificate, which is electronically assigned to the citizen by the municipality. Second way requires the citizen to enter her personal data, such as the date of birth and national ID number. Following this, the citizen will have to fill in the forms and supply the municipality with additional data, which will be different for each service. Then, the citizen may or may not upload the documents, which is determined after a system check. If the service includes payment of a certain fee, the citizen will be asked whether to pay online or via an invoice to pay later in the bank. In the last step, the platform checks whether the request should be approved by a public servant. Depending on the result of this step, the citizen will receive a registration proof or a registration and acceptance proof. The process is illustrated in Figure 3.12.

Depending on the selected service, a suitable sub process should be executed in the generic process. For instance, when the client chooses marriage registration service, the registration form is filled with data about the couple and other relevant information. Then, after the confirmation of the citizen, data is exchanged with the civil registry in order to check if all data is correct and if the couple is allowed to continue with the procedure. If this is not the case, they are suggested to continue with it in person.

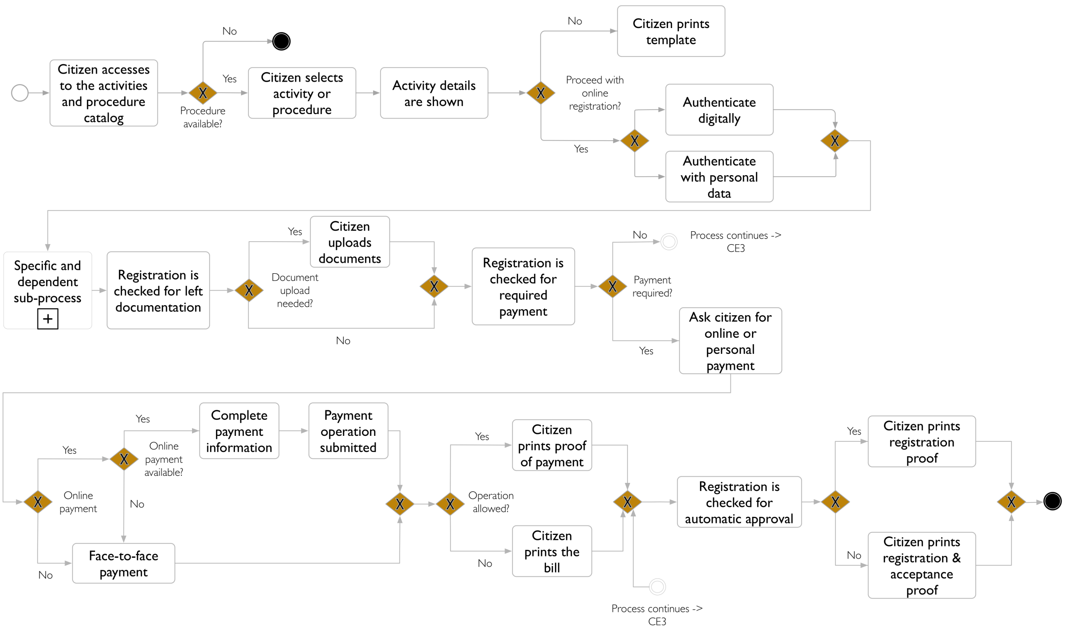


Figure 3.12.: Registration service business process, adapted from [116]

Next, the citizen is requested to choose from the available dates. The process continues with the general registration process once the citizen confirms the date. This sub process is depicted in Figure 3.13.

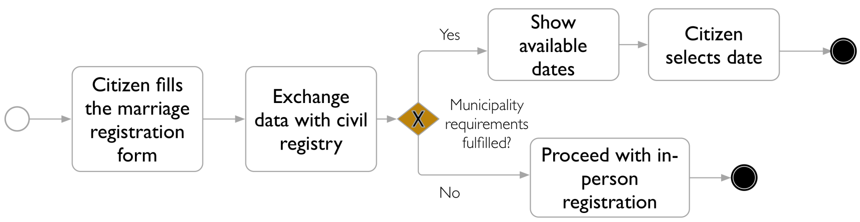


Figure 3.13.: Marriage registration sub process, adapted from [116]

Currently, it is not possible to offer the registration services 100% digitally due to following reasons:

- The business processes are separately modelled and stored in the SOA platform. Each change in one model can affect one or more related processes and it is not possible to identify such interrelations in everis' current state.
- There are many drivers that cause a derivation from a central process and result in so called *process variants*. Current state fails to analyse, extract and identify these drivers and relate them with the processes, which necessarily negatively affects the first reason explained above.

- Even though the related stakeholder roles are knowledgeable about the change drivers, e.g. when to reject a marriage registration or in what cases additional documentation is required, there is no systematic way that supports them when collecting such factors influencing the digital service delivery.

As a result, to improve the user satisfaction by providing the registration services continuously and increase the automation rate, everis envisions implementing a solution which enhances the flexibility of the registration service. Flexibility in that case encompasses the capability to respond to each and every citizen by taking their individual context into account in digital service delivery.

3.5 ROOT CAUSE ANALYSIS

In the prior sections, the application cases regarding the digital service provision in different sectors are described. This section analyses the causes of the problems to reach a detailed understanding about them. Obviously, there are many causes to the aforementioned problems and it is not possible to cure them all with the design proposal, but only a set of them, as will be shown in the following.

Problem from the practical point of view: Why is it a challenge to offer flexible digital services?

Both SIV Group and everis have established development and operating processes that are used during the conceptualization, provision and configuration of the digital services (cf. Figure 3.1). It is possible to classify the artefacts and roles from the engineering and technology stack point of views and the former into *conceptual solution*, *technical solution* and *executed solution* steps. In SIV's application case, the design of the conceptual solution relates to the provision of digital services to the clients in the utility industry and consists of modelling goals of the enterprise as well as processes of the service to be implemented. The technical solution phase corresponds to the configuration of kVASy in SIV's case or the SOA platform in everis' case by solution engineers for a specific client or for other application contexts. The executable solution phase concerns the selection of the exceptional workflows from the task manager in kVASy and clearing the cases in line with the contractual agreement that the SIV Group specifies with the client. For everis, it is related to the manual promotion of digital services in a municipality page or maintenance of the business process models stored in the SOA platform.

We already addressed that digital services are developed for a specific customer group, yet they need to be configured before being delivered to the customer in line with the application context. For instance, in SIV Group, the handling instructions specify how the service provision should be adjusted to the needs of the client. In everis, the adjustment corresponds to the types of the services, which need to be promoted in accordance with the municipality context. Different roles participate to the process of engineering, design and adaptation of digital services, they use different tools and notations to carry out various tasks. In the root cause analysis, following problems are identified relating that phenomena to digital service flexibility.

Problem 1) A shared understanding among the different roles participating to the engineering of a digital service is missing. Also, from the management point of view, flexibility requires alignment on various levels, which should be easily mapped to the technical implementations.

Problem 2) The manual configuration of the services to different application scenarios is necessary. Since contextual aspects are not taken into account during service design, the applications cannot respond to changing demands at runtime and thus are not agile enough.

Problem 3) Representing the flexible parts of a digital service requires approaches to cope with uncertain factors, such as the management of staff availability or adapting the service-level agreements to provide individualized services.

Problem 4) Enterprises possess enough knowledge about the drivers causing changes in the service provision, whereas they do not know how to capture and model this type of contextual knowledge systematically. Adjustments are implemented manually on a code level. Tacit knowledge applied during the configuration is hard to be explicated. As a result, only a small share of organizations provide context-aware services.

Problem 5) Provision of the flexible digital services require constant updates in the underlying business processes. In addition to that, deviations in such process models and in the related processes are expected, which requires additional efforts in the modelling and management of process variants.

Problem 6) Since a range of possible configurations exist, both configuring the existing system as well as migrating to new settings is a cost and time-intensive task. The fact that the enterprise applications cannot be taken off-line to be adapted, the changes must be realized during the service provision.

Next section derives requirements and outlines the initial solution that is supposed to solve the aforementioned problems.

3.6 INITIAL SOLUTION AND REQUIREMENTS ELICITATION

3.6.1 *Outlining the Artefact: A Method to Capture and Elicit Context*

Both SIV and everis are classified as KBSOs and offer digital services that have to be configured according to the business context of the customer. Currently these organizations envision reducing operative costs required to adjust the digital service provision by increasing the flexibility[10]. One way to increase the flexibility is augmenting the awareness of contextual factors between the aformenetioned roles (cf. Figure 3.1) that influence the design and delivery of digital services. An approach taking the business context into account to enable an alignment on various levels is proposed in [127] and evaluated in [128]. The authors state that conceptual modelling should be concerned with business context to extend its boundaries and answer to the requirements of stakeholder goals in changing business environments. Consequently, this work argues the need for manual configuration of such digital services can be reduced by *model-based design* of the service application context, which in turn allows for a digital service delivery responsive to customers' demands [112]. From the IT point of view, this challenge has important implications. The growing complexity of software motivated the investigation of approaches to ease the difficulties basically resulting from the various requirements in problem and software implementation domains [7]. MDA has been proposed as a solution, which is based on the principles of abstraction and deriving value from models to deal with complexity (cf. section 4.1). The benefit of the paradigm is that the high-level models will be created by humans whereas the machines transform them until the source code is generated. By doing that the focus should be moved to model building rather than coding, which obviously speaks for separation of concerns [129]. The *roles, processes and technology stack* illustrated in Figure 3.1 is also conform with such separation. MDA gives enterprises the flexibility and agility to evolve business requirements independently from technology [130, 131] and reduces the software artefacts' sensitivity to changing situations [132][11].

As IT has become crucial in the support, sustainability, and growth of enterprises, the alignment of these strategies with the IT is a prereq-

10 Two further enterprises, namely CLMS and FreshTL followed the same objectives in CaaS project and benefited partly from the purposeful artefact that is defined in this thesis. CLMS is a UK-based enterprise that develops an Industrial Symbiosis Platform, namely ZappDev®. The platform brings together companies from different business sectors, with the aim to improve cross-industry resource efficiency through the commercial trading of waste materials, energy and water, sharing of processes and assets such as logistics and expertise. FreshTL provides cloud-based digital services, which enable companies to collaborate more effectively and demonstrate their regulatory compliance. However, the thesis does not detail the application cases of both companies, as the solution approach was not evaluated wihtin the aforementioned companies due to limited resources.

11 MDA distinguishes between three layers or abstraction viewpoints. Each shift from one abstraction level to another requires model transformations based on formally defined mechanisms, i.e. meta-models and transformation rules. It should be clearly stated that the work does not focus on the aspects of the paradigm as manifested by the Object Management Group (OMG), such as the Computation Independent Model (CIM) and Platform Independent Model (PIM). Instead, Model-Driven Development (MDD) is mentioned, since the solution artefact proposed in the thesis uses the model-based design principles as discussed in section 4.1.

uisite to transform strategic objectives into operational actions. From the stakeholders point of view, the **Problem 1** addresses the subject of **Business-IT alignment**, which is the application of IT in an appropriate and timely way, in harmony with business strategies, goals and needs [133]. The triggers for such alignment are twofold. First, IT evolves constantly from an enabler towards an industrial sector at its own right. Second, regulations, business requirements, economic factors should be supported by technological trends also from a business viewpoint [134]. Consequently, [135] states that the performance of business and IT are tightly coupled.

In the ISR, the term **capability** is used often for the alignment of business and IT [1, 23, 27, 28]. Due to their roots in strategic management, capabilities can complement services by operating as a glue between business and technical aspects. Capabilities help to design digital services and are related to organizational strategies. In addition to that, they connect strategic objectives with the technological artefacts required for the service provision. Therefore, I recommend to use throughout this thesis the concept of capability for capturing and expressing the tight relationship between business challenges and IT solutions.

Another area in ISR concerned with the description of key components of both the business and its IT infrastructure to enable Business-IT alignment is **enterprise modelling** [136]. Digital services are modelled process-based, i.e. there is an underlying business process that is modelled and implemented during the service delivery[73]. As [113] states "...it is relatively easy to support structured processes. However, processes involving people and organisations tend to be less structured. Often, the process is not stable and changes continuously or there are many cases that require people to deviate from the predefined process. Consequently, updating, adapting, adjusting a digital service to its application context requires also alterations in the business process models implementing the services. The problems numbered from **2** to **6** address the flexibility improvement in the **design and configuration of the digital services** without directly concerning Business-IT alignment.

Essentially, both organizations possess necessary knowledge on various application contexts of the digital services influenced by various drivers, such as the changes in type of services offered, SLAs and regulations. However, a methodological support on how to capture and model such application context is missing (see also **Problem 4**). A way to contribute to the solution of the six problem instances is engineering an artefact, a **component-oriented and capability-based method for context modelling**, which can be adopted by the organizations envisioning flexible provision of digital services and derives value from enterprise models as enablers of Business-IT alignment.

3.6.2 *Requirements Elicitation*

3.6.2.1 *Applied Techniques for Requirements Elicitation*

Industry-wide survey

This section details the results of the applied techniques, which are introduced in section 2.1.3.2 and then elicits the requirements that the method should fulfil. First, the requirements were gathered by analysing the results of an industry-wide survey that have been carried out in the course of the CaaS project [137]. The overall goal of the survey was to provide insight into organizations change management, usage of context awareness and digital services and to gather requirements for CDD, which integrates parts of deCOM as its context modelling method component. Two important survey objectives concerning the requirements related to the context modelling method are defined as follows: [137, p. 7]:

- Analyse the usage level of Enterprise Modeling in industrial companies.
- Analyse the reasons for changes in companies business processes and information systems, find out a common points of variation in different companies, in particular with respect to changes in the delivery context.

The target group of the survey was European companies engaged in digital business activities with the following characteristics [137, p. 7]:

- Location - Europe, in particular Latvia, Sweden, Germany, Spain, UK and Greece. This was done as the project partners could perform face-to-face interviews in these countries in case of a low response rate. The questions included in the survey did not dependent on national characteristics.
- Type of business - IT service development companies, IT service providers or companies using advanced IT solutions.

The survey included four main sections (adapted from [137, pp. 11]):

- Introduction
- Demographic questions
- Core questions
    1. Level of enterprise modelling maturity
    2. Business and IS change management
    3. Goals and key performance indicators (KPI)
    4. Context data

5. Usage of knowledge (Patterns)
6. Dynamic adjustment
7. Development methodologies
8. Variability and line management

In this work, the responses to the three questions were investigated to derive requirements for the context modelling method. These are core questions **1**, **2** and **7**, i.e. the ones regarding *level of enterprise modelling, business and IS change management* and *development methodologies*, the former of which are depicted in Figure 3.14. The whole survey is available at http://survey.caas-project.eu/en.

Survey results

The 64 responses indicate that there is a high variability of the business situation (cf. Figure 3.15), an important share of the business is effected by acquisition of new markets, dealing with changing legislation regulations and having a large number of customers with unique requirements.

Interestingly, 59% of respondents have pointed out that they use methods for adapting their information systems, although there is a high business situation variability and software systems are being changed often. The most popular methods for dynamic adaptation of information systems are custom reporting (29%), user interface adaptation (27%) and customer reconfigurable settings (22%). These results indicate that the change needs and factors causing variability are actually captured somehow, yet not systematically. Such finding also motivates another result, namely that only one third of the respondents arrange their products/services in product lines which conflicts with previously identified high level of variability and need to customize products for different markets and customers. More than 84% of respondents have indicated that they use enterprise models, the vast majority being static enterprise models. The business process modelling is used in most cases (34%) (cf. Figure 3.16), followed by data modelling, organizational structure modelling and goal modelling. Regarding the enterprise objectives, the goals are captured (85%) and measured by KPIs (72%). This is a positive indicator that a model-based solution can be designed that analyses variability in business process models and relate it to enterprise goals.

Other techniques for requirements elicitation

The observation and document-centric techniques were used to map the results of the industry survey to the application cases. Based on the available resources, the activities concerned only SIV and included a through analysis of secondary data regarding the enterprise goals, service specifications, client agreements and business process models. Most importantly, and as explained in section 3.3.4, the author encountered services provided by SIV Utility Services GmbH, which informally described the processes followed by a knowledge worker when clearing a message (for instance in form of manual han-

LEVEL OF ENTERPRISE MODELLING MATURITY

Does your company use enterprise models?
No
Data modeling is used
Process modeling is used
Organizational structure modeling is used
Goal modeling is used
Other models are used

Do enterprise models cover the whole enterprise?
Very few parts are covered (few stand-alone models)
Some parts are covered (important sections are missing)
Most crucial parts are covered
Majority is covered
Whole enterprise is covered

What form of enterprise models is maintained?
Static
Dynamic
Other

What Enterprise architecture frameworks are used in your company?
None
Zachman framework for Enterprise Architecture
The Open Group Architectural Framework (TOGAF)
Department of Defense Architecture Framework (DoDAF/MoDAF)
Gartner Enterprise Architecture Framework and Practice
Other

Does your company use international, regional, national or industry-specific standardization organizations?
None
International Organization for Standardization (ISO)
International Electrotechnical Commission (IEC)
International Telecommunication Union (ITU)
European Committee for Standardization (CEN)
Object Management Group (OMG)
World Wide Web Consortium (W3C)
Open Group Standard (OGS)
Organization for the Advancement of Structured Information Standards (OASIS)
Other

Does your company perform any information systems development activities?
No
Yes

Does your company provide any information systems development or information technology services to external customers
No
Yes

What is the level of IT service outsourcing?
Very low (only a few supporting activities are outsourced)
Low
Medium
High
Very high (everything is outsourced)

Figure 3.14.: Questions concerning the level of enterprise modelling maturity

dling instructions and other textual documents including case-based best practices).

Support techniques are used to enrich and elaborate the derived requirements and relate them to the stakeholder objectives. As the

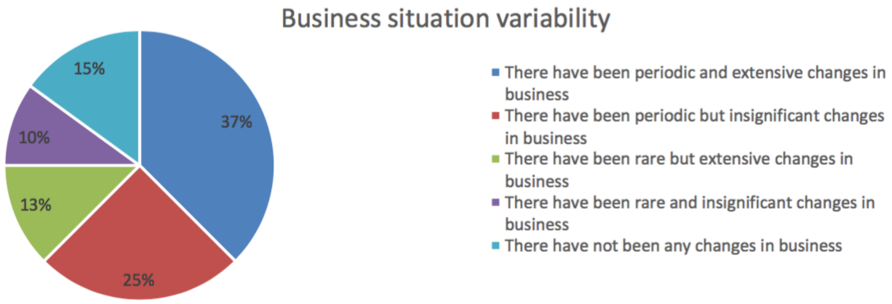


Figure 3.15.: High variability of the business situation [137]

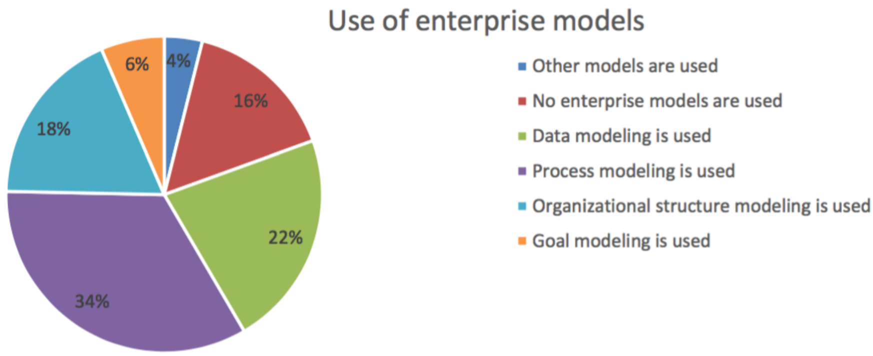


Figure 3.16.: Use of enterprise models [73]

properties have to be expressed using a simple and unambiguous language that is also in line with the terminology used in the enterprise, workshops and focus groups were performed. The author of the work also participated to the technical and plenary meetings of the CaaS project, where other researchers and stakeholders provided requirements that the context modelling method should fulfil. In addition to that, the properties were exemplified by the application cases, the results of which have already been extensively documented in section 3.3.3 and section 3.3.4.

To summarize the results, the survey has confirmed that enterprises act in dynamically changing environment, i.e. they operate in different markets, have to deal with various types of legislation regulations and have to customize products and services for specific customer requirements. In contrast to this fact, they do not adopt methods for system adaptation. The observation and document-centric techniques helped to understand the contextual assumptions and boundaries of the environments, contributed to the set of requirements. The relevance of the expressed requirements were confirmed by applying the support techniques. Moreover, these helped to align them with the objectives of the stakeholders.

3.6.2.2 *Derived Requirements*

This section derives the functional and non-functional requirements and explains them. Functional requirements basically define what the artefact (in this case the *method*) should do. In the following, functional requirements (FREQ) are listed. The boxes provide brief examples or statements linking the requirements to the application cases.

Functional requirements

(FREQ1). The method should document the procedure to identify and model the application context of a digital service. The documentation should indicate, which inputs are needed to produce certain outputs and how those outputs contribute to the objectives of the respective procedure.

> This requirement means for both cases that the method should stepwise describe how to find out the contextual parameters related to the digital services (e.g. clearing service, registration service). The descriptions should not only consist of the actions to be performed, but also include concretely the consumed resources (inputs, e.g. enterprise models related to the clearing service) as well as the generated outputs (e.g. a table including information about variants of a registration service or a goals model).

(FREQ2). The important concepts that the method user needs to be acquainted with must be described to have an ontological commitment to the terms. To increase the level of formalism, the concepts and their relationship should be represented with a meta-model.

> On the one side, when describing procedures, the method will use terms (e.g. "elicit context element") to communicate the way of performing them. On the other side, there will be a terminology which has been used in SIV and everis for a long time (e.g. "handling instruction" in SIV or "virtual office" in everis). In order to create shared meanings between the method and the terminology used in the enterprise as well as to increase the method understandability, the concepts should be explained in the method. These should be supported by a meta-model, which does not only provide the method users with a conceptual framework, but also illustrates the relationships between different concepts.

(FREQ3). Graphical notation should be provided to support context modelling activities and to enhance the communication between different stakeholders. Moreover, the method should point out tools that support modelling tasks.

> As shown in Figure 3.1, different experts such as business analysts, solution engineers and knowledge workers participate to the design and implementation of the digital services. The graphical notation should help to represent the model elements visually and to communicate the contextual factors between different levels (e.g before a solution engineer prepares the solution deployment for the clearing service, a business analyst can present him the contextual factors in a more understandable way). To enable modelling activities, experts in SIV and everis using the method should be supported with a proper modelling tool.

(FREQ4). The standard processes are altered when offering services to the customers and variants of these standard processes are modelled and implemented. Thus, the method should offer mechanisms to highlight change factors in the business situation variability.

> Both enterprises have variants that define the way of offering a digital service in certain conditions. For instance, in everis' registration case, there is one task which is not clearly described (cf. Figure 3.12, task "specific sub-process ...") that depends on activity or procedure type. Similarly, in SIV's case, there are *n* ways of clearing a faulty message (cf. Figure 3.8). The method should be able to analyse how the variant implementation relates to the change factors which directly influences the application context of the digital service.

(FREQ5). After applying the method, the stakeholders should be able to identify what kind of context information will be used and how they can be collected when designing digital services.

> Stakeholders in SIV and everis cases need to know what constitutes a context element and how it is distinguished from other information objects relevant to the digital service design and implementation. To exemplify, in SIV's case, clearing a message depends on a number of parameters, such as "market role, kVASy installation type or the number of messages that must be cleared". The method should be able to extract the context elements amongst them. Moreover, it should define the resources to investigate (e.g. process variables of a process instance, a contractual agreement with the client or the clearing procedure), which would help to justify the decision as to whether something is a context element or not.

(FREQ6). The method should provide support on adjustment of the services to the current context information, without explicit user intervention.

> Representing the contextual influences of digital services in the e-Government and utility industry on a model level is beneficial. Though, both enterprises operate with the doctrine that they offer *solutions* to their clients by the digital services[12], which require implementation of those models. Consequently, they envision to create (semi)-automatized solutions that would adapt the digital services subject to investigation based on their application context. In this respect, the method should provide initial support concerning the implementation aspects.

(FREQ7). The method should offer support for context elicitation in situations, where formal enterprise knowledge is missing (or is not represented via conceptual models) and such knowledge is documented only textually.

> During the investigation of SIV's *enhanced exception handling* application case, we observed that the handling instructions, i.e. the instructions guiding a knowledge worker when clearing a faulty message, were only documented textually. The instructions consist of very valuable information concerning the followed steps and hence the method should allow for analysing contextual information within them. Although taking a stance on conceptual modelling as an artefact, allowing an additional support for such cases where no conceptual models exist would also enhance the method's expressiveness.

`Non-functional requirements`

Rather than being specific, the non-functional requirements relate to the global properties of the artefact, such as environmental and structural qualities. In the following, non-functional requirements (NFREQ) are listed.

(NFREQ1). To support different ways of working, the method has to provide an adaptable development methodology and should be modular. The modularity should be supported by low coupling (method has optional and mandatory parts) and high composability (method provides different entry points to the user).

(NFREQ2). The method should be easy to use and learn and provide practical guidelines to enhance the understandability.

Table 6 maps the documented problems in section 3.5 to the derived requirements and relates them with the elicitation techniques introduced in section 2.1.3.2.

12 This is not a doctrine reflected only in the practice. In the literature, there are works that define services as solutions, as will be shown in section 4.2.

Table 6.: Mapping the requirements to the problems and elicitation techniques

Problem	Requirements	Elicitation Technique
P1	FREQ1 FREQ2 FREQ3 NFREQ1 FREQ5 NFREQ2	Survey Observation Support
P2	FREQ6	Support Document-centric
P3	FREQ5	Observation
P4	FREQ7	Document-centric
P5	FREQ4	Survey
P6	FREQ6	Support Document-centric

3.7 SUMMARY

This chapter aims to demonstrate the relevance of the flexibility problem by analysing both the literature (knowledge base) and the application cases from two enterprises offering digital services, i.e. digital enterprises. Furthermore, it derives the requirements that the solution proposal should fulfil. Revisiting the DSR procedure followed in this thesis, this chapter corresponds to *problem identification & motivation* and *objectives of the solution* steps illustrated in Figure 2.2.

Knowledge base analysis

Changes around an organisation necessarily affects its IT systems due to the intrinsic relationship between them. The rising importance of service economy is characterised by the SDL, which together with the digitalization triggers the need for capability to adapt to new situations as fast as possible. In the context of digital services, the ability to be malleable or to be able to adapt to changing market needs or requirements is considered to be the most important quality attribute [11]. Enterprises need to offer flexible digital services to improve their chances of survival [17, 23, 48].

Problem analysis in the industry

The aforementioned need is investigated in selected industrial settings to confirm the practical relevance of the flexibility problem. The application cases are taken from the two CaaS project partners, **SIV** and **everis**, offering digital services in utility and e-Government domains respectively. In both enterprises, digital service provision requires involvement and cooperation of different roles, as shown in Figure 3.1. Obviously, a shared understanding on different levels is decisive in the design of the digital services.

Root cause analysis and initial solution

Against the background provided by the analysis of the knowledge base and investigation of the application cases in the industry, six main problems have been identified by applying root cause analysis [49]. The identified problems show the need for taking the contextual aspects into account during service design. Moreover, an alignment between stakeholders performing different tasks to design and implement a digital service is required to reach higher flexibility levels. Consequently, the solution proposal is centred on developing an artefact that provides a methodological support to identify the service application context and at the same time enables the alignment on various levels.

Requirements elicitation

To shape the artefact in detail, requirements are derived by using a number of different techniques. In order to increase the degree of generalisability provided by the artefact, an industry-wide survey covering IT service development companies, IT service providers or companies using advanced IT solutions is introduced. The findings confirm that enterprises act in changing environments, as a result of which they customise products and services for specific customer requirements. In contrast to that, they lack methods that may enhance system adaptation and flexibility. In particular, this concerns eliciting contextual factors influencing service delivery. Hence, the solution proposal can be a model-based artefact that examines variability in business process models, identifies context and relates it to enterprise goals, as most of them use enterprise models, capture goals and acknowledge high business situation variability. The observation and document-centric techniques helped to map the results to the application cases and shape the requirements, the relevance of which were shown by applying the support techniques. As a result, seven functional and two non-functional requirements are derived. The functional requirements are supported by statements or examples to enhance their understanding and relevance in the application cases.

4

BACKGROUND: STATE OF THE ART IN RELATED AREAS

In today's fast-paced economy, enterprises need to be flexible and respond to the changes caused by dynamic markets, novel technologies and new customer demands. The need for flexibility and constant adaptation of service/ product offerings to gain and sustain competitiveness is addressed in the literature from different standpoints. This chapter investigates the proposals related to flexibility enhancement from two different perspectives; IS perspective in section 4.1 and Service Science perspective in section 4.2 Afterwards, the state of the art related to the solution proposal is investigated by performing literature reviews concerning context modelling in section 4.3 and section 4.4 as well as capability modelling in section 4.5 respectively.

4.1 FLEXIBILITY IN INFORMATION SYSTEMS DESIGN

IS is "an information processing system, together with the associated organizational resources such as human, technical and financial resources that provides and distributes information" [1]. IS is a cross-disciplinary field, which embraces both social and technology-oriented approaches. [55] states *"if a just technology-oriented approach would be taken, IS would be not different from Engineering or Computer Science discipline, a solely behavioural approach would make IS not different from other behavioural fields, such as sociology or psychology"*. This view is adopted throughout the thesis.

In an age where the information society transforms into the digital society [13], capabilities of IS to adapt to the new conditions determine the extent, to which an enterprise reaches its objectives. Continuously changing business environment demands a flexible IS that is easy to modify and maintain [6, 9] and poses new problems for IS. Lacking support for adapting the software systems to changing situations, which is termed in the literature as *poor flexibility*, is obviously an important problem in this respect [3, 5, 6, 7]. This is supported by the statement in [8], who reports that 65"%" of system modification costs base on adapting the system after it has been delivered in consequence of changes in the requirements.

Enterprises require flexible systems which can be easily customised to meet changing demands and are easier to modify and maintain [9, p. 93]. A solution approach to provide agile and flexible software systems is shortening the software development process in terms of the methods employed in their development [9]. [138] emphasizes that the software engineering techniques break down for applications, where system boundaries are not fixed and subject to constant urgent change, which is also supported by [139] and [5]. In this respect, the special issue of Information Systems Journal focused on the role of agile and flexible methods for Information Systems development [140]. [141] argues that the need for flexible systems is well known in the software engineering research area and proposes a component-based approach to enable flexible software applications. The approach is based on the main idea of re-designing or re-developing software in line with its application context during its use. [142] argues that there are different forms of flexibility suited for a given instance of development and based on control theory, the work analyses the existing software development methods from the flexibility point of view. Concerning flexibility, two important software design principles have been proposed in IS literature, which are shortly mentioned in the following two sections.

4.1.1 *Service-Oriented Architecture*

Service-oriented paradigm is emerging as a solution to handle the evolution, flexibility and complexity of IS [143]. SOA in this context represents a software design principle that has been proposed to close the gap between the software systems and the way the business operates. Based on defined and standardized interfaces, SOA provides flexibility by orchestrating distributed and heterogeneous components that carry out various functions (services). A service in that sense is a logical representation of a repeatable business activity that has a specified outcome (e.g., check customer credit, provide weather data, consolidate drilling reports)[1]. Services are presented as functions, which are modularizations of the applications' business logic. The loosely coupled nature of services allows an abstraction, i.e. the service interface is independent of its implementation. Consequently, enterprises can plug in new services or update existing ones based on the new requirements whereas the service consumers are completely isolated from such changes [15].

This interpretation of "services" encompasses the technical aspects [39] and does not correspond to the "services" definition adopted by the thesis (see section 4.2 for detailed discussion). Still, the briefly mentioned SOA paradigm helps us to transfer and apply the princi-

1 http://www.opengroup.org/soa/source-book/soa/soa.htm, Last Retrieved 21.07.2015

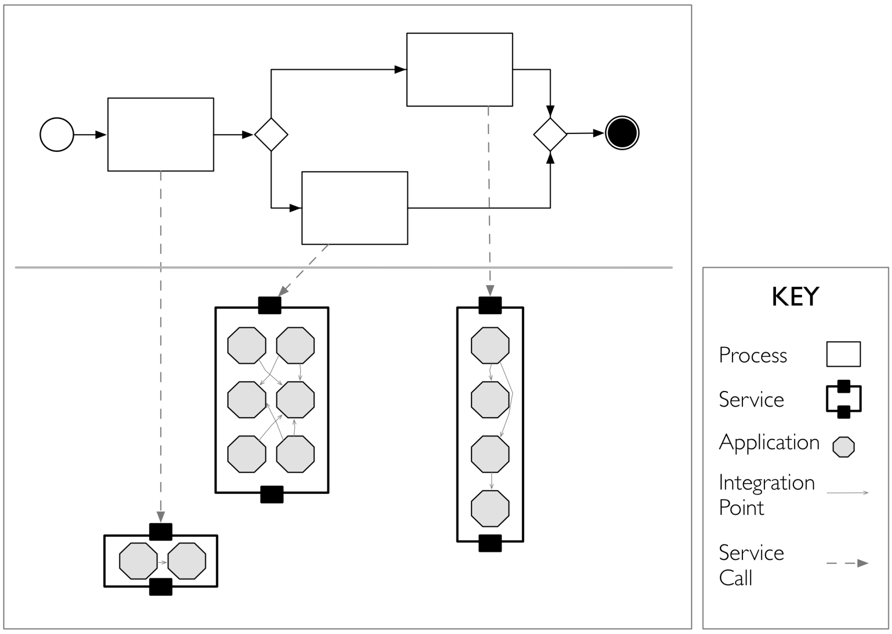


Figure 4.1.: An illustration of processes and decomposition principles, based on [15, p. 54]

ples of SOA in the design of digital services. First, it is indicated that on top of these services, enterprises implement business processes and technical workflows as compositions of services (cf. Figure 4.1). Hence a through understanding of the business processes is important to offer flexible digital services. Second, the terminology used within the SOA researchers supported the finding that when mentioning the ”services”, Computer Scientists refer to coarsely grained processes and tasks, implemented by Web services [24]. Third and last, as software systems based on SOA provides high flexibility [144], the quality characteristics of a Web service (self-contained, loosely coupled, high composability, cf. Figure 4.1) further motivated the design of a component-oriented solution to enhance digital service flexibility.

4.1.2 *Model-Driven Architecture*

The growing complexity of software motivated the investigation of approaches to ease the difficulties resulting from the various requirements in problem and software implementation domains [7]. MDA has been proposed as a solution, which is based on the principles of abstraction and deriving value from models to deal with complexity. Different approaches are attributed to the paradigm, such as Model-Driven Engineering (MDE) or MDD. In this work we will use the term MDA.

The MDA can represent systems from different viewpoints. To address this, MDA distinguishes between three layers (or abstraction viewpoints). The *computation independent* viewpoint focuses on the environment, in which the system will operate and the required features. Modelling a system from this view results in a CIM (often referred to as business or domain model), which disregards the actual implementation. The *platform independent* viewpoint focuses on the system properties that are invariant to platform changes; PIM describes the system construction without specific implementation details. The Platform Specific Model (PSM) combines the specifications of PIM with the details of that particular type of platform used by the system. In other words, when a model of a system is defined in terms of a specific platform, it is called PSM [7, 131]. The abstraction viewpoints are illustrated in Figure 4.2. Each shift from one abstraction level to another requires model transformations based on formally defined mechanisms, i.e. meta-models and transformation rules.

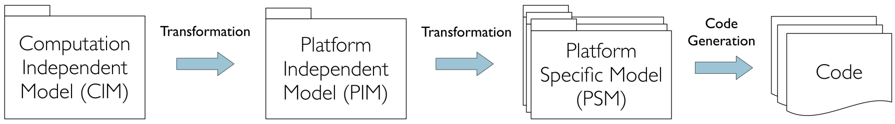


Figure 4.2.: Abstraction viewpoints in MDA, based on [145]

From the flexibility point of view, MDA keeps business domain code loosely coupled with platform-specific code. As it establishes "a distinction between the problem space (where analysts and modellers work) from the solution space (where designers and programmers work), this separation brings room for analysts and modellers to think and specify their business requirements by ignoring technical aspects" [146]. As a result, MDA gives enterprises the flexibility and agility to evolve business requirements independently from technology [131, 130] and reduces the software artefacts' sensitivity to changing situations [132]. Benefits of MDA (partly based on [131, 129]) are as follows:

- Models are used as communication vehicle. Providing well defined terms, notations and a degree of formalism, models facilitate a consensus or a common sense in a team.
- The gap between business requirements and technical implementations are reduced due to different levels of abstraction (viewpoints). This necessarily enhances the communication between various stakeholders.
- Models reduce the costs of realizing a design since it is possible to derive artefacts and implementations from them.
- Models produce consistent results when applied to different domains or platforms with correct transformation rules and other formalities.

- Models minimize the need for program code modification.
- Separation of concerns: software developers are shielded from the complexities of the underlying system platform, business analysts are free to model the world they perceive without focusing on implementation details.

It should be clearly stated that this thesis does not focus on the aspects of the paradigm as manifested by the OMG, such as the CIM and PIM. Instead, MDA is mentioned, since aforementioned benefits of the paradigm contribute to the Enterprise Modelling area and thus the proposed solution artefact (the context modelling method) in the thesis uses the model-based design principles. As the solution proposal cannot cover the whole IS Design, the focus in this thesis is shifted to organisations offering digital services, reasons of which have already been motivated in Chapter 1. For this purposes, next section investigates the current state in Service Science.

4.2 SERVICES AND SERVICE SCIENCE

Service-oriented way of thinking in the business caused growth of the service economy, which necessarily had a vital impact on the business processes and culture of the organizations. Motivated by the SDL, a gigantic shift from a product based economy to the one based on services in general and digital services in particular has been observed [11]. In terms of the employment numbers, the most developed countries of today have become service-based economies [15]. This section examines the notion of Service in IS and the related disciplines, investigates the importance of services in the digital era, introduces frameworks for classifying digital services and concludes by the approaches to enhance flexibility in digital service provision.

4.2.1 *Definitions of the Term Service*

Service is a broadly applied term in Economics, Computer Science and Information Science. Taken the wide scope of Service Science, it is inevitable that there is an uncertainty about the definition of services in the literature and no widely accepted definition of the concept [147]. Yet, the most cited definition of service is from [14], which states "service is the application of competence for the benefit of another". This definition emphasizes the notion of value co-creation. The IT Infrastructure Library (ITIL) defines service as "means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs and risks"[2]. This

2 http://wiki.en.it-processmaps.com/index.php/ITIL_Glossary, Last Retrieved 15.11.2016.

extends the former definition by the notion of costs and risks, hence emphasizes to the differentiation between service design (delivering value to customers. . .) and service implementation (relieving the customers from dealing with risks associated with the outcomes they desire) [148]. [42] defines service as ”a change in the condition of a person or a good belonging to some economic entity brought about as the result of the activity of some other economic entity, with the approval of the first person or economic entity”. [25, p. 154]

In the literature, we identified a number of works that analyse service definitions and derive important concepts. An example of such analysis is performed by Sumita et al., who collect service definitions from 15 papers and extract 45 characteristics. The authors then define 3 groups, to which characteristics are related to, namely *process*, *provision* and *value*. Taken the definitions above, which are revisited in brackets and italics, provision implies the existence of a provider (*economic entity*) and a receiver (*customers requesting a service*). Process reflects the intangibility (*competence*), action (*application of competence, delivering*) and change of state in the situation of the receiver after being provided with the service (*a change in the condition*). Finally the value is associated with usefulness (*benefit of another, delivering value*) [149].

Ontological approaches

There are also endeavours towards defining and understanding the concept of service by using ontological approaches. In this field, [150] presents an ontological representation of SDL to analyse the term service and distinguishes between three main approaches in the definition of the service concept; service as an *event*, service as a *process* and service as a *resource*. The authors argue that the concept of the service as an event requires adding a contextual dimension to it. By aligning services with *processes* and *goods* with objects, which are two disjoint ontological categories, [151] argue that services are entities occurring in time, while goods represent entities lasting in time. As such services are radically incompatible with goods due to their temporal dimension.

Service in different disciplines

Another example investigating the service characteristics and its interpretation in various disciplines can be found in [24]. The authors perform an extensive analysis addressing the different understandings of the term and state that multiple interpretations result in confusion[3] (see Figure 4.3). The *Business Science* perspective uses *natural language for a high-level description of services*, referring to value exchanges. The *Computer Science* perspective points out to *coarsely*

3 The ontological analysis in [25] confirms this, which states ”sometimes the term ”service” is used to indicate an action (. . .) or a generic type of action (. . .) or perhaps the capability to perform some action; other times it refers to the result of such action, which is typically a change affecting an object or a person, or just the (subjective) value, or utility of such change; moreover, in certain settings. (. . .) The term denotes an organization acting (or in charge of acting) in a certain way in the interest of somebody”.

grained processes and tasks, implemented by Web services, to realize the IT-part of the service offering described by the business. The tasks neglect the details, such as how service is performed, which are relevant from the business point of view [151]. The authors conclude that *Information Science* researchers aim to bridge the gap between both communities by transforming the service notion *to a well-defined concept with concrete tasks that together realize this value-oriented activity* [24, p. 6]. As shortly mentioned in the introduction of this thesis, we position ourselves in line with the Information Science perspective and interpret services as socio-technical aspects of an organization rather than a purely technical aspect. In doing so, we align our perception of services with Welke's statement that they are "solutions to a current problem" [47, p. 34]. This also corresponds to Tiwana and Ramesh's finding that in service industries, customers do not buy products or services, but instead, results and solutions [152], as we have shown in SIV's and everis' cases in Chapter 3.

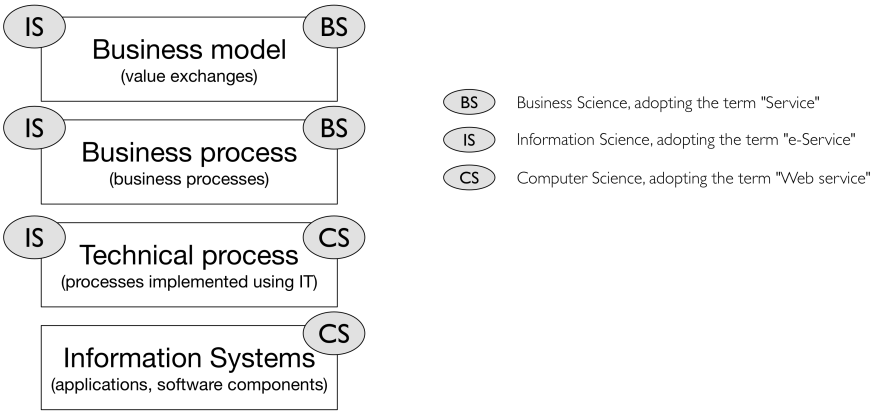


Figure 4.3.: Notion of service in different communities, adapted from [24, p. 7]

After investigating the notion of services and positioning ourselves, we derive a number of implications, which are relevant for this thesis and were briefly documented in the introduction [25, 26]:

i. Services are high-level implementation components that operationalize the organization's strategy. This is visible in the *business model* layer in Figure 4.3.

ii. Modelling of services in changing environments should not only cover the technical aspects as reflected in the *information systems* layer in Figure 4.3. It should also include the business context (e.g. different implementation scenarios in *business process* layer in Figure 4.3) and enterprise goals to ensure Business-IT alignment, i.e. the relationship between the layers.

iii. Certain aspects of Services should be designed in an understandable way for the stakeholders, e.g. strategies and enterprise objectives, who do not necessarily have a deep IT knowledge, as there are other perspectives to them besides Computer Science (cf. *business model* and *business process* layers in Figure 4.3).

4.2.2 *Services and Digitalization*

The digital economy is developing rapidly worldwide and considered as the most important driver of innovation, competitiveness and growth [12]. The penetration and accesibility of IT in our everyday life calls for a transformation from an *information society* to *digital society*, the former of which was preceded by the *industrial society* [13]. This transformation is illustrated in Figure 4.4.

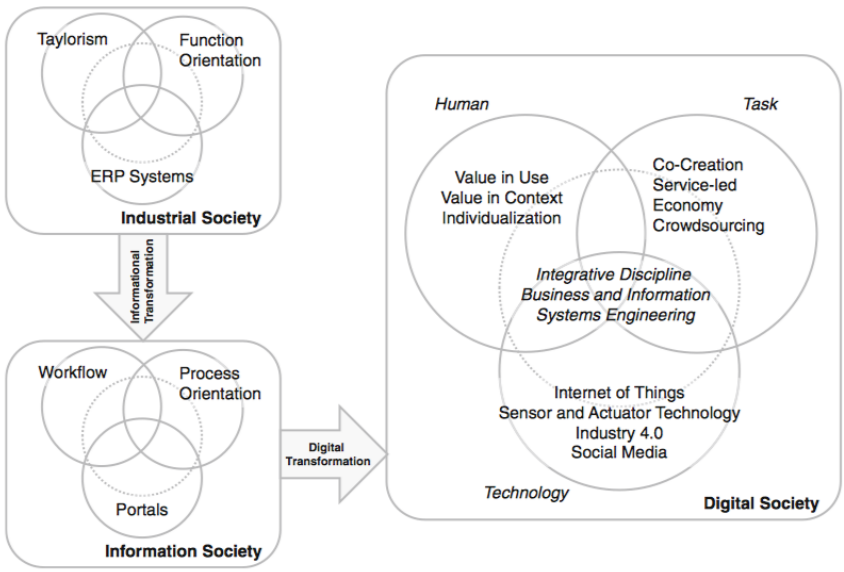


Figure 4.4.: The path to the digital society, taken from [13, p. 256]

Value creation in digital age

The intangible nature of services, the pace of the disruptive technologies and competition in the market require developing customised, user-specific solutions [17]. In a market offering services to the consumers of the digital society, the enterprises must know their digital customers, understand their preferences and are thus seeking ways that would allow them to reach a certain degree of flexibility. In this respect, [13] and [153] argue that one requirement to bind the digital user to a service offering is context-adaptiveness of the service and [46] suggests digital services need to keep up with contextual changes. Keen and Williams share this view and claim that in digital businesses, the value is not a function of the service, i.e., it is not stable and fixed. Instead, it is a function of the choice space, which can be expanded by adding new dimensions and opportunities [154, p. 643]. Against this background, the authors define four "rules of thumbs" concerning the realities of value generation, one of which is that the buyer determines the value and not the seller. In other words, the buyers compare offers in the choice space and determine the value. A new dimension to expand the choice space is taking the user context into account [155][4].

What is a digital service?

Services and digitalization gave rise to another term, *digital services*, which is central for the purposes of this thesis. A digital service is defined as *an activity or benefit that one party can give to another (...) through a digital transaction (information, software modules, or consumer goods) over Internet Protocol (IP).* [11, pp. 506]. In the literature, we came across similar terms, such as e-services, online services, web services. A number of authors attempt to create a taxonomy in this area, including the works of [11, 15] and [152]. Following summarizes the findings from their work, based on which we ground and justify our definition in this thesis.

Taxonomical approaches

Tiwana and Ramesh view e-services as "Internet-based applications that fulfil service needs by seamlessly bringing together distributed, specialized resources to enable complex transactions" [152, p. 1]. They argue that e-services involve a series of parallel-executed transactions, they are self contained and modular. As the e-services are non-monolithic by nature, they allow for the delivery of flexible solutions for client businesses. The authors create a taxonomy that is based on the end product types supported by the e-services as well as on the nature of participants (cf. Figure 4.5). As one can simply notice, the examples provided in the taxonomy are barely up-to-date. Yet, it is possible to learn that the term "digital service" is considered as an end product of an e-service.

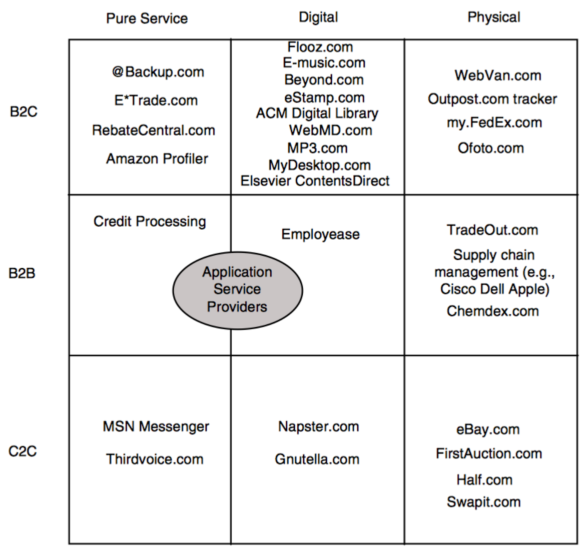


Figure 4.5.: A taxonomy of e-services, taken from [152, p. 1]

4 Considering the application cases investigated in Chapter 3, identifying and modelling the contextual factors influencing the digital service offerings in SIV and everis would allow the clients to configure them in line with their needs.

The shifting role of technology and digitalization required investigating their influence on services and creating new taxonomies. In this respect, Froehle and Roth developed a concept concerning the role of the customer in the service offering and the extent, to which "technology" is included in the interactions [156]. This taxonomy, which is slightly adapted in [15], is depicted in Figure 4.6. In the technology-free customer contact, the service provider (depicted as "service rep" in the figure) is in direct contact with the customer without any technological infrastructure, e.g. "an old-fashioned, general store clerk transacting the sale of merchandise with a cash drawer", [p. 2] [156]. The technology-assisted service is considered, when the service provider uses technology to offer its service, e.g. when a bank teller interacts with its customer at the counter. In the technology-facilitated service, the customer and the provider are co-located and both have access to the same technology used in the service provision (e.g. when a music producer and an artist mix and master a music album in the studio). All three types correspond to face-to-face services. The face-to-screen services are observed in two forms. In the first form, the technology-mediated-services, both the customer and the service provider have access to the technology and thus their involvement is not necessary for realizing the service. An example of this type is the provision of the labour-intensive administrative services from low-wage countries over electronic networks [15]. Technology-generated services correspond to the second form, in which the human service is completely replaced by the technology, e.g. when the customer transfers money via an online banking service.

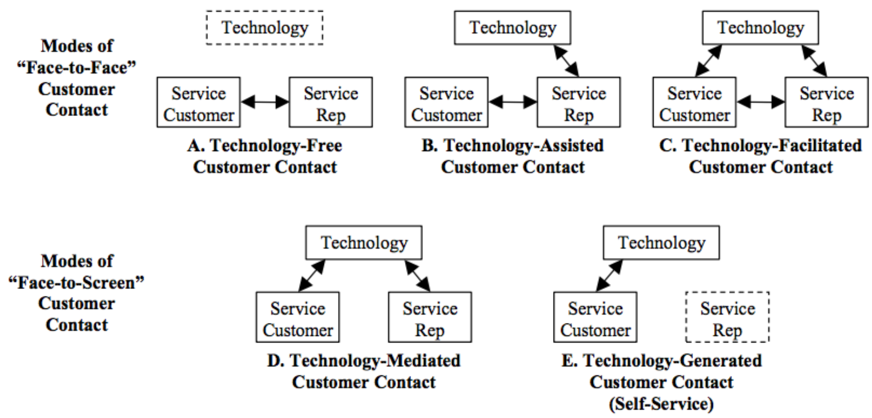


Figure 4.6.: The role of technology on electronic services, taken from [156, p. 3]

In Cardoso and Fromm's classification, e-services are defined as both *technology-mediated* and *technology-generated* services [15]. The authors view that the term *electronic* refers to the use of IT-based solutions, which is in line with the digital service definition provided above. This is obviously voiced in the authors' work, as they state "the term digital services has the same meaning as electronic services" [15, p. 48]. Also, Ølnes and Jansen share this view and suggest "the concept of e-service has several names, e.g. "digital service" [44, p. 198].

We argue that Tiwana and Ramesh's "e-service" definition is not aligned with Cardoso and Fromm's. The latter author team explicitly advises against the equation of the term e-service with the technical term "web services" and defines web services as "a method of communication between computers using the world wide web. They offer functionalities that developers can use in their software applications to invoke and execute remote functions or methods using open and standardized protocols". [15, p. 34]. As such, digital services are perceived to be *web-enabled e-services* and not *web services*, latter of which seems to be adopted in Tiwana and Ramesh's definition.

The last taxonomical approach in the area of digital services can be found in William and college's work [11]. By examining 12 leading digital services, the authors propose a design taxonomy that classify and contrast digital services consisting of five dimensions.

- **Service delivery**. Describes how the service is provided and the range of service consumer' s participation. Four ranges are defined in this dimension, high, medium, low and none.

- **Service maturity**. Focuses on the interaction levels between system designers and users. Four ranges are defined in this dimension, enthusiast, professional, consumer and embedded systems. Towards the last ranges, the technical skills required by system users decrease.

- **Service malleability**. Describes the level of effort concerning the adaptation and change of the digital service based on the circumstances. Four ranges are defined in this dimension, high, medium, low and none[5].

- **Pricing and funding**. Concerns the revenue models, such as licensing, revenue sharing, loss-leader pricing, media model, effort-, cost-, value-based pricing, premium subscription fees and corporate sponsorships.

- **Fundamental service provide objectives**. By offering digital services, service providers aim to fulfil certain objectives. Prioritizing the business, technological and interaction objectives may influence the design of the digital services. Each objective has two ranges respectively, high and low.

In the following, we analyse the digital services of SIV and everis introduced in Chapter 3 based on the aforementioned framework and

5 The authors consider malleability both from the service provider and service user point of view. In this work, we focus only on the former.

show that they can be categorised as digital services. The results are depicted in Figure 4.7. Then, we summarise the three most important differences between a digital service and non-digital service [11].

	SIV	everis
Service Delivery	**Low**. For providing the clearing services, the client has to use kVASy and fulfil certain hardware and software requirements.	**Low**. e-Government services require using the SOA platform provided by everis. The client has to fulfil certain hardware requirements to use the service.
Service Maturity	**Consumer**. The workflows needed to offer clearing services are pre-installed in kVASy environment.	**Consumer**. Best practices are built into the application environment. Interaction between system designers and users are required only for customisation purposes.
Malleability (Service Provider)	**Low**. Changes concerning the provision of clearing services are rather difficult and expensive to implement.	**Medium**. Changes require adapting more than a few parts of the service and limited testing.
Pricing and Funding	**Licensing + Effort-based**. kVASy is installed based on the licensing model. Clearing services are billed to the kVASy client depending on the number of the cases that have been cleared.	**Licensing**. Digital services are published in the SOA platform, installation of which is performed based on the licensing model.
Fundamental Objectives	Business objectives. **High** Technological objectives. **Low** Interaction objectives. **Low**	Business objectives. **High** Technological objectives. **Low** Interaction objectives. **High**

Figure 4.7.: Application of the digital service taxonomy proposed in [11] to SIV and everis

- Digital services require the infrastructure of an IT-based Internet as a result of which the method of delivery is more restrictive for them.
- In digital services, there is certainly a portion of the interaction which is performed digitally. Obviously, this does not mean that all interactions are limited to be digital (e.g. when ordering a product over a web portal).
- The idea of ownership is more subtle including digital rights for a certain purpose vs. outright ownership. In digital services, it is not clear who owns what and where does the rights of the owner/ provider end and start. In non-digital services, this is easier to indicate.

Notion of Service in this work

Against this background, when using the term (business) service in this work, we refer to a broader context, including the value exchange, business processes implemented using IT as well as the information systems used to provide them. The term digital service (or e-service) encompasses the IT-based design and provision of such (business) services (or *solutions*), mainly focusing on the related business processes and enterprise objectives to create and exchange value. Web services, although they certainly play an improtant role in digital service provision, are not further investigated in this thesis. Regardless of the type of the service, we share the view that the roots of service lie in development of capabilities by various entities that compete and cooperate [157].

4.2.3 *Flexibility in Digital Services*

Sections 4.2.1 and 4.2.2 showed the need for more flexibility in digital service provision. Nevertheless, the amount of work in the literature that directly concerns this subject and aims to create new solutions seem to be scarce. The contributions focus on the role of BPM in making organisations or services more flexible. In particular, context-aware business processes and process variant management seem to be the two areas that develop solutions, which would contribute to the flexibility in digital services. This is not suprising, since business process modelling is used extensively when composing digital services into business applications [24, 15, 44]. Welke even mentions a certain duality between business processes and business services, i.e. services are composed by processes and they represent value proposition to the service client [47]. The value proposition is created and delivered to the client, after the service is initiated and *a series of actions* are set in motion to fulfil the client's request. The author states that this series of actions are nothing different then business processes, which help the service provider to deliver the solution to the client. The close collaboration between services and business processes is depicted in Figure 4.8 on an architectural level. We argue that due to its IT-based characteristics, the aforementioned duality can be transferred to and used in the context of digital services.

Shi and Daniels studied flexibility issues in digital services and came to the conclusion that the flexibility of business processes related to the service provision determine the overall digital service flexibility. Furthermore, the authors state "the principle developed earlier indicates that much of the available benefit associated with (digital service) flexibility may be realized by introducing only a small amount of flexibility into the underlying business processes" [48, p. 419].

`1st approach: Context-aware BPM`

BPM is increasingly used in cross-boundary organizational processes including unstructured components [158, p. 806]. In BPM, investigation of organizational flexibility has been encompassed in the notion of context-aware BPM [53, p. 764]. In order to reach a higher degree of flexibility, the identified solution proposals can be categorised in two classes; i) Context-aware BPM and ii) process variant management. Regarding the first possible solution[6], the contributions mainly focus on adding functionality to process modelling

6 Context-awareness and BPM will be investigated in detail in section 4.4.3, which documents the results of a systematic literature review concerning context modelling methods.

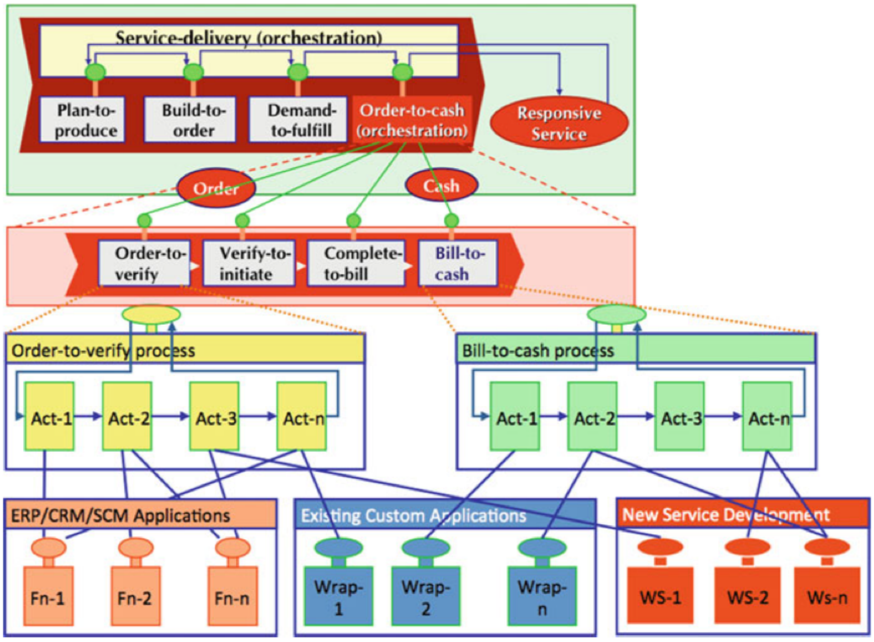


Figure 4.8.: A service-oriented enterprise view, taken from [47, p. 33]

languages and making them context-aware, as suggested in [159] and in [160]. Although proving to be efficient in the field of original domain, we have identified a number of shortcomings when applying them in the digital services area and in KBSOs [114, pp. 67-68], [158, p. 808]:

- In the area of digital services, a business process is expected to handle highly customizable requests. It may not be feasible to accommodate the full complexity of the process including the configurable parts in the computer application.
- In a KBSO, the course of action depends on idiosyncratic factors and on the judgement of the people involved which, in turn, depends on their knowledge and previous experience.
- Following from the second observation, trying to capture all the relevant knowledge in a formal model may be a vain exercise because,
  - the process has many variants (cf. next solution proposal). Representing the contextual factors in one single model would be too complex, which would necessarily deteriorate the quintessence of ”modelling”[7].

7 Here, the author of this thesis would like to mention a short but important anecdote experienced during a keynote performed in BIR 2015 in Tartu, Estonia by Mr. Manfred Reichert, who is cited a number of times in this work. In the question and answer session after the keynote, the author of this thesis shared his observation that flexibility approaches in BPM result in producing more complex business process

– the organization is constantly evolving and so are its processes or,
– because a significant part of the knowledge engaged in the management of the process is intrinsically tacit.

2nd approach: Process variant management

The second possible solution could be extending the boundaries of business process modelling languages (e.g. Configurable Event-driven Process Chain (C-EPC) [161]) or using approaches for process variant modelling [162, 163] (e.g. PROVOP [164])[8]. In an environment with frequent changes, process variant management is a complex undertaking [165]. Based on a case from eBay, Sakr et al. reports that a business process having, which is influenced by six environmental (contextual) factors having the respective subtypes {8,2,5,5,3,7} will result in more than 8000 process variants [166]. Overall, the number of possible process variations and the extent to which are managed successfully is closely related to the degree of freedom the system has.

There are solutions concerning how to cope with process variability. [163] recommends *multi-model* and *single-model* approaches. In the former approach, the process variants are kept as separate instances. Usually, this technique results in modelling certain parts of the business process redundantly, which hinders the maintainability of the models. An example of the multi-model approach is shown in Figure 4.9a, where three variants BP1, BP2 and BP3 are modelled. The single model approach keeps all the variants in one model by using conditional branchings. Generally, the resulting models are expected to be larger and harder to understand, whereas the redundancy rates are reduced (cf. Figure 4.9b).

Regardless of the selected variation management approach, concerning the flexibility and integration of contextual knowledge in process models, one can add factors causing deviations to the models as

models, in which the stakeholders suffer identifying the flexible parts and the need for flexibility. Following that, the author asked the question whether modelling contextual factors would be a solution to reduce that complexity by separating concerns. Mr. Reichert shared this view that flexibility representation in business process models raises the complexity and added that this is only in some cases manageable. Context modelling is perceived it to be a useful approach to cope with flexibility. Though, Mr. Reichert addressed one important problem in this regard, that the stakeholders or domain experts cannot differentiate what a contextual factor is and they do not know how to extract this type of factors. Therefore they tend to apply "standard solutions"; the contextual information is kept in the business process models, although it results in complex models that are harder to communicate. Consequently the reusability of the contextual factors that might influence other processes reduce. Moreover, the contextual factors evolve since the environment evolves, so it is even harder to manage the contextual information when kept in business process models. The author of this thesis took this answer as a further motivation (alongside with other relevant findings in this thesis) to develop a method for context modelling. The conversation can be watched from http://www.uttv.ee/naita?id=22436 between 67:45-70:15.

8 An in-detail analysis of process variability approaches can be retrieved from [83].

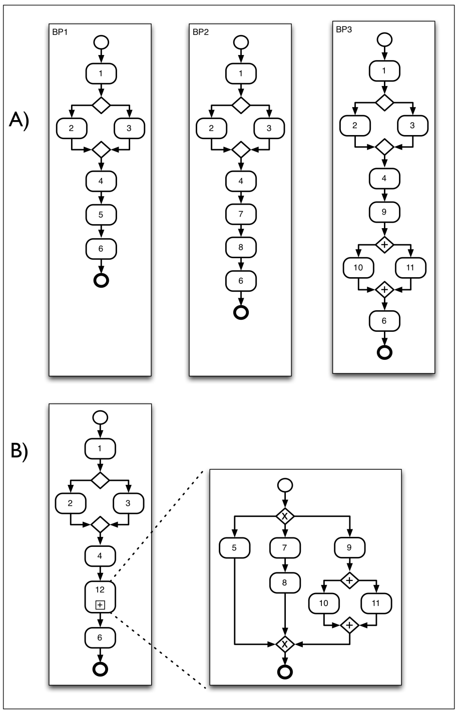


Figure 4.9.: Multi and single-model approaches, taken from [167]

process meta-data or branching conditions. One example of this is shown in Figure 4.10, where the factors are denoted as $F_m \dots F_n$. Another example is illustrated in Figure 4.11, where a check in process is modelled in C-EPC notation. The configuration requirements attached to the gateways and activities represent the context, in which the task should be enacted.

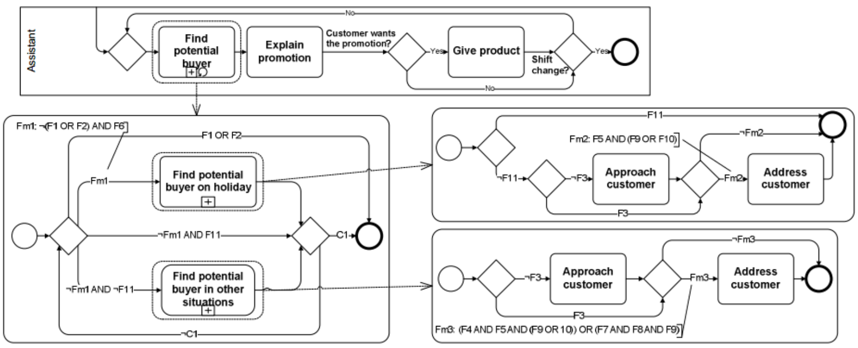


Figure 4.10.: An example of a contextualised business process model, taken from [168, p. 476]

The applicability of process variant management was observed in the context of the application cases. Apart from the shortcomings inherited from BPM languages, approaches in this field proved to be rather complicated to apply for digital services due to following additional reasons:

- Capturing the possible variations of the enterprise models result in a complex view of what the "digital service" actually does and which part of it should be flexible.

- Concerning the digital service design, this type of approaches require an intensive participation of *solution engineers* (see Figure 3.1) since i) they need to implement conceptual solutions, such as rules and ii) update the processes that are affected by contextual information. Moreover this should be done for each and every customer at the solution execution level.

- We have observed that the *business analysts* (see Figure 3.1) have the conceptual solutions and are knowledgeable on what type of services need adjustments based on the context situation. A solution on a technical level as mentioned in the aforementioned points proved to be also not useful from the business analyst point of view, since they do not necessarily have the programming skills needed to implement business rules.

- Even the flexible parts are represented as process variants, the factors that cause a deviation from standard processes should be identified systematically.

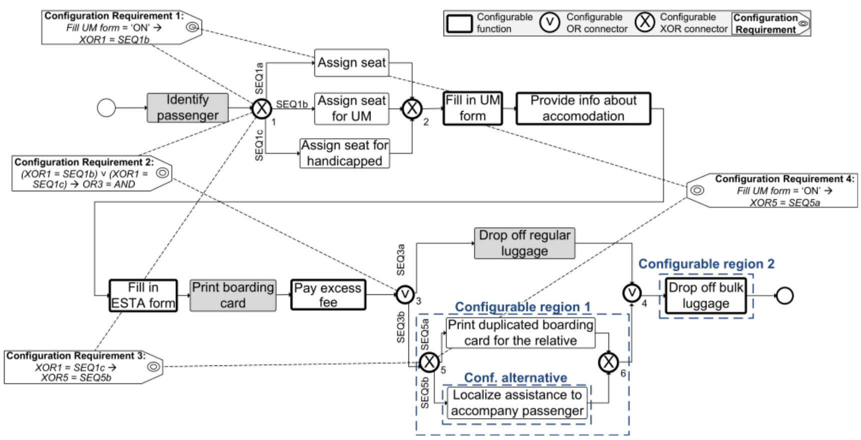


Figure 4.11.: A configurable business process model, taken from [83, p. 267]

Proposal for digital service flexibility

We argue that solutions in that field do not provide the most efficient way to understand contextual factors and eventually communicate it between stakeholders, as discussed earlier. Based on this limitations, a design proposal is made in this thesis, which is based on modelling the application context of a digital service to enhance its flexibility. Context modelling is a promising approach, since it allows representing the flexible parts of a digital service by adhering to the principle of *separation of concerns*, i.e. the process models are used to capture the organisational activities and not further complicated with additional contextual information. Thus, we argue that by representing the flexible parts of a digital service delivery within a context model, the process models would be somewhat relaxed. We observed during the analysis of Service notion that several disciplines had diverse perceptions. These are all relevant in the context of digital services, when one revisits the provided definition in this thesis and checks the implications in section 4.2.1. Consequently, the need rises to find a vehicle that acts as a glue between those various layers (cf. Figure 4.3 and roles participating to digital service design (cf. Figure 3.1). In this work, the idea of capability and capability-oriented thinking is proposed to enable the aforementioned alignment. Against this background, following sections investigate the current state in those fields and summarize the extent, to which the proposals suffice to solve the problem at hand.

4.3 UNDERSTANDING CONTEXT AND ITS MODELLING

The notion of context plays an important role in many areas, both theoretical and applied, such as Formal Logic, Artificial Intelligence, Philosophy, Pragmatics, Computational Linguistics, Computer Science, Cognitive Psychology [169]. It is interpreted in many ways and there is no standard concept, theory or model for the notion of context [170]. For this purposes, following subsections study the notion of context, its various dimensions, selected definitions and context modelling approaches in detail.

4.3.1 *Notion of Context*

Context in Computer Science

In Computer Science the notion of context have appeared first in operating systems field where contexts are regarded as states about the processes, e.g. running, blocked or waiting. Several areas, such as artificial intelligence, software development, databases, data integration, machine learning, and knowledge representation fields also used their own definitions of context, mainly perceiving it as a collection of things associated to some specific situation [170]. Following [171, pp. 24-25], "in software development and databases, the notion of context appears in the form of views, aspects, roles, or even workspaces (. . .). In machine learning, context is treated as environmental information for concept classification. In the area of data integration, contexts are used to exchange and adapt value from local information sources to the global application domain. In artificial intelligence, the notion of context appears as a means of partitioning knowledge into manageable sets, or as a logical construct that facilitates reasoning activities. Finally, in the area of knowledge representation, the notion of context appears as an abstraction mechanism for partitioning an information base into possibly overlapping parts, or for dividing the global schema of a database into clusters in order to deal with schema complexity".

Furthermore, the notion of context refers to situational cognition; as such, it is used to fully describe the conditions of a situation. In computational frameworks, one of the first considerations of context-sensitivity is found in Aspect-oriented Programming (AOP), where the modalities of agents state such as obligations or capabilities, are affected by a context [172]. Many consider context in a user-centric way, with "where the entity is", "who the entity is with", and "what resources are nearby". Others see it as entity-centric, i.e. as the subset of physical and conceptual states of interest to a particular entity [173, 174].

Context in cognitive sciences

Different than computer science, sociological approaches typically regard context as networks of interacting entities (people, agents or actors and artifacts) created and continually updated by the interactions among them [170]. Cognitive sciences define context as the set of all entities that influence human (or system's) behavior on a particular occasion [175].

4.3.2 *Dimensions of Context and Selected Definitions*

Context dimensions

Various definitions of context arise due to its widespread use in different domains as explained in the above section. According to the framework of context use, the definitions and characteristics vary [76, p. 57]. It is important that one should speak of the context in reference to its use [176, p. 193], since there is no real consensual definition. Hence, the interpretation of context depends on the field of knowledge that it belongs to [77]. [177] provides a way to classify these interpretations as follows (taken from [178]).

- Linguistic context is used for disambiguating the meaning of words in texts and denotes the words surrounding the word of interest. An example is the approach presented in [179] to disambiguate keyword-based search using the paragraph surrounding a keyword of interest.

- Situational context includes any information characterizing the state or situation of a person, object or location. This information has to support the purpose of understanding or being relevant for the interaction between a user and an application. Situational context models are often used in ubiquitous computing [180].

- Relational context includes any information pertinent to characterizing the relation of an entity to other entities, where this information is judged according to a given purpose. Examples emphasising relational context can be retrieved from the problem solving domain, which uses contextual graphs to represent contextual information [181, p. 124].

- Formal representations of a perception or part of reality, like a model of an individual's viewpoint, which expresses a local view of the reality.
- The organizational context describes mostly static information about a person. Such an information includes things like roles, positions, tasks, titles etc. and can be provided for instance by an employee database and by a workflow management system [182].

After analysing 13 context meta-models, Bauer provides information about the context dimensions in pervasive computing [183]. The author defines the following dimensions.

- Physical World. Refers to everything concerned with the physical environment, the location (e.g. absolute location, relative orientation), and objects as part of the physical environment.
- Individual. Refers to single persons, e.g. identity, eye color, psychological state.
- Social Groups. Refers to groups in their social environment (e.g. community, social pressure).
- Activity. Refers to variables influencing and surrounding a task.
- Technology. Refers to computing resources, networks or communication infrastructure (e.g., device, computing environment, application).
- Change over Time. Reflects historical changes in the context variable.

The author concludes her work by stating that the physical world is the most discussed dimension, whereas the activity dimension is only very little mentioning. Towards the end of next section, we will discuss the results of this view in the overall context of this thesis.

Context definitions

In the literature mostly cited context definition is from Dey, who describes context as "any information that can be used to characterize the situation of any entity" [174]. According to Winograd this definition is too broad since "something is context because of the way it is used in interpretation, not due to its inherent properties" [184, p. 405]. Although having a common definition of context is a challenging issue, [76, p. 57] identifies invariant characteristics of the context such as (i) context relates always to some entity, (ii) is used to solve a problem (iii) depends on the domain and (iv) is a dynamic process.

This is illustrated in Figure 4.12. Last but not least [77] identifies main components of the concept "context" by examining a corpus of 150 definitions. The study concludes that context definitions can be analysed in terms of six parameters "constraint, influence, behaviour, nature, structure and system". As a result "the context acts like a set of constraints that influence the behaviour of a system (a user or a computer) embedded in a given task".

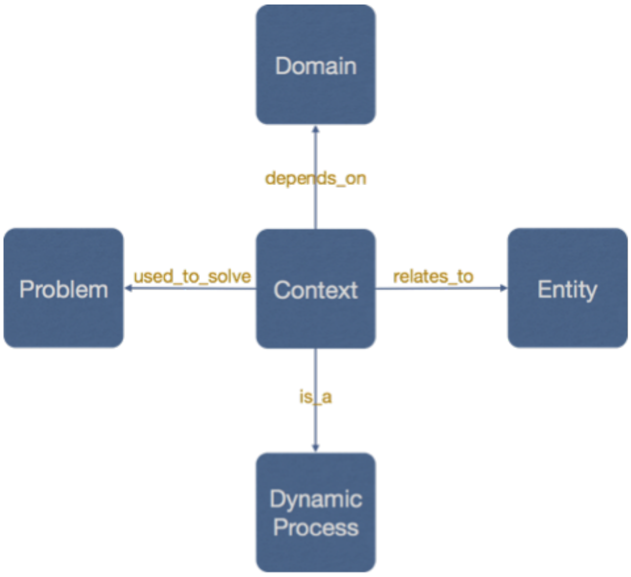


Figure 4.12.: The invariant characteristics of context based on [76]

Regarding the business context, we share Winograd's view that Dey's definition remains very generic and the focus of the observer, i.e. *the way the information is used in interpretation* cannot be detached from the context. However, we argue that based on this seminal definition, it is possible to reduce the abstraction level and limit the scope to find a detailed definition for the purposes of this thesis. In this respect, we first introduce the classification framework of Brézillion and Pomerol [185], who uses three context categories. *Contextual knowledge* contains general information about the situation (compared to Dey's definition, there is not a characterisation yet, but only a situation) and is not focused. For instance, a knowledge worker in SIV has the "normal" focus of attention to ensure that the messages in the task list are cleared. Here, the normal part includes many different contexts, e.g. the schedule of available workers, the contractual agreements, pace of the worker and backlogs. As the contextual knowledge does not have a clear limit, it is possible to extend the list with many "normal" contexts. Furthermore, contextual knowledge is loosely tied to the tasks and goals. When a certain task becomes more precise (e.g. clearing for a certain client), a large part of this contextual knowledge can be proceduralized according to the current focus of the decision making, which is called *proceduralized context*. Again returning back to Dey's definition, the characterisation of the situation happens in the focusing part. The focus determines "what is relevant and might represent a task or a stage while solving a problem or making decision" [53, p. 766]. The rest of the context, which is not relevant for a given situation, is called *external knowledge* in Brézillion and Pomerol's framework.

Based on this classification framework, in this thesis context is defined as any information characterising (i.e. changing, influencing) the provision and design of a digital service that fulfils enterprise goals in a changing environment. The definition puts the emphasis mainly on the proceduralized context based on two facts. First, the **focus of attention** is given and expressed as change factors influencing the provision of a digital service. Second, the context is tied to the **goals**, i.e. the characterising information or its use in digital service provision should be related to certain enterprise objectives.

4.3.3 *Approaches in Context Modelling*

The context modelling allows for describing and structuring of the contextual information [186]. In the following, some examples of context modelling approaches are introduced.

[187] provides a survey of six context modelling approaches in ubiquitous computing. These approaches consist of (i) key-value modelling, (ii) mark-up scheme modelling (*Comprehensive Structured Context Profiles, Pervasive Profile Description Language, ConteXtML,* etc.), (iii) graphical modelling (*Unified Modeling Language (UML), Object Role Modelling, Entity-relationship Model (ER),* etc.), (iv) object oriented modelling (*cues, Active Object Model*), (v) logic-based modelling and (vi) ontology-based modelling (*Context Ontology Language, CONtext Ontology,* etc.). The same article concludes that ontology-based modelling is the most suitable approach for context modelling for ubiquitous computing environments. In this respect, [188] classifies the existing context models into three categories. Application-oriented approaches are mostly used to represent low-level context information and lack formality. Model-oriented approaches utilize conceptual modelling techniques like ER, UML and Object-role Modeling (ORM). Ontology-oriented approaches intend to share knowledge across distributed systems. Finally the authors present a context model based on ontology using Web Ontology Language (OWL). Also [189, p. 267] compares different context modelling approaches for context-aware systems. Similar to [187], they identified relational data models, ontologies, attribute-value tuples, object oriented models and 4-ary predicates in context modelling.

Ontology-based modelling

[190] presents a semantic based context management model and an adaptation strategy of applications to different context situations. In this model, context is considered as an operational term whose

definition depends on the interpretation of the operations involved on an entity at a particular time and space rather than the inherent characteristics of the entity itself[9]. The proposed context model uses the ontology representation for the adaptation of application to new contexts that is based on five context descriptors (subject, predicate, value, time, certainty). As an example, basic context descriptors like "user, device and location" are used to represent domain independent concepts whereas domain specific concepts are defined as subclasses. Semantic Web Rule Language (SWRL) is applied in building specific knowledge for context-aware services, e.g. "if an application is set to run on a device and if the device does not support a particular type of service () then lock this service in the application and take some other action ()". The context-aware architecture is applied by realizing web services, which are defined in Petri-Net formalism. Figure 4.13 shows the context flow and representation model. The Context Manager maps the aggregated context data to Generic Context Ontology in order to make this data "ready for reasoning and decisions". The rules are integrated via the Domain Specific Rule Capture that supplies and retrieves rules from/ to Domain Specific Rule DB. Finally the Context-Aware Service module uses the captured sources of data context, ontology and rules to perform reasoning and decisions.

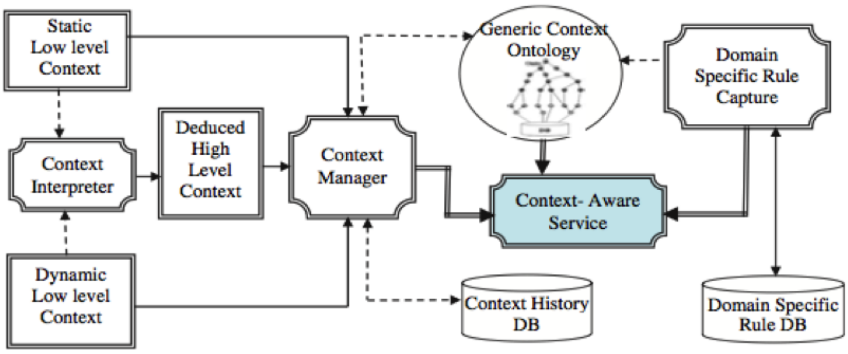


Figure 4.13.: Context flow and representation model, taken from [190, p. 1977]

Authors from [191], propose a context-aware model driven approach, which uses a context model to deal with the automation of user routine tasks. Specifically, they propose a context-adaptive task model, where each routine is specified with user participation as a hierarchical composition of tasks. These tasks are specified according to context in such a way that they are capable of adapting to it. This context information is described in an ontology-based context model

9 This narrows down Dey's seminal context definition in [174], since it does not focus on "any information" but the way that it is used.

based on the SOUPA ontology, the Standard Ontology for Ubiquitous and Pervasive Applications.

After comparing existing approaches on context modelling, [192, p. 287] provides an integrated ontology-based approach comprising of three layers, i.e. conceptual, exchange and functional for pervasive computing environments. Conceptual layer defines the context artifacts and adopts UML and OWL. The context ontology establishes a common vocabulary and is utilized at design time to support the MDD. From the high-level specifications provided at this layer, appropriate data representations and data structures for the other layers can be automatically generated. The exchange layer is applied for interoperability purposes and expresses context information in different formats like XML, JASON or CSV. The functional layer represents the implementation of the context model.

Another contribution in the ontogoloy-based context modelling is found in [193]. The authors propose a context model consisting of four independent and related OWL ontologies: users, devices, environment and services. Each ontology specifies general concepts and relationships involved in intelligent environments. The model can be extended by means of specialization, in order to fit the needs of a given ambient intelligence system. It also supports inference mechanisms to enhance automatic context generation and it enables a proactive and interoperable behavior of information visualization services. In a similar fashion, other context models have been proposed, such as those designed in projects CORTEX [194] and Hydrogen [195].

Graphical modelling

[196] provides MLContext, a textual Domain Specific Language (DSL) which is tailored for modelling context information that has been implemented by MDD techniques. In this approach context is interpreted in accordance with Dey's definition. The abstract syntax of MLContext is provided as a metamodel (cf. Figure 4.14) and the concrete syntax is defined with EMFText tool. The MLContext is designed (i) to provide high-level abstraction for building platform independent models (ii) to be a language which is simple to learn and finally (iii) to promote the reuse of context models in different context-aware applications. Moreover, the authors have automatically generated an OWL ontology from MLContext models using a concrete middleware.

Each decision-making process is under influence of a specific context which is why it is hard to re-use experiences. Thus one needs to model context in order to reflect experience successfully. [197] proposes a Contextual-Graph (CxG) formalism to delineate a process of problem solving in which "a decision-making episode is represented as a contextual graph where each path represents a practice developed by actors for making this decision in a specific working context". Due to time-directed representation and warranty of ter-

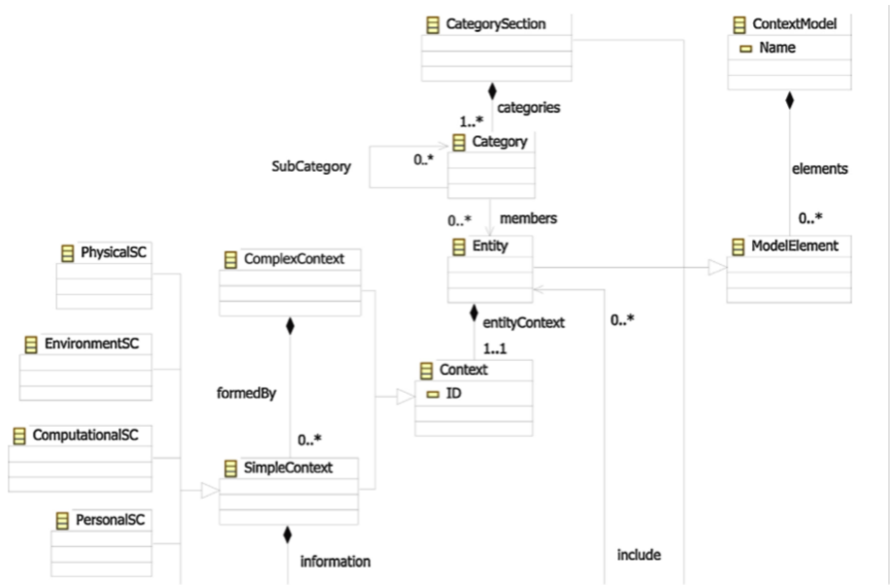


Figure 4.14.: Partial view of MLContext, taken from [196, p. 2895]

mination, contextual graphs are acyclic. Each contextual graph has exactly one root and one end node.

[198] proposes a model-driven development method for context-aware software applications. The method includes a UML profile to create platform-independent models of the application. This allows disregarding the complex and heterogeneous mechanisms that are required to acquire context information and to perform adaptations. Then, by means of automatic transformations, more concrete models can be obtained and, eventually, the software code can be generated.

[199] proposes a graphical context modelling approach, the Context Modeling Language (CML), as a notation for specifying the context requirements in the context-aware domain. CML is based on the modelling constructs of the ORM. Specifically the model defines the user activities, the association between users and hardware resources that receive context data (devices, sensor, communication channel, and location of both users and devices.

Authors from [200], propose ContextUML, a UML profile for specifying context-aware web services. This approach proposes a meta-model (abstract syntax) as an extension using stereotyped classes of the UML meta-model. This meta-model introduces concepts such as, context source, context constraints or context service, and the relationships among them. Authors also introduce a context-awareness modelling perspective; an aspect that considers how services adapt and react to the environment and user preferences. The model is also supported by an UML-like notation (concrete syntax) for defining context-aware services.

Organizational Memory (OM) is the complete knowledge of an organization collected over the time of its existence. [201, p. 6] summarizes the context modelling approaches in organizational memory field as conversational modelling, ontologies, matrix-based relation calculations, process modelling and integration of organizational memory with workflow management systems. In order to represent and use contextual information within an organizational memory application, the author develops a framework by differentiating between organizational, domain/content based, personal and physical contexts.

Same inter-organizational process may be executed in different countries, industries or even regions. Processes as such have to be customized to specific business context. For this purposes, [202] introduces E-UCM, which extends the Unified Context Model (UCM) introduced by the United Nations Centre for Trade Facilitation and Electronic Business (UN/CEFACT). They define "business context" as any information that can be used to characterize the situation of an entity within a scope where business operates. In their proposal the authors extend Business Context Graph (BCG) provided by UN/CEFACT with decentralized sub-graphs that can be adapted to BCG.

Object-oriented modelling

Under the assumption that context is the set of circumstances that frames an event or an object, [77] builds a model of context that represents the components of a situation and the relationship between them. In this respect, [171] defines a context as "a set of objects, within which each object has a set of names and possibly a reference". Studying the interaction between traditional abstraction methods (classification, generalization, attribution) and contextualization, they provide a formal contextualization framework for structuring the contents of a context.

[170] proposes an informal agent-centric and context-aware approach, which depends on activities and relationships between them. The activity is only than executed, if the relevant context is activated via action rules. Roles are also linked to particular contexts and the relevant context is capable of executing different processes.

Lessons learned

This section shows clearly that typically proposals to represent contextual factors in IS are related to the context-awareness paradigm and cover approaches in the mobile applications area, focus around the user and their interaction with the system [159]. In these types of proposals, the most relevant context has a physical nature (e.g. temperature, luminosity, presence sensors) [183]. However, the context of an enterprise and its operations (tasks, actions) require a different conceptualisation to the existing ones. The work of Bauer introduced in section 4.3.2 supports this hypothesis, the conclusion of which is that the context meta-models used in pervasive computing usually focus on the physical part of the context. As such, it is not a coincidence that the understanding of the term context is strongly related to sensory occurrences. In contrast, the least covered context dimension is found to be the activities. Activity dimension comprises of the variables such as task, work, action. We derived an important result from these observations:

- We have shown that digital services are offered process based and changes in the environment should be reflected in the processes that are affected from them. As such, the changes, i.e. the contextual factors, should be related to the activities that are undertaken when providing the customers with the digital service. The modelling approaches and methods from pervasive computing are not expected to be fit to the landscape which is being investigated in this work, since they lack the most important dimension, namely activity required for the provision of the digital services. This is a further motivation in this thesis to develop a different context conceptualisation for the work at hand.

4.4 SLR IN CONTEXT MODELLING METHODS

This section presents the findings of a SLR which is performed to screen the state of the art in the support for identifying, eliciting and modelling context.

To investigate the current state in methods for context modelling, Webster & Watson's snowballing procedure has been used, which was already discussed in section 2.2 [92]. The steps of the snowballing procedure is depicted in Figure 4.15. Following sections first discuss each step in detail. Then, section 4.4.3 discusses the findings and section 4.4.4 summarises them.

4.4.1 *Review Design*

This section introduces the first step of the snowballing procedure (cf. Figure 4.15), i.e. the selection of the literature sources included in the analysis.

The most challenging task when performing a SLR is the identification of the literature sources as there is no clear criteria governing the choice of particular journals [204]. To select the literature sources, we used the rankings provided by the VHB-Jourqual3[10] VHB-JOURQUAL is a journal rating that has been published by the German Academic Association for Business Research (VHB) for many years. It rates the academic business research journals from various disciplines (e.g. Finance, Business Administration, Logistics, Marketing, Business Information Systems). To increase the efficiency and have more relevant results, this work focused on the sub-ratings list

10 `http://vhbonline.org/en/service/jourqual/vhb-jourqual-3/teilrating-wi/`, Last Retrieved 30.08.2016.

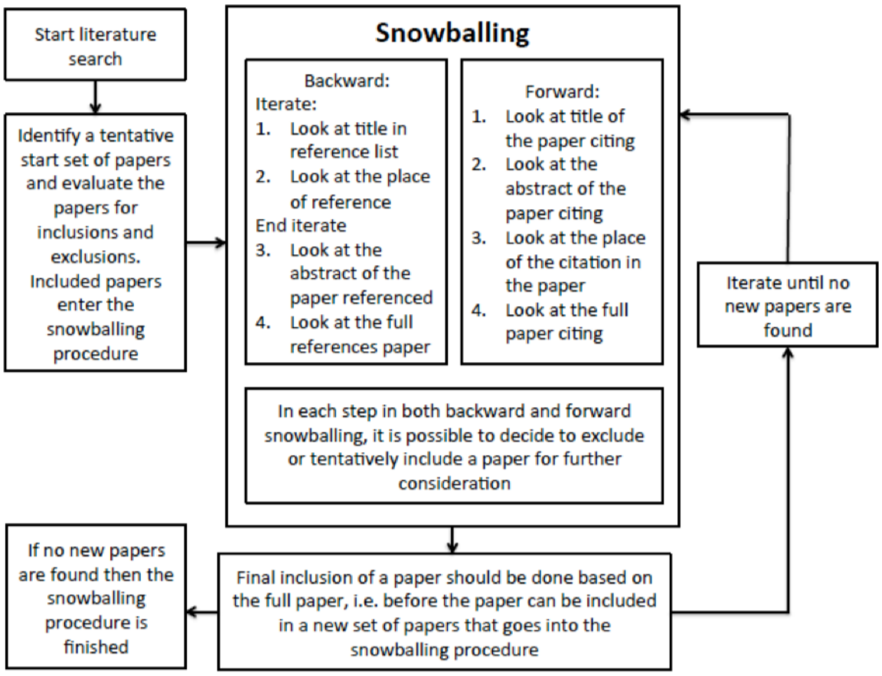


Figure 4.15.: Snowballing procedure taken from [203]

in Business Information Systems (German:Wirtschaftsinformatik)[11]. From this list, A+, A and B journals and proceedings have been selected, which are illustrated in Table 7.

The relevant research questions for this investigation are:

- **RQ1** Which research fields in IS investigate context modelling methods and what motivates the author(s) to analyse and identify context in the respective research field?
  As context and its modelling interested researchers from different areas, this question aims to classify the proposals to the subject fields in IS. Furthermore, it aims to understand the relevance of *context* for the subject under investigation, i.e. what is the perceived problem that should be solved via understanding, managing, modelling, identifying context?

- **RQ2** Which context definitions are provided in the relevant literature?
  This question explicates the context definition adopted by the papers.

- **RQ3** Which ources are used in the proposals to elicit contextual information?
  This question analyses the sources, based on which the proposals derive contextual information. Sources may include DSR

11 http://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/teilrating-wi/, Last Retrieved 30.08.2016

Table 7.: Selected literature sources

Journals & Proceedings	ISSN	JQ3 Rating
Information Systems Research (ISR)	1047-7047	A+
Management Information Systems Quarterly (MISQ)	0276-7783	A+
Journal of Management Information Systems	0742-1222	A
Mathematical Programming	0025-5610	A
Journal of the Association for Information Systems (JAIS)	1536-9323	A
Journal of Information Technology	0268-3962	A
Proceedings of the International Conference on Information Systems (ICIS)	-	A
Information Systems Journal (ISJ)	1350-1917	A
The Journal of Strategic Information Systems	0963-8687	A
European Journal of Information Systems (EJIS)	0960-085X	A
INFORMS Journal on Computing (JOC)	1091-9856	A
SIAM Journal on Computing	0097-5397	A
Journal of the ACM (JACM)	0004-5411	B
Decision Support Systems (DSS)	0167-9236	B
Decision Sciences	0011-7315	B
Computers and Operations Research	0305-0548	B
IEEE Transactions on Engineering Management	0018-9391	B
Business & Information Systems Engineering (BISE)	0937-6429	B
ACM Transactions on Information Systems	1046-8188	B
International Journal of Electronic Commerce (IJEC)	1086-4415	B
ACM Transactions on Management Information Systems	2158-656X	B
ACM Computing Surveys	0360-0300	B
Journal of Computational Finance	1460-1559	B
Artificial Intelligence	0004-3702	B
Group Decision and Negotiation	0926-2644	B
ACM SIGMIS Database	0095-0033	B
Proceedings of the European Conference on Information Systems (ECIS)	-	B
IEEE Transactions on Software Engineering	0098-5589	B
Data & Knowledge Engineering	0169-023X	B
Proceedings of the International Conference on Conceptual Modeling (ER)	-	B
Communications of the ACM (CACM)	0001-0782	B
Information & Management	0378-7206	B
Information Systems (IS)	0306-4379	B
MIS Quarterly Executive	1540-1960	B
Journal of Decision Systems	1246-0125	B
Information and Organization	1471-7727	B
Information Systems Frontiers	1387-3326	B
Electronic Markets (em)	1019-6781	B
ACM Transactions on Computer-Human Interaction	1073-0516	B

artefacts (models, methods, constructions), roles or organisational structures.

- **RQ4** How do the results compare? What are the strengths and weaknesses of the proposals?
  This question compares the methods and discusses them from different viewpoints to identify their strengths and weaknesses. For this, method framework of Goldkuhl (cf. section 5.1.2) is used to define the main variables [51]. These variables were extended with additional conceptual aspects, which seemed relevant considering the derived requirements in section 3.6.2.2.

4.4.1.1 *Step 1: Start Literature Search*

As described in section 2.2, [93] compares Webster and Watson's guidelines to Kitchenham's approach for conducting literature review studies. One shortfall of snowballing is found to be that it might miss the articles with no relevant keywords in the title, since the judgement is mostly based on the title of the paper. To eliminate this weakness, we also searched in the keywords of the publications in the selected literature sources. The search term we used was "context*" and it should either be mentioned in the title or in the keywords of the respective publication.

Scopus is the largest abstract and citation database of peer-reviewed literature[12]. Scopus also allows for an advanced search, where one can create a search string using field codes (author name, abstract, title, keyword etc.) and Boolean operators (AND, OR etc.) to narrow the scope of the search. The final search string applied to the selected 39 journals and proceedings was:[13]

("Journal ISSN" AND (TITLE(context*) OR KEY(context*)))

We did not use any exclusion criteria in this phase, i.e. the findings were not limited to any time frame. A total of 1050 papers resulted from this search string, which should be analysed for an initial inclusion or exclusion in the next step.

4.4.1.2 *Step 2: Define Starting Set*

This step evaluates the papers that enter the snowballing procedure. First, the articles that are not written in English and the articles for which the author had limited access were eliminated. Then, screening of the titles and abstracts of the remaining papers was performed. As a result, 19 papers were included in the tentative start set. To conclude this step, a full-text reading of these 19 papers were performed and 7 publications were rated relevant to enter a snowballing procedure.

12 https://www.scopus.com/, Last Retrieved 18.08.2016.
13 Note that the field "Journal ISSN" was adapted each time.

Main reason to eliminate the 12 articles was that they mostly presume which factors are contextual in a specific setting and do not provide ways to elicit these. To exemplify, [205] provides a way to represent contextual information (as contextual graphs) but does not show how to elicit such information. In [206, 207], context is predefined, the activities that have been carried out to classify this information as contextual is completely missing. [208] develops a solution for contextual decision making, yet, the work does not show how to elicit that context. Publications entering the snowballing procedure are shown in Table 8. The column *ID* refers to the unique code given to the papers by the author of this thesis. *Title* and *Author(s)* column include the name of the publication and the authors respectively. The column *Type* indicates whether the paper is identified in a conference proceeding or a journal article, the name of which is mentioned in the *Name* column. The column *Year* shows the publication year of the paper.

4.4.2 *Snowballing Procedure*

In this section, the author of the thesis goes *backward* by reviewing the reference lists of the articles identified in step 2. Furthermore, he goes *forward* by identifying articles that cite the articles found in step 2. Each new paper triggers another iteration, the procedure continues until no new papers are found. This technique is called backward and forward snowballing respectively, which are detailed in the following sections.

4.4.2.1 *Step 3: Iteration 1: Backward Snowballing*

In the first iteration of the backward snowballing procedure, *references* section of the papers P1 to P7 are analysed. As a first step, the titles of the cited publications as well as the place of publication (name of the conference or journal) in the reference list are checked. If there is a relevancy to the methods for context identification, elicitation or modelling, then abstract and/or full-text reading[14] is conducted, based on which the respective article is included or excluded.

To ensure the compatibility for providing an ID to the relevant papers, a simple naming convention was used. The included articles received the ID "ITxBx", which refers to <IterationNr.><Backward(B) or Forward(F) Snowballing><Nr. of the article found in this iteration>. Figure 4.16 shows an ID of a publication, which is the first relevant paper ("**1**" at the end) in the 1st iteration ("**IT1**") of a backward snowballing ("**B**"). Beginning with the P1, the first iteration of backward snowballing is detailed in the following.

14 In the cases, where the author was not clear whether to include or exclude the publication.

Table 8.: Publications entering the snowballing procedure

ID	Title	Author(s)	Type	Name	Year
P1	Context-based Modelling of Information Demand: Approaches from Information Logistics and Decision Support	Levashova,T., Lundqvist, M., Sandkuhl, K., Smirnov, A.	Conference	European Conference on Information Systems	2005
P2	Conceptualizing Context for Adaptive Pervasive Commerce	Bauer, C., Spiekermann, S.	Conference	European Conference on Information Systems	2011
P3	Challenges in the Context-aware Management of Business Processes: A multiple case study	Ploesser, K., Recker, J., Rosemann, M.	Conference	European Conference on Information Systems	2011
P4	Building a Methodology for Context-Aware Business Processes: Insights from an Exploratory Case Study	Ploesser, K., Recker, J., Rosemann, M.	Conference	European Conference on Information Systems	2010
P5	Automated Planning of context-aware Process Models	Heinrich, B., Schn, D.	Conference	European Conference on Information Systems	2015
P6	Business Processes Contextualisation via Context Analysis	De La Vara, J.L., Ali, R., Dalpiaz, F., Sanchez, J., Giorgini, P.	Conference	International Conference on Conceptual Modeling	2010
P7	Modeling Domain Variability in Requirements Engineering with Contexts	Lapouchnian, A., Mylopoulos, J.	Conference	International Conference on Conceptual Modeling	2009

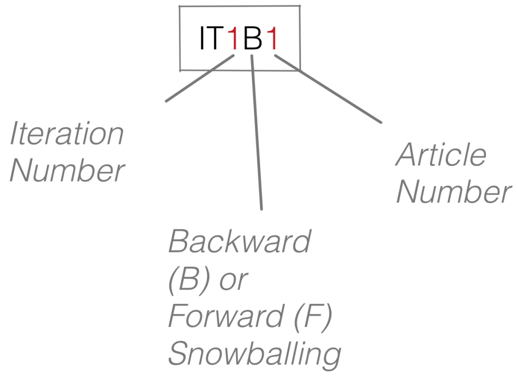


Figure 4.16.: ID naming convention for the identified publications

- **P1** cites 19 publications, none of which is found relevant.
- **P2** cites 40 publications. 4 papers are tentatively included and extracted for a full-text reading. After a closer examination, the four papers are not found relevant.
- **P3** cites 33 publications. 4 papers are relevant, one of which is eliminated as it referred to P4, which is already included. Consequently, the set of relevant papers are extended with 3 papers. These are named IT1B1, IT1B2 and IT1B3 (see Table 9).
- **P4** cites 33 publications, 3 of which are found relevant. Though, two of them have been already included. The set of relevant papers is extended with IT1B4.
- **P5** cites 69 publications, of which 8 are relevant. 5 of them are not included, either because similar or same articles from the same authors were already identified. Two articles are eliminated due to the restricted access. As a result, the set of relevant papers is extended with IT1B5.
- **P6** cites only 5 publications. 2 of these papers are relevant, however, only 1 article (IT1B6) is added to the set, since the other 2 articles are already included.
- **P7** cites 18 publications. 4 papers are tentatively included and are extracted for a full-text reading. 1 of them is directly eliminated due to restricted access. The remaining three are not included as the content did not seem relevant after a closer examination.

Preliminary result in Step 3

The set of seven articles (P1 to P7) is extended with 6 further articles (IT1B1 to IT1B6). As a result, we have a total of 13 articles, which are

Table 9.: Included papers in the 1st backward snowballing iteration

Code	Title	Author(s)	Type	Name	Year
IT1B1	Context Change Archetypes: Understanding the Impact of Context Change on Business Processes	Ploesser, K., Janiesch, C., Recker, J., Rosemann, M.	Conference	Australasian Conference on Information Systems	2009
IT1B2	Supporting Context-aware Process Design: Learnings from a Design Science Study	Ploesser, K., Recker, J., Rosemann, M.	Conference	Business Process Management Workshops	2011
IT1B3	Contextualisation of Business Processes	Rosemann, M., Recker, J., Flender, C.	Journal	International Journal of Business Process Integration and Management	2008
IT1B4	Context-based Configuration of Process Variants	Hallerbach, A., Bauer, T., Reichert, M.	Conference	Int. Workshop Technol. Context-Aware Bus. Process Manage. - TCoB @ICEIS	2008
IT1B5	Capturing Variability in Business Process Models	Hallerbach, A., Bauer, T., Reichert, M.	Journal	Journal of Software Maintenance and Evolution: Research and Practice,	2010
IT1B6	A Goal-based Framework for Contextual Requirements Modeling and Analysis	Ali, R., Dalpiaz, F., Giorgini, P.	Journal	Requirements Engineering Journal	2010

shown in Table 9. In the next step, publications P1 to P7 will enter to the forward snowballing procedure and the first iteration will be closed.

4.4.2.2 *Step 3: Iteration 1: Forward Snowballing*

In the first iteration of the forward snowballing procedure, the publications that refer to the paper set P1 to P7 are investigated. Forward snowballing is performed by using Google Scholar[15], as it exposes more precise results than Scopus. For instance, according to Scopus, no papers refer to P1, whereas Google Scholar shows 7 citing papers. Similar to the backward snowballing, the titles of the publications referring to the set (P1 to P7) as well as the place of publication (name of the conference or journal) are checked first. If the paper contributed to the field "methods for context identification, elicitation or modelling", then abstract and/or full-text reading[16] is conducted. In the final step, the article is either included or excluded. The included articles received the ID "ITxFx" (cf. Figure 4.16 for naming convention).

Beginning with the P1, the first iteration of forward snowballing is detailed in the following.

- **P1** is cited by 7 publications, one of which is found relevant and named as IT1F1.
- **P2** is cited by 3 publications, none of which are relevant.
- **P3** is cited by 6 publications and 2 of them are relevant. Those receive the IDs IT1F2 and IT1F3.
- **P4** is cited by 12 publications. The relevant publications were already included in the set. Hence, no new papers are identified.
- **P5** is cited by 6 publications, none of which are relevant.
- **P6** is cited by 22 publications. Three seem relevant, yet, two papers are directly eliminated due to the restricted access. The remaining paper is included and receives the ID IT1F4.
- **P7** is cited by 22 publications, one of which is found relevant and named as IT1F5.

Preliminary result in Step 3

Before this step, P7 was extended with 6 articles (IT1B1 to IT1B6) by backward snowballing. At this stage, forward snowballing of P7 identifies 5 (IT1F1 to IT1F5) new articles, which results in a total of 18 relevant papers. New papers found in this step are illustrated in Table 10.

15 `https://scholar.google.com/`.

16 In the cases, where the author was not clear whether to include or exclude the publication

Table 10.: Included papers in the 1st forward snowballing iteration

Code	Title	Author(s)	Type	Name	Year
IT1F1	How to Identify the Relevant Elements of "Context" in Context-Aware Information Systems?	Sandkuhl, K., Borchardt, U.	Conference	Perspectives on Business Information Research	2014
IT1F2	Towards a Generic Context Model for BPM	Saidani, O., Rolland, C., Nurcan, S.	Conference	Hawaii International Conference on System Sciences	2015
IT1F3	Conceptualisation of Contextual Factors for Business Process Performance	Kronsbein, D., Meiser, D., Leyer, M.	Conference	International MultiConference of Engineers and Computer Scientists.	2013
IT1F4	COMPRO: A Methodological Approach for Business Process Contextualisation.	de La Vara, J.L., Ali, R., Dalpiaz, F., Sanchez, J., Giorgini, P.	Conference	On the Move to Meaningful Internet Systems	2010
IT1F5	Eliciting Contextual Requirements at Design Time: A Case Study	Knauss, A., Damian, D., Schneider, K.	Conference	International Workshop on Empirical Requirements Engineering	2014

4.4.2.3 *Step 3: Iteration 2: Backward Snowballing*

The results of the first iteration in backward snowballing are used as an input in this step, i.e *references* section of each paper from IT1B1 to IT1B6 are analysed. A total of 200 citations are screened. The relevant publications mostly cite to the older works of the authors, which to a large extent reflect the same findings with the paper under study. As such, no new papers are added to the set after this iteration.

4.4.2.4 *Step 3: Iteration 2: Forward Snowballing*

In this step, the publications that refer to the paper set IT1F1 to IT1F6 are investigated. Findings are briefly summarized as follows.

- **IT1B1** is cited by 5 articles, one of which is found relevant and receives the ID IT2F1.
- **IT1B2** is cited by 4 articles, none of which are relevant.
- **IT1B3** is cited by 168 articles. After eliminating the papers that are already included, the list is extended with 3 additional articles, receiving the IDs IT2F2, IT2F3 and IT2F4 respectively.
- **IT1B4, IT1B5 and IT1B6** are cited by 74, 252 and 133 publications respectively. A large amount of overlaps are identified in the citing articles, i.e. the authors cite to the relevant papers in their future articles or the relevant articles were already included. Consequently, no new papers are identified.

Preliminary result in Step 3

Before this step, the set of relevant papers included 18 papers (P1-P7 + IT1B1-IT1B6 + IT1F1-IT1F5) In this step, four new papers are added (IT2F1-IT2F4, as shown in Table 11), which sums to 22 papers.

4.4.2.5 *Step 3: Iteration 3: Backward Snowballing*

References section of each paper from IT1F1 to IT1F5 are analysed in this iteration. Findings are summarized as follows.

- **IT1F1** cites 18 publications, 1 paper is relevant (IT3B2).
- **IT1F4** cites 26 articles, 1 paper is relevant (IT3B1).
- **IT1F2, IT1F3, IT1F5** cite 42, 29 and 29 articles respectively. After eliminating the overlaps, no relevant papers are identified.

Preliminary result in Step 3

During this iteration, 144 citations are analysed and the set of relevant publications including 22 papers are extended with two additional articles, which are shown in Table 12.

Table 11.: Included papers in the 2nd forward snowballing iteration

Code	Title	Author(s)	Type	Name	Year
IT2F1	The Quest for Organizational Flexibility: Driving Changes in Business Processes Through the Identification of Relevant Context.	Anastassiu, M., Santoro, F.M., Recker, J., Rosemann, M.	Journal	Business Process Management Journal	2016
IT2F2	Dynamic Process Adaptation: A Context-aware Approach	Vanessa, N., Werner, C.M.L., Santoro, F.M.	Conference	Computer Supported Cooperative Work in Design	2011
IT2F3	Process Improvement Based on External Knowledge Context	Ramos, E., Santoro, F.M., Baiao, F.	Conference	Australasian Conference on Information Systems	2010
IT2F4	Towards a Context-aware Analysis of Business Process Performance.	Leyer, M.	Conference	Pacific Asia Conference of Information Systems	2011

Table 12.: Included papers in the 3rd backward snowballing iteration

Code	Title	Author(s)	Type	Name	Year
IT3B2	Towards a Methodology for Context Sensitive Systems Development	Mena, B.T., Saoud, N.B., Ahmed, M.B., Pavard, B.	Conference	CONTEXT	20007
IT3B1	A Methodology for Designing and Managing Context-Aware Workflows	Modafferi, S., Benatallah, B., Casati, F., Pernici, B.	Conference	Mobile Information Systems II	2005

Table 13.: Included papers in the 4th backward snowballing iteration

Code	Title	Author(s)	Type	Name	Year
IT4B1	Making Workflows Context-aware: A Way to Support Knowledge-intensive Tasks	Heravizadeh, M., Edmond, D.	Conference	Asia-Pacific Conference on Conceptual Modelling	2008

4.4.2.6 *Step 3: Iteration 3: Forward Snowballing*

After investigating 24 papers citing to the publication set IT1F1-IT1F5. No new papers are added to the set after this iteration.

4.4.2.7 *Step 3: Iteration 4: Backward Snowballing*

References section of each paper from IT2F1 to IT2F4 are analysed. Findings are summarized as follows.

- **IT2F1** cites 42 publications, 1 paper is relevant (IT4B1).
- **IT2F2, IT2F3, IT2F4** cite 36, 31 and 38 articles respectively. After eliminating the overlaps, no relevant papers are identified.

Preliminary result in Step 3

In this iteration, 147 citations are analysed and the set of relevant publications including 24 papers are extended with one article, which is shown in Table 13.

4.4.2.8 *Step 3: Iteration 4: Forward Snowballing*

This step investigates 32 papers citing to the publication set IT2F1-IT2F4. After eliminating the already included articles, the remaining list does not expose any relevant papers.

4.4.2.9 *Step 3: Iteration 5: Backward Snowballing*

References section of IT3B1 and IT3B2 are analysed. The works refer to 46 articles and as most of them are already included. Hence the final set of relevant papers is not extended.

4.4.2.10 *Step 3: Iteration 5: Forward Snowballing*

Publications referring to IT3B1 (26 papers) and IT3B2 (10 papers) are screened. Only one paper citing to IT3B1 seems relevant. However, due to the restricted access, this article cannot be included.

4.4.2.11 *Step 3: Iteration 6: Backward Snowballing*

References section of IT4B1 is analysed. The work cites 17 articles, none of which seems relevant for the investigation purposes.

4.4.2.12 *Step 3: Iteration 6: Forward Snowballing*

Publications referring to IT4B1 (cited by 16 articles) are screened. Also in this phase it is not possible to identify any relevant work.

4.4.2.13 *Step 3: List of the Selected Articles*

As no further relevant articles are found, the snowballing procedure is finished. The final set comprises of a total of 25 papers, which need to be analysed. The iterations, the identified articles and the relations between them are illustrated in Figure 4.17. The list of selected articles including the author names, publication venue and publication year is shown in Table 46 in the Appendix.

4.4.3 *Data Analysis*

The snowballing procedure resulted in a total of 25 papers, which will establish the basis for answering the research questions expressed in section 4.4.1.

RQ1: Which research fields in IS investigate context modelling methods and what motivates the author(s) to analyse and identify context in the respective research field?

The need for **organizational flexibility** seems to be the most prominent reason for understanding context and developing context-aware solutions. IT1B1 argues [209] "if the enterprises and supporting information systems understand and capture context, then they can react to the changes appropriately and timely enough". Similarly, IT2F3 [210] uses context to "identify and answer appropriately to changes in the internal and external environments of organisations" and in IT1F4 [211] context is perceived to be a useful instrument to adapt the behaviour of organizations and their software systems, which operate in an environment where changes happen frequently. One way of using context is classifying the change drivers, as shown in IT2F1 [53].

Considering the leading role of **BPM** in changing environments, most of the works focus on identification, classification and elicitation of the process context, which an enterprise implements to deliver a service. To begin with, IT1B3 [159] argues that root causes driving the demand for flexible business processes can be found in the context of a process. P3 [212] interprets contextual information as an aid to conceptualize the business processes of an enterprise from an external

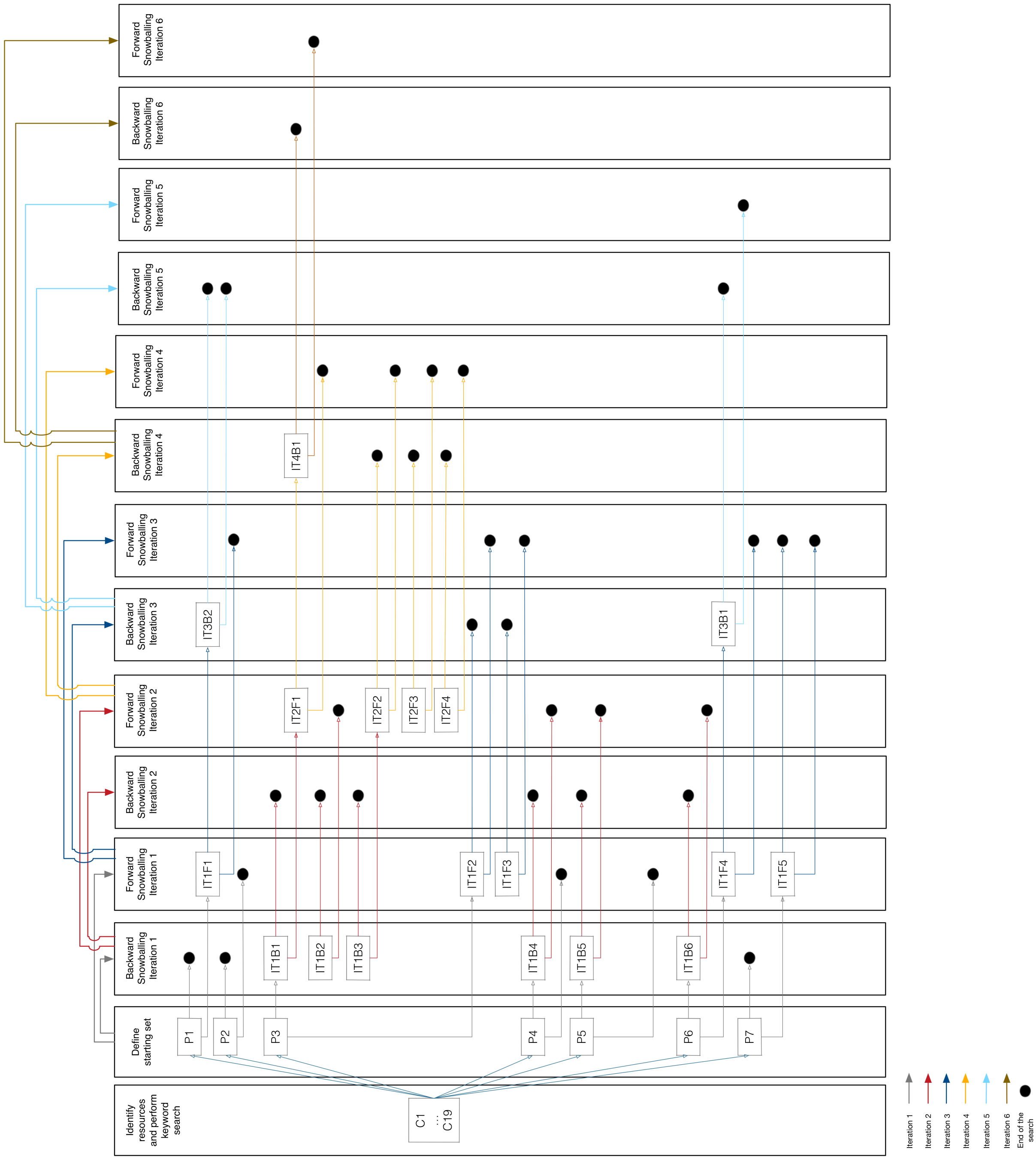


Figure 4.17.: Papers identified during the snowballing procedure and their relation

perspective. This view is supported in P4 [213] and in IT1B2 [214], where context is proposed as a solution to the structural problems caused by highly dynamic factors influencing the business processes. Likewise, P6 [168] and IT1F2 [186] address the fast-changing environments in which the business processes are modelled and implemented and uses context as an instrument to understand such factors. Last but not least, IT2F2 [215] states "flexibility in processes could be managed in real time, using context information."

The changes in the environment in which a business process is executed usually cause designing and implementing variants of respective processes. Context is used in IT1B4 [162] and IT1B5 [164] to identify and represent the business process variants. Context-based variant selection mechanisms are provided in P5 [216], which uses context to support the non-static aspects of processes to enhance the flexibility. Investigating context in the BPM area is not only limited to the process modelling tasks at design time and process execution alternatives at run-time. IT1F3 [217] proposes a context-aware approach to understand the factors that influence the performance of business processes and IT2F4 [218] demonstrates the benefits of considering context during the analysis of business process performance.

Proposing context-aware solutions to fulfil the need for organizational flexibility is not only stressed in the BPM field. Also, enterprise objectives are influenced from the dynamic environments, strategies need to be adapted to various situations. IT1B6 [219] argues that "it is essential to monitor and adapt to an inherently varying context, as context influences software and stakeholders goals as well as their choices". Approaches in Requirements Engineering (RE) deal with context to tackle with the problems that may arise from changing stakeholder requirements, IT1F5 [220] argues that context is an important factor that needs to be taken into account in requirements modelling, as the systems and their users change. In this respect, context is used in P7 [221] to help to capture the domain variability when modelling requirements.

Another research field investigating context-aware solutions is the Decision Support in knowledge intensive tasks. P1 [222] states "context is required to provide accurate, purpose-oriented and up-to-date information to the users that perform knowledge intensive work". IT4B1 [223] uses context to extend the boundaries of the current workflow technology, to provide the users with the right information at right time to perform their knowledge intensive tasks.

Last research field proposing context elicitation and modelling methods is context-aware computing, where solutions to improve personalization aspects are investigated. As an example, P2 [224] stresses the importance of context recognition to enhance the success of adaptive advertisements and develops an approach to conceptualize context for adaptive pervasive advertising applications. IT3B1

[225] states "capturing and managing user context is becoming more and more important in business applications". In this respect, IT1F1 [178] proposes modelling and using context in order to adapt to an application user's situation on demand. For this, IT3B2 [76] integrates context elicitation steps to traditional engineering processes.

To sum up, BPM, RE, Context-aware Computing and Decision Support in knowledge intensive tasks investigate methods to elicit and model context in IS research. The proposals mainly aim to solve the problems that limit the capability of organizations to adapt to ever-changing environments, or in short, they aim to enhance flexibility in organizations.

RQ2: Which context definitions are provided in the relevant literature?

When analysing the definitions of the term "context", it becomes very clear that Dey's seminal definition "context is any information characterising the situation of an entity" [174] inspired many scholars. A number of the authors applied it as it is, e.g. IT1F5 [220] and P5 [216]. As this definition is generic enough, a few papers adapted this definition to the field of investigation, e.g. in IT1F1 [178], context is defined as "any information that can be used to characterize the situation of an entity, where an entity is a person, place, or object that is considered relevant to the **interaction between a user and an application**[17], including the user and the application themselves". Similar attemps are observed in IT1F3 [217], in IT3B1 [225] and in IT2F1 [53], where context is defined as "the basis for differentiating one situation from another, and characterize entities and events".

Nevertheless, efforts to construct an own context definition exist. To exemplify, P2 [224] defines context as "the process by which a personalization situation is deconstructed into measurable and logically disjunctive information units, all of which must be combined to create an adaptive service." IT1B6 [219] states "context is a partial state of the world that is relevant to an actor's goals". Extending the actors goals to the organizational goals, IT2F2 [215] proposes a "unique" definition of the term and expresses context as "a pointer to distinguish among the available information during the execution of a process, those that are relevant in order to provide inputs for the analysis of the people who is collaboratively participating and the process instance adequacy to the current situation, addressing organizations goals and strategy".

Three works define context by relating it to certain variables and environmental properties. IT2F3 [210] states "(context is) the minimum set of variables containing all relevant information impacting the design and implementation of a business process". Similarly,

17 This is the part, where Dey's definition is adapted

IT1F4 [211] argues that context is "the set of environmental properties that have an impact on process design and/or execution". The brief and generic definition provided in IT3B2 [76] seems to cover the two former expressions, where the authors define context as "an abstract and relative notion, which depends on the triplet <Domain, Entity, Problem>". Considering the contribution of IT3B2 - to develop a context modelling method which can be used to extend traditional engineering processes - it is comprehensible to choose a more general definition of the term.

Interestingly P3 [212], P4 [213], P7 [221], IT1B1 [209], IT1B2 [214], IT1B4 [162], IT1B5 [164], IT2F4 [218], IT4B1 [223] do not mention how they define context, instead, the authors present examples of how context is defined in the literature. There are also works that only ambigiously define the term, e.g. P6 [168] speaks only of "the context of a business process".

To summarize, Dey's seminal work paved the way to define context and even adapt it to different "contexts". Nevertheless, the amount of publications that do not describe the term explicitly nor select an existing definition is higher than author's expectations.

RQ3: Which resources are used in the proposals to elicit contextual information?

The analysis of the relevant publications resulted in three distinct resource classes that are used to elicit contextual information.

1. Conceptual Models

This class includes Enterprise Modelling artefacts, e.g. graphical representations of business processes, enterprise objectives or use case scenarios. Using those artefacts as a resource to elicit contextual information seems to dominate. One such artefact is the business process models. IT1B1 [209] uses business process models and asks four questions allow for the identification of measures for the awareness of the organisation with respect to contextual variables; a) what is relevant context; b) where does context change impact processes; c) how does context change impact processes; and d) when does context change occur. IT1B4 [162] and IT1B5 [164] analyse the reasons why a process changes and classifies contextual information as *attributes of the change request*. IT2F1 [53] proposes a method, ORGANON, for identifying business process-relevant contextual information that is likely to impact the process goal. The method is fundamentally based on the analysis of a process model. Similarly, P6 [168] analyses the business processes and IT4B1 [223] derives contextual information from business process models and the problems that may arise during their execution. Last but not least, IT3B1 [225] investigates contextual information by analysing workflows of the related service.

Not only the conceptual models reflecting the activities and their sequences are relevant to identify context, but also the goals aspect is considered important. P7 [221] derives contextual information from goal models by using certain formalisms. Both IT1B3 [159] and IT2F3 [210] analyse process goals and elicit contextual information from them.

In some cases, analysis of variations in conceptual models create the basis for the context elicitation. To examplify, IT1B6 [219] extracts context from a set of variation points defined in a goal model. In IT1F4 [211], starting from an initial business process model, context is analysed in order to discover its relevant variations and specify their effect on a business process.

We also encountered examples that represent more generic types of what we call Enterprise Modelling artefacts. IT1F1 [178] analyses scenario representations (diagrams, visual models) to identify contextual information to be used in context-aware applications. Another example is provided in P1 [222], which investigates amongst others enterprise models (process models, organisational structures and resources) to derive an information demand context.

2. Stakeholder Aspect

This class includes the publications which use strategies, roles, Key Performance Indicator (KPI)s and stakeholder views to elicit contextual information. IT1F5 [220] proposes conducting interviews with various groups of stakeholders, investigates how requirements from those groups differ (conflicts). Then, from this delta, contextual requirements (requirements that are valid in a specific context) will be derived. IT3B2 [76] also elicits contextual information from the results of the requirement analysis, which are defined as problems to be solved. Without detailing the required inputs and resources, IT2F2 [215] proposes to analyse goals and strategies to derive contextual information.

Variation analysis plays also from the stakeholder point of view a distinguished role for context indetification. Both P4 [213] and IT1B2 [214] elicit contextual information by interviewing related roles about the recurring deviations in KPIs and reasoning about such deviations.

3. Other Aspects

This class is populated by the articles, which i) do not describe the resources that are required to derive contextual information or ii) do not use the enterprise models nor stakeholder aspects. While P2 [224] does not mention such aspects, the work conceptualizes context by using a top-down and a bottom-up approach. The top-down approach is informed by a literature review and involves reflecting on the overall dimensions of the system under review. Also IT2F4 [218] skips those aspects, though the importance of process data and the extracted information from the literature seem to be the resources of context elicitiation. IT1F3 [217] does not identify contextual information, instead assumes that the context is known (such as "workload of the process") and it structures them by using a framework. P5 [216] creates a plan graph with belief states and actions and derives context variables automatically with the help of mathematical formalisms.

Only two publicatons, namely P3 [212] and IT1F2 [186] does not mention, which resources are used to elicit or derive contextual information.

To sum up, the number of papers analysing conceptual models to derive contextual information are high. More than a half of the papers (14/25) use the visual artefacts that describe business processes, enterprise goals or application scenarios to derive contextual information, the "change reasons", "affected goals" and "variations" being the focal point of investigation.

RQ4: How do the results compare? What are the strengths and weaknesses of the proposals?

To answer this research question, an extension of Goldkuhl's method framework (cf. section 5.1.2) is used as a basis to compare the results and define the main criteria for it [51]. These criteria are enriched with additional conceptual aspects, which help to extract information that relate to the requirements listed in section 3.6.2.2 and to the outlined solution proposal. After defining the variables, a comparison of 25 papers are performed from the method[18] support point of view. The variables are defined as follows:

- Procedure: Is the method described in terms of activities or steps to be followed?
- Input/ Output: Does the method describe the input required by the activities and the output produced by them?
- Tool Support: Does the method mention tool(s) that can be used to model context?
- Notation: What type of graphical representation is used for modelling context? (if none is used, then the cells get the value "no")
- Concept: Does the method define important aspects of reality that are relevant in the modelling process?
- Stakeholders: Does the method support certain stakeholders in modelling, eliciting and identifying context or mention roles that are supposed to use the method?
- Prerequisites: Does the method mention the preconditions or requirements to use the method?

18 When describing the variables in the following, the term "method" is used, which is supposed to cover other related terms such as "approach, framework" or, "model".

- Flexible: Does the method allow for different starting points or does it have a component-wise structure?
- Guidelines: Does the method provide guidelines to elicit, identify or model the context?
- Meta-model: Does the method include a meta-model, e.g. to define the important concepts and the relationships among them?

Additional conceptual aspects are defined as follows:

- Supports/ uses Goals: Does the method consider enterprise objectives for context elicitation or address its relation to the organizational strategies explicitly?
- Supports/ uses BPM: Does the method support designing context-aware business processes or address its relation to the business processes explicitly?
- Supports runtime aspects: Does the method support run-time aspects, i.e. how the context models can be put into operation or how they can be incorporated into running systems?
- Supports capability modelling: Does the method provide support for modelling the capabilities?
- Research Field: The area, in which the method is supposed to be applicable (reflects the information from RQ1). As already discussed in RQ1, four main fields seem relevant, Context-aware Computing, BPM, Decision Support and RE.
- Terminology: Which naming conventions are used by the author(s) of the paper to characterise the contribution (e.g. method, methodology, task, approach or framework)?
- Formalised: Is the method defined in terms of formalisms, such as graphs, edges, nodes or mathematical equations?

Analysing the results of the RQ 4

Procedure: Most of the publications (17 out of 25, i.e. 68%) describe the procedures that the proposed method should follow. As expected, the level of detail when explaining them vary. For instance, the procedure shown in P1 [222] divides the tasks for context modelling as activities, whereby P2 [224] and IT1B1 [209] remain very generic regarding the steps to elicit and model context (cf. Figure 4.18).

Input/ Output: Traditionally, methods are seen as blackboxes which take inputs to produce outputs [129, 102]. In this respect, the papers were screened to find out whether required inputs and produced outputs are documented by the methods. The percentage

Table 14.: Comparing the findings

ID	Procedure	Input/ Output	Tool Support	Notation	Concept	Supports/ uses Goals	Supports/ uses BPM	Supports runtime aspects	Stakeholders	Prerequisites	Flexible	Supports capability modelling	Guidelines	Meta-model	Research Field	Terminology	Formalised
P1 [222]	Yes	Yes	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Decision Support	Approach	No
P2 [224]	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	Context-aware Computing	Methodology	No
P3 [212]	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	BPM	Task	No
P4 [213]	Yes	No	No	Causal Loop Diagrams	Yes	Yes	Yes	No	No	No	No	No	No	Yes	BPM	Methodology	No
P5 [216]	Yes	No	No	Accept Event Actions	Yes	No	Yes	Yes	No	No	No	No	Yes	No	BPM	Approach	Yes
P6 [168]	Yes	Yes	No	Tables & BPMN	Refers to IT1B7	No	Yes	Yes	No	No	No	No	No	No	BPM	Technique	Yes
P7 [221]	Yes	No	No	Tropos Goal Modeling	Yes	Yes	No	No	No	No	No	No	No	Yes	RE	Method	Yes
IT1B1 [209]	Yes	No	No	No	No	No	Yes	Yes	No	No	No	No	No	No	BPM	Framework	No
IT1B2 [214]	No	No	No	No	No	No	Yes	Yes	No	No	No	No	Yes	Yes	BPM	Framework	No
IT1B3 [159]	Yes	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	BPM	Framework	No
IT1B4 [162]	No	No	No	Tables	Yes	No	Yes	Yes	No	No	No	No	No	No	BPM	Approach	No
IT1B5 [164]	No	No	No	Tables	Yes	No	Yes	Yes	No	No	No	No	No	No	BPM	Approach	No
IT1B6 [219]	No	No	No	Tropos Goal Modeling	Yes	Yes	No	Yes	No	No	No	No	No	No	RE	Framework	Yes
IT1F1 [178]	Yes	No	No	No	Yes	No	No	Yes	No	Yes	No	No	Yes	No	Context-aware Computing	Approach	No
IT1F2 [186]	No	No	No	No	Yes	Yes	Yes	Yes	No	No	No	No	No	Yes	BPM	Model	No
IT1F3 [217]	Yes	No	No	No	No	No	No	No	No	No	No	No	No	No	BPM	Framework	No
IT1F4 [211]	Yes	Yes	No	Extends BPMN	Yes	No	Yes	Yes	No	No	No	No	No	No	BPM	Method	Yes
IT1F5 [220]	Yes	No	No	No	No	Yes	No	No	No	No	No	No	Yes	No	RE	Approach	No
IT2F1 [53]	Yes	Yes	No	Tables	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	BPM	Method	No
IT2F2 [215]	No	No	No	No	No	Yes	Yes	Yes	No	No	No	No	No	No	BPM	Approach	No
IT2F3 [210]	Yes	No	No	Tables	Yes	Yes	Yes	Yes	No	No	No	No	No	No	BPM	Method	No
IT2F4 [218]	Yes	No	No	Tables	Yes	No	Yes	Yes	No	Yes	No	No	No	No	BPM	Method	No
IT3B1 [225]	No	No	No	No	Yes	No	Yes	Yes	No	No	No	No	No	No	Context-aware Computing	Methodology	Yes
IT3B2 [76]	Yes	No	No	No	Yes	No	No	Yes	No	No	No	No	No	No	Context-aware Computing	Methodology	Yes
IT4B1 [223]	Yes	No	No	Tables	Yes	No	Yes	No	No	No	No	No	No	Yes	Decision Support	Approach	No

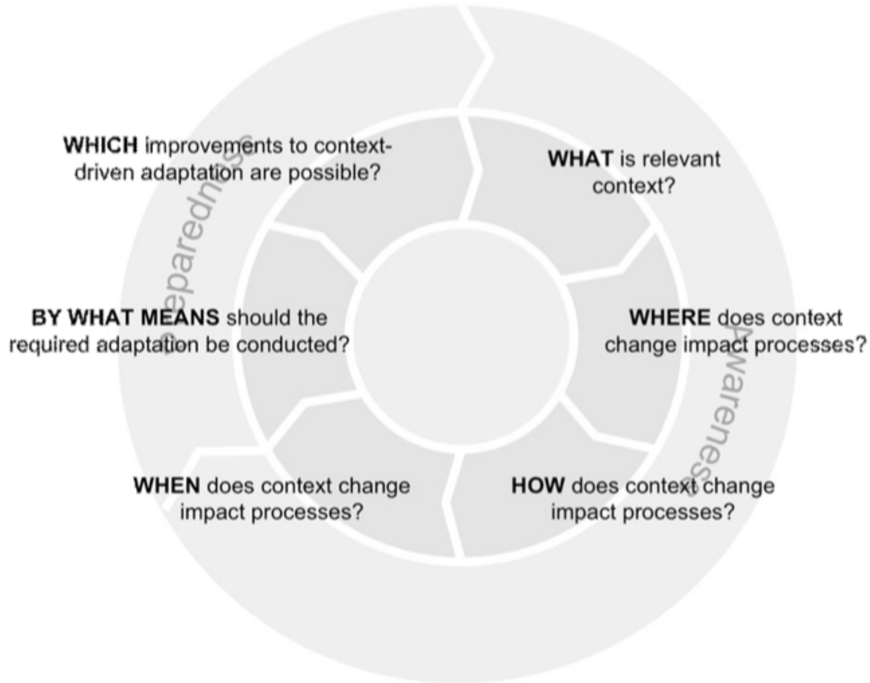


Figure 4.18.: A generic procedure for context elicitation and modelling, taken from [214]

of articles mentioning them remain quite low (16%), i.e. only 4 articles point out these aspects (cf. Table 14). Here, two interesting findings can be discussed. First, the publications mentioning the inputs required and outputs produced by the respective method also describe the important concepts used in the procedures. This might indicate that explaining important concepts may help to define what a task produces or consumes. Second finding relates to the number of methods that include a procedure for context modelling, as explained above. Considering such high percentages, it is interesting to see that the artefacts produced and consumed by the procedures are not further detailed. This is clearly a gap and should be considered when developing context modelling methods.

Tool Support, Meta-model and Notation: Tools are understood as instruments which help a role to execute its responsibilities in an automated way [129, p. 192]. Tool support in context modelling methods seems to be very scarce, as none of the methods name any tools for context modelling (0%). This can be related to the fact that 58% (7 out of 12) of the methods proposing a notation use tables to represent contextual information. Tables are useful instruments to model context, still, we argue that method users should be supported with modelling environments to represent the contextual information. Fortunately, a number of publications (7 out of 25, i.e. 28%) describe important concepts of the method as meta-models, which may allow to generate software applications in accordance with model-driven engineering principles. One such example is provided in Figure 4.19.

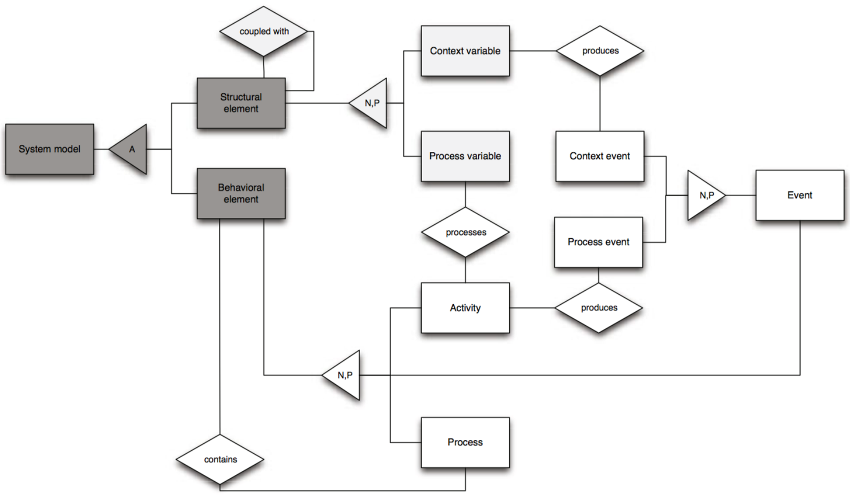


Figure 4.19.: A meta-model for context modelling, taken from [209]

Concept: Selected articles predominantly define important aspects of reality that are relevant for context modelling (18 articles, i.e. 72%). Here, both conceptual and formal approaches are encountered, whereas the former approach is adopted more often. The formal explanations, provided for instance in P7 [221], have the benefit of being unambiguous and certain, however, it can be challenging to understand the meaning of the subject under study, compared to the conceptual explanations. Another finding in terms of concepts concerns the level of completeness provided by the methods. For instance, the method proposed in IT1F2 [186] first introduces a meta-model and then describes the important terms used in it. On the other side, important terms used by the methods are defined in IT1B4, IT1B5 and IT1F4 [162, 164, 178] somewhat implicit, i.e. the authors mention them in the narrative text but not necessarily express them as "concepts". We argue that illustrating relevant aspects of reality via a meta-model and conceptually describing them supports the method user in eliciting and modelling context, rather than expressing them in mathematical formalisms.

Stakeholders: Modelling tasks usually require cooperation between different roles. One shortfall of the identified methods is they do not mention the stakeholder roles, i.e. only 1 article (4%) address this aspect. This gap can be closed by explicitly defining in a method who does what, who should be informed about the results of activities and who should support the roles under consideration. As such, RACI[19] approach can be integrated to the methods. This is especially

19 RACI is an abbreviation for Responsible-Accountable-Consulted-Informed. See section 5.4 for more information.

necessary in the context of component-oriented methods, where various roles can be attributed to activities in different method components.

Prerequisites: Modelling tasks require different skill sets and a number of conditions to be performed. We screened the publications concerning the organisational preconditions to be established before using the respective method. This includes both, the structures and roles within the team using the method, and the enterprise or organization where the method is applied for modelling. The results show that the number of methods considering such aspects remain quite low, as only 3 papers mention them (12%). For instance, IT1F1 [178] state that scenario descriptions need to incorporate three properties in order to be suitable for context modelling, i.e. i) "the different user groups of the future context-based IT system, ii) the tasks the users are supposed to perform with the future system and iii) information input or conditions which cause branching in the flow of actions during the tasks"[178].

This low number points out to the another research gap in this field. We argue that including the stakeholder roles and cooperation possibilities in a (context modelling) method would motivate the method engineer to consider which skills the method users should possess and what requirements should be fulfilled before the context elicitation and modelling activities can be performed.

Flexibility, Guidelines: A method needs to be purpose-fit and adapted to the particular needs and characteristics of its user. We investigated the question whether the proposed methods in the relevant set of papers allow for different starting points (e.g. strategies and guidelines, which help to use the method in organisational situations, under which they are most convenient) or have a component-wise structure. Interestingly, none of the papers mention such aspects (0%). The proposed methods seem to be designed in a monolithic fashion as the authors do not provide instruments to support different ways of working. Consequently it is hard for the stakeholders to focus on the parts of the method that are needed for a specific task, especially when the involvement on different stakeholder roles with varying backgrounds and perspectives are required to capture the business context. Nevertheless we identified 5 papers (20%) which provided guidelines to the method user for context elicitation and modelling (and not for the application of the method itself). To exemplify, P5 [216] suggests to focus on non-static process variables to identify context. IT1B2 [214] outlines *principles of implementation*, which are basically guidelines for context-aware process adaptation. IT1F5 [220] reports experiences from the application of elicitation techniques to identify context. The aforementioned guidelines remain generic. In contrast, IT1F1 [178] explicitly documents the guidelines when identifying contextual information in form of questions (e.g. "does the context element influence the information provision or the application behavior or both?").

Following aspects do not relate to Goldkuhl's framework, still, they are considered as important since they relate to the derived requirements (see section 3.6.2.2) as well as to the outlined artefact.

Supports capability modelling: Capabilities are defined in this work as *context-aware digital services that are related to the enterprise goals and implemented by the business processes*. In other words, digital services are refined and extended by adding context awareness and adaptability so as to establish a capability that can deliver this digital service in varying situations. None of the identified papers provide support to analyse context for modelling capabilities.

Supports/ uses Goals: Capabilities are strongly related with enterprise strategies and stakeholder goals for a company to deliver value [31, 32, 33]. One good example of this is demonstrated in CaaS project, which defines capability as the *ability and capacity that enables an enterprise to achieve a business goal in a certain context* [38]. Inevitably, the process of context analysis and identification should be related with enterprise objectives, e.g. how the stakeholder goals are achieved in different situations. 9 papers (36%) mention the role of goals in their method. P4 [213] uses context elements as "the representation elements in the system environment" and goals as "the intentions that determine purposeful behaviour of the system". IT1B3 [159] derives contextual information from process goals. IT1F2 [186], IT2F1 [53] and IT2F3 [210] follow a similar approach and state that a context element may be extracted by analysing the process goals. In P7 and IT1B6 [221, 219] context is strongly related to the end user goals, for it changes the current goals of a stakeholder and the possible ways to satisfy them. The methods provided in these works capture and refine stakeholder goals in different contexts. IT1F5 [220] analyses end user goals to capture contextual requirements.

IT2F2 [215] derives contextual information by analysing goals and strategies. As opposed to the other articles mentioning the goals in their methods, not only process goals or stakeholder goals are relevant, strategies of the respective enterprise using the method is also taken into account when eliciting business context. Apart from IT2F2, methods for context modelling and elicitation mainly investigate process and end user goals.

Supports/ uses BPM: As motivated in Chapter 1, BPM plays a central role on the design, provision and innovation of digital services. The number of articles supporting or using BPM is quite high (16 papers, corresponding to 64%). The findings have already been discussed in RQ1 on page 145.

Supports runtime aspects: Eliciting and documenting contextual information can help enterprises to specify the behaviour of the sys-

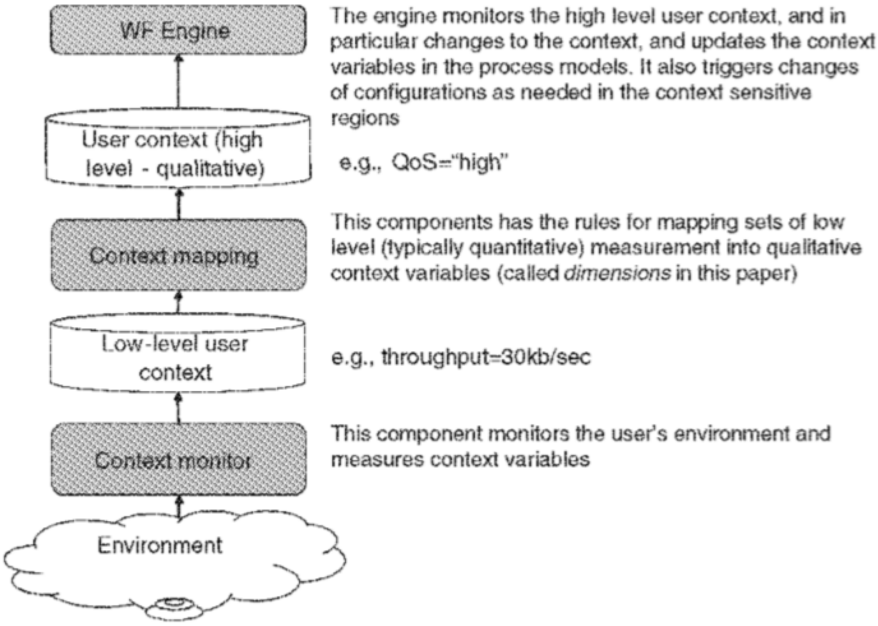


Figure 4.20.: Architecture for context-sensitive process models, taken from [225, p. 95]

tem at runtime, i.e. the information system under study can be adjusted to the different contexts during runtime. As discussed in RQ 3, more than a half of the papers (14/25, 56%) use the visual enterprise modelling artefacts to represent contextual information. Thanks to the principles of MDA, it is possible and feasible to create applications, program code or algorithms from such artefacts. This variable investigates whether the methods mention the application of the contextual information at runtime. Results show that 17 articles (68%) provide insights about the way that context models can be put into operation. To exemplify, IT1B6 [219] demonstrates how the context model can be incorporated into a museum-guide mobile information system. IT3B1 [225] introduces an architecture which enables monitoring, mapping and interpreting contextual variables as shown in Figure 4.20. Similarly, the context management architecture proposed in IT2F2 [215] consists of activities to monitor the context and adapt the running processes accordingly. To summarize, the relevant methods mostly cover the runtime aspects and support the method user regarding the application of contextual information during the system operates.

Research Field: This part of the comparison investigates the areas, in which the method is supposed to be applicable. 16 papers (64%) develop approaches aiming at a use in the field of BPM, which is by far the most interesting area for the scholars designing context elicitation and modelling methods. This is followed by context-aware computing (4 papers, 16%), RE (3 papers, 12%) and Decision Support (2 papers, 8%), as illustrated in Figure 4.21. The implications of such distribution have already been discussed intensively in RQ1.

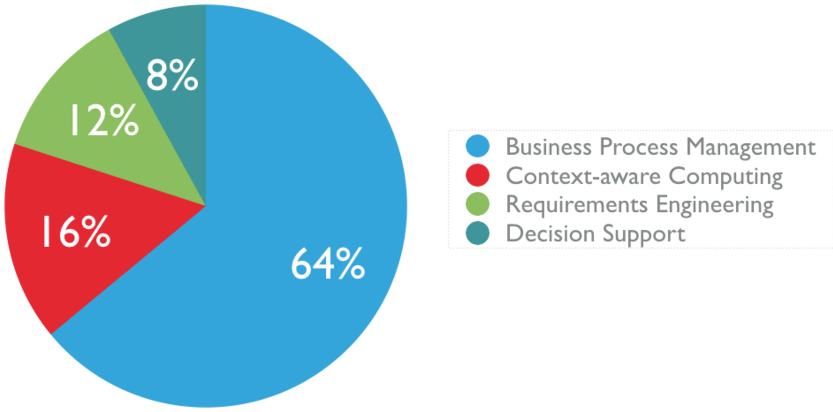


Figure 4.21.: The distribution of the research fields in context modelling methods

Terminology: The authors of the selected publications use various terms to describe their proposals, (e.g. *method, framework, model etc.*). Without discussing the ontological aspects of such terms, this part compares the findings regarding the applied terminology. As shown in Figure 4.22, the authors used the term *method* or *methodology* most commonly. In particular, 5 papers preferred to name their proposals as "methods" and 4 papers as "methodologies" (cf. Table 14). This is followed by the term "approach" (32%) and "framework" (20%).

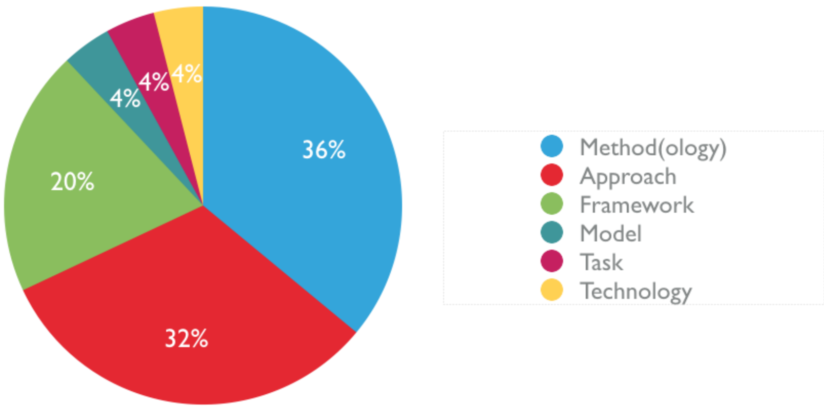


Figure 4.22.: Terminology used in the relevant set of papers

Formalised: The methods are predominantly described by using conceptual techniques, such as meta-models, tables and graphical notations. When compared, we found out that 39% of the analysed methods are formalised (cf. Table 14). The implications have been already discussed in the criteria "concept" on page 155.

4.4.4 *Summary*

Context and its modelling interested researchers from various disciplines. [224] criticizes the research on context modelling and states that "existing work takes a more intuitive approach to context rather than following a systematical and methodologically sound procedure." Against this background, this section summarizes the results of the investigation concerning the state of the art in the support for identifying, eliciting and modelling context.

RQ1 - Research Fields in IS and Addressed Problems: This question aimed to classify the proposals for eliciting and modelling context to the subject fields in IS and investigated the problem areas that the methods are supposed to solve. BPM, RE, context-aware computing and Decision Support in knowledge intensive tasks investigate methods to elicit and model context in ISR (cf. Figure 4.21). The need for organizational flexibility seems to be the most prominent reason for understanding context and developing context-aware solutions as the proposals mainly aim to solve the problems that limit the capability of organizations to adapt to ever-changing environments.

RQ2 - Definitions of "Context": Obviously, Dey's seminal definition "context is any information characterising the situation of an entity" [174] inspired many scholars, a number of works adopted and adjusted this definition. Interestingly, there is also a considerable amount of articles, which do not clearly define the term.

RQ3 - Eliciting Contextual Information: The number of proposals analysing conceptual models to derive contextual information are high. A total of 14 papers (56%) use the visual artefacts that describe business processes, enterprise goals or application scenarios to derive contextual information, the "change reasons", "affected goals" and "variations" being the focal point of investigation.

RQ4 - Strengths and Weaknesses of Methods: Using Goldkuhl's framework as a basis, a number of characteristics are defined that a method should fulfil (e.g. procedure, notation, tool support etc.). Those characteristics are enriched with additional aspects and they served as means to compare the methods.

- Procedure - Concept - Input/ Output: Most of the methods recommend certain sequences of tasks to elicit and model contextual information. Depending on the application scenario, the detail levels may vary. Likewise, selected articles mostly define important aspects of reality that are relevant for context modelling. However, there is a gap concerning the documentation of inputs required by and outputs produced by the method. The procedures are quite often not elaborated with such information.

- Tool Support, Meta-model and Notation: Tool support in context modelling methods seems to be very scarce, there is no method including appropriate tools to model context. Tables are used extensively to document contextual information. As 28% publications use meta-models, one can exploit the possibility of generating software applications. We argue that method users require enhanced support in terms of modelling environments to represent the contextual information.

- Stakeholders, Prerequisites: The methods proposed in the relevant papers are considered only for certain roles in the enterprise. It is hard to speak of an alignment on various stakeholder levels. As motivated in section 3.3 and section 3.4, contextual factors need to be represented in an understandable and acceptable way to everyone involved. Another research gap in this field is the low number of methods informing the user on the conditions of method application. We argue that including the stakeholder roles and cooperation possibilities in a (context modelling) method would motivate the method engineer to consider which skills the method users should possess and what requirements should be fulfilled before the context elicitation and modelling activities can be performed.

- Flexibility, Guidelines: The proposed methods in the relevant set of publications are of monolithic nature, i.e. they neither provide mechanisms to be tailored to user needs nor allow for different starting points. Furthermore, only 20% of the relevant papers provide guidelines on method use, which remains very low.

The above-mentioned findings are represented in Table 15, which only includes the extracted criteria from Goldkuhl's framework. The last column exposes criteria fulfilment results, i.e. whether the proposals qualify as a "method" from the perspective of the method engineering framework. In the frame of this thesis, the fulfilment rates can be interpreted as "level of completeness" of the proposed context modelling methods. Consequently, they clearly indicate the room for additional engineering work in the design and development of context modelling methods in IS. With that in mind, it is not our expectation that such criteria (and their fulfilment) can solely define the research direction in other potential focal areas with completely different requirements and application scenarios. Nevertheless, remaining in the boundaries of this thesis, the findings and completeness levels compared to the requirements that the solution should fulfil further motivate the need for engineering deCOM.

Table 15.: Criteria fulfilment according to Goldkuhl's method framework

ID	Procedure	Input/ Output	Tool Support	Notation	Concept	Stakeholders	Prerequisites	Flexible	Guidelines	Meta-model	Criteria Fulfilment
P1 [222]	Yes	Yes	No	No	Yes	No	No	No	No	No	30%
P2 [224]	Yes	No	No	No	No	No	No	No	No	No	10%
P3 [212]	No	No	No	No	No	No	No	No	No	No	0%
P4 [213]	Yes	No	No	Causal Loop Diagrams	Yes	No	No	No	No	Yes	40%
P5 [216]	Yes	No	No	Accept Event Actions	Yes	No	No	No	Yes	No	40%
P6 [168]	Yes	Yes	No	Tables & BPMN	Yes	No	No	No	No	No	40%
P7 [221]	Yes	No	No	Tropos Goal Modeling	Yes	No	No	No	No	Yes	40%
IT1B1 [209]	Yes	No	No	No	No	No	No	No	No	No	10%
IT1B2 [214]	No	No	No	No	No	No	No	No	Yes	Yes	20%
IT1B3 [159]	Yes	No	No	No	Yes	No	No	No	No	Yes	30%
IT1B4 [162]	No	No	No	Tables	Yes	No	No	No	No	No	20%
IT1B5 [164]	No	No	No	Tables	Yes	No	No	No	No	No	20%
IT1B6 [219]	No	No	No	Tropos Goal Modeling	Yes	No	No	No	No	No	20%
IT1F1 [178]	Yes	No	No	No	Yes	No	Yes	No	Yes	No	40%
IT1F2 [186]	No	No	No	No	Yes	No	No	No	No	Yes	20%
IT1F3 [217]	Yes	No	No	No	No	No	No	No	No	No	10%
IT1F4 [211]	Yes	Yes	No	Extends BPMN	Yes	No	No	No	No	No	40%
IT1F5 [220]	Yes	No	No	No	No	No	No	No	Yes	No	20%
IT2F1 [53]	Yes	Yes	No	Tables	Yes	Yes	Yes	No	Yes	Yes	80%
IT2F2 [215]	No	No	No	No	No	No	No	No	No	No	0%
IT2F3 [210]	Yes	No	No	Tables	Yes	No	No	No	No	No	30%
IT2F4 [218]	Yes	No	No	Tables	Yes	No	Yes	No	No	No	40%
IT3B1 [225]	No	No	No	No	Yes	No	No	No	No	No	10%
IT3B2 [76]	Yes	No	No	No	Yes	No	No	No	No	No	20%
IT4B1 [223]	Yes	No	No	Tables	Yes	No	No	No	No	Yes	40%

4.5 APPROACHES IN CAPABILITY MODELLING

The flexible design and delivery of digital services require a successful alignment of both management-oriented and technology-oriented aspects in an enterprise, which has been reflected in Figure 3.1 on the stakeholders' role level and Figure 4.8 on the architectural level. Approaches are needed to bridge the gap between the design of digital services and their actual implementation. The notion of capability has received a lot of attention as an instrument to align business and IT in changing environments to enable a competitive advantage. This section investigates the notion of capability, introduces approaches for managing capabilities and concludes by a systematic mapping study concerning the design and development of capabilities.

4.5.1 *Notion of Capability*

The organizations are operating in an ever-shifting environment. Due to rapid changes in regulations, globalization, time-to-market pressures and technological advances, the Business-IT alignment becomes a serious challenge. Enterprises thus require the agility to adjust their offerings for a sustainable competitive advantage. One way to tackle these challenges is the management and design of capabilities.

The term capability originates from the system engineering and military domain, where it has been used synonymous with *military capability*, meaning to apply the overall potential of the armed forces for combat or other operations [226, pp. 234]. Linguistically, the term means *having power of doing something* [28]. The literature analysis shows that the capabilities are used mainly in three domains, systems engineering, strategic management and IS. As such, its definition depends on the field in which it is applied.

Systems engineering

In systems engineering domain, capabilities are defined as "the ability to do something useful under a particular set of conditions" [227]. People that work in organisations have competences. The organizations and enterprises develop, operate and use systems to fulfil stakeholder goals. As such, three different kinds of capabilities are defined that help organisations, systems and enterprises to do "something useful"; *organizational* capability, *system* capability, and *operational* capability. Individual competence is the basis for the organizational capability, which is defined as "the capability of an organization to perform systems engineering that contributes towards organizational value and purpose"[20]. They enable *system capabilities*, which is defined as "the ability of a system to execute a particular course of action or achieve a desired effect, under a specified set of

20 http://sebokwiki.org/draft/Organizational_Capability_(glossary), Last Retrieved 29.11.2016.

conditions"[21]. *Operational* capabilities are related to value-creation activities and concern meeting the stakeholder requirements. The relationship between the capabilities are shown in Figure 4.23.

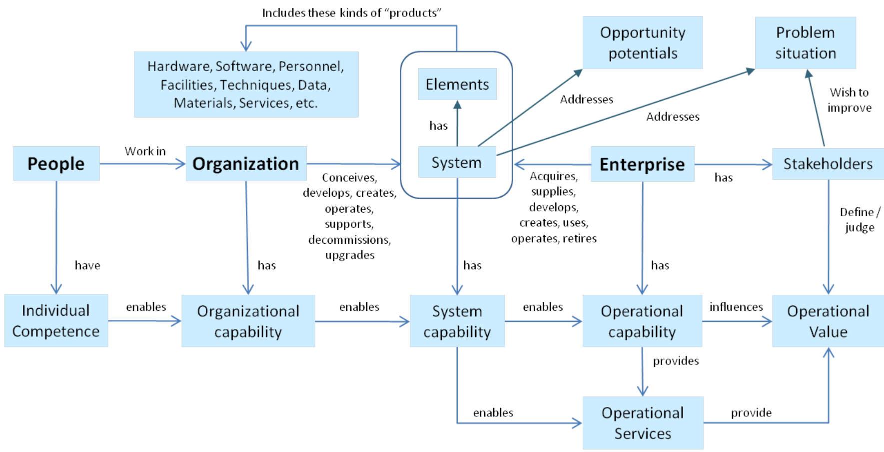


Figure 4.23.: Capabilities in systems engineering domain, taken from [227, p. 628]

Strategic management

Capabilities in the strategic management literature are conceptualized as a business unit's intended or realized competitive performance or operational strengths. Consequently, these are assessed with KPIs such as cost, quality, flexibility, and delivery measures. [228]. Here, the capabilities are perceived to be a resource, alongside with assets, processes and knowledge. Note that resources are inputs through the productive processes or strengths that firms can use to conceive of and implement their strategies, whereas capabilities are the ability of executing certain activity or assignment by using one or some resources [229, 230]. As such capabilities in the field of strategic management are defined as the foundation in which organizations utilize their strengths to increase competitiveness, contribute to growth, and enhance organizational performance [231].

We also encountered different capability types in the strategic management domain. Companies in changing environments need to anticipate changes and to react to them. The ability to do this systematically has been referred to as *dynamic capability* [232]. Dynamic capabilities are defined as "the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments". Consequently, they reflect an organization's ability to achieve new and innovative forms of competitive advantage given path dependencies and market positions [233]. Many authors perceive dynamic capabilities as higher-order capabilities that influence the development of *operational capabilities*, which are often combinations of simpler capabilities and the routines related to them [234].

21 http://sebokwiki.org/draft/System_Capability_(glossary), Last Retrieved 29.11.2016.

One example is the *organizational* capabilities, which are conceptualized as "the networks of knowledge combining people and assets which, as a whole, will enable organizations to perform their given tasks more effectively" [231].

Information Systems

From the IS point of view, capabilities are perceived as high-level abstraction instruments and applied as a concept that address facilitating varying business needs, which cannot be taken into account during system design. For instance, in [35], the capability allows delivering business value in a dynamically changing context by applying reusable knowledge in form of patterns to reach a specific goal. They combine different elements, such as actors, business functions, business processes, enterprise objectives and technology [235]. Danesh et al. state that the use of capability is its infancy in IS, open issues are observed concerning the role of capabilities in BPM, in SOA and in Enterprise Architecture Management (EAM) [4]. Nevertheless, Zdravkovic et al. define useful directions, towards which capability research in IS can be performed [28]. They state that capabilities should allow fairly straightforward integrations with established enterprise model components, such as goals, processes and services. We share this view, which is also conform with deCOM, the core artefact developed in this thesis.

Enterprises are complex systems operating in changing environments. Ahlemann et al. state that managing strategies, processes, applications, information infrastructures and roles is a challenge for an enterprise and there is a need to have an holistic view [236]. Such an integrated view can be reached by implementing EAM. The IS domain uses capabilities as instruments to develop Enterprise Architectures (EA) and tools for tackling the dynamic complexity of systems with diverse concerns.

Capabilities and Services

In this thesis, the need for an integration between capabilities and services is motivated in the introduction and section 4.2.3. This becomes clearer considering the fact that combination of service and capability research streams is very rare in the literature [17]. There are two types of research streams concerning capabilities and services.

- Research that investigates and relates capabilities and its dimensions to services, examples of which can be found in [1, 237] as well as in the related works section of Bärenfänger et al.'s work [17]. A conceptual proposal from this research stream is illustrated in Figure 4.24, where "a capability is realized through processes (which involve people), and is driven or constrained by the availability and quality of the resources, and by the strategic decisions made. A process might in turn orchestrate business services or might be a part of a larger grained business service" [1, p. 38].

- Research which investigates capabilities and services from the enterprise modelling perspective, as performed in this thesis and in [238, 239, 136, 26]. The findings from this research stream will be discussed in section 4.5.2.

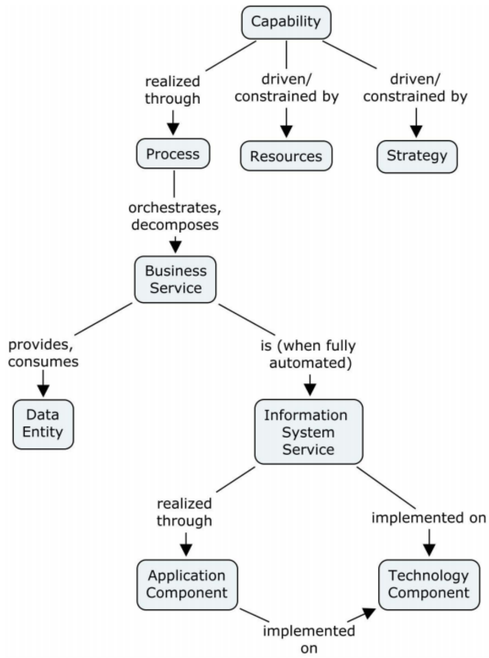


Figure 4.24.: An approach to align capabilities with services, taken from [1, p. 39]

Although there seems to be an agreement about what constitutes a capability, it is hard to find a standard definition. The definitions mainly put the focus on "combination of resources" [1, 240], "capacity to execute an activity" [241], "perform better than competitors" [231] and "possessed ability" [176, 242]. A general consensus is that the capabilities are enablers of competitive advantage; they help companies to continuously deliver a certain business value in dynamically changing circumstances and they are considered as a means of dealing with flexibility [4, 238]. In this thesis, we interpret capability as the ability and capacity to deliver flexible digital services to fulfil enterprise objectives in different contexts.

4.5.2 *Capability Management and Capability Engineering*

System of Systems

Systems Engineering Body of Knowledge (SEBoK) defines capability management as "development and maintenance of all aspects of the ability to conduct certain types of missions in a given environment, which comprises of the management of operational, organizational and system capabilities" [227]. Also, [1] considers capability management as an integrating framework consisting of the i) generation, ii) sustainment and iii) employment of the capabilities. In the generation phase the capability is planned and developed. After this, the quality of the capability has to be assured. To this end, different instruments can be applied to assess to what extent the capabilities are ready to be delivered, such as maturity models. The last phase involves the implementation of the capability itself.

Lately, the term "*capability engineering*" emerged in the field of IS. Antunes defines capability engineering as "a process which supports capability management throughout the life cycle of a capability" [1]. Bernier et al. consider capability management as series of activities (develop & improve, sustain, employ & operate capabilities) and classify the capability engineering into the develop & improve capability management activity [243, p.3] as shown in Figure 4.25. However, as the term seems to be applied mostly in Systems of Systems area, it will not be detailed further in this thesis.

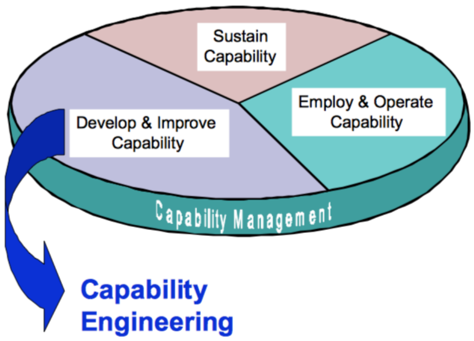


Figure 4.25.: Capability engineering as a domain of capability management, taken from [243, p. 3]

Capability-driven development

In the EU-FP7 research project CaaS, CDD approach has been developed to enable capability-based design and management of enterprises. The CDD approach focuses on supporting flexibility and adaptability in developing digital services by using enterprise modelling techniques. It is an integrated approach consisting of a method (the CDD methodology) and tools (the CDD environment) that enable enterprises to sense and take advantage of changes in business context. The CDD methodology consists of six upper-level method components, which are described in the following [244].

- **Getting Started with CDD.** Supports decision-making whether or not the CDD is suitable for an organization. Furthermore, the required steps to get started with the CDD are described.
- **Capability Design Process.** Contains an overview on how to design, evaluate, and develop capabilities by using process models, goal models and other types of models.

- **Enterprise Modelling.** The component contains method components that guide the creation of enterprise models that are used as input for capability design.

- **Context Modelling.** Describes the method components needed for analysing the capability context, and the variations needed to deal with changes. Parts of the design artefact proposed in this thesis is used in this method component.

- **Reuse of Capability Design.** This component contains guidelines for the elicitation and documentation of patterns for capability design.

- **Run-time Delivery Adjustment.** Describes the components needed to adjust a capability at runtime.

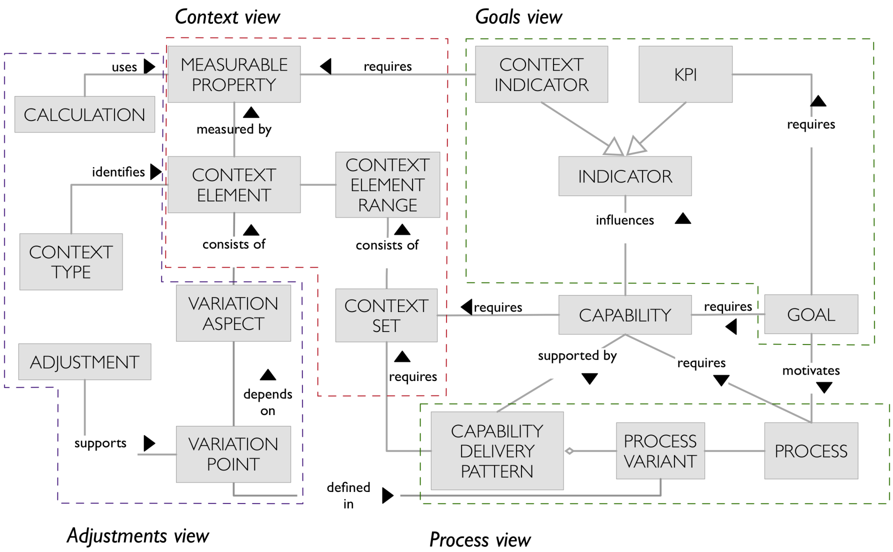


Figure 4.26.: Capability meta model adapted from [239]

The capability models developed based on the CDD method allows for an holistic view of the enterprise, comprising of capability, context, business processes, adjustments and goals views. This is ensured via the capability meta-model, which is the core element of the CDD approach. The meta-model shown in Figure 4.26 defines all concepts and their interrelationships needed to integrate those views. In terms of service design, capabilities enable flexible utilization of resources in various contexts and aim to support a model-based configuration of services. This part is represented in CDD meta-model with the concepts of *Context element* (the contextual factor), *Context element range* (configurable and relevant value ranges of a context element for the digital service at hand), *Context set* (a set of relevant ranges, which are monitored during runtime), and *Measurable property* (attributes used to calculate the context value). The adjustment part is represented mainly with the concepts *Variation point* (gateways in business process models that require contextual knowledge at runtime to be resolved) and *Adjustment* (adaptation of the digital service to the new situation by selecting an appropriate process variant). Each *Capability* is motivated by one business *Goal* measured by KPIs represented in goals view. A *Capability* always requires implementation of at least one *Process* that is motivated by the enterprise objectives. In many cases, there is a master or reference process and several deviations from that, which are called *Process variants*. *Patterns* are used to represent most frequent variants to reduce the complexity raised by capturing all possible variations.

In order to implement the artefacts developed by the CDD method, a number of tools have been developed in CaaS project, which are termed as the CDD environment. The simplified architecture of the environment is illustrated in Figure 4.27. The numbers between the arrows are added to refer to the dependencies between the components in the following text.

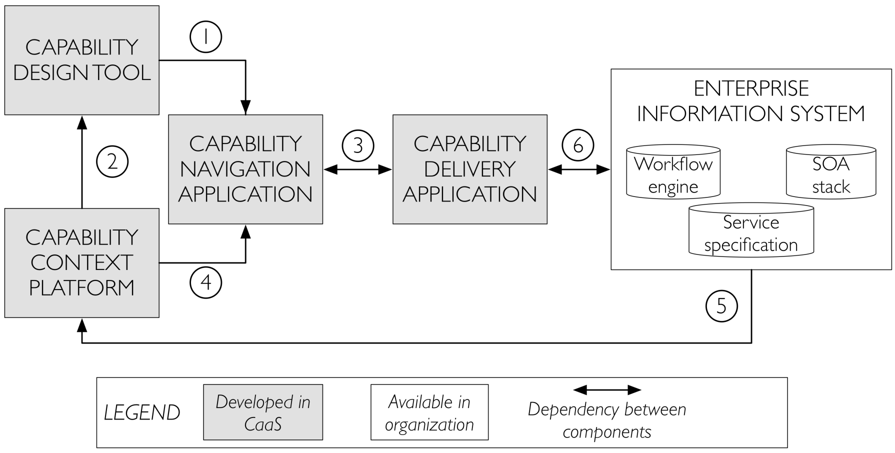


Figure 4.27.: The simplified architecture of the CDD environment

- **Capability Development Tool (CDT).** Provides a modelling environment based on the CDD meta-model, i.e. capabilities can be modelled including business services (e.g., business process models), business goals, context and relations to patterns. The model designed in the CDT is uploaded to the Capability Navigation Application (CNA) together with the adjustments code (1).

- **Capability Context Platform (CCP).** Captures data from external sources, such as sensing hardware and social networks (5). At runtime, CCP aggregates data and provides them to the CNA for further calculations (4). Also, at design time, the information about the context sources can be imported as new objects into CDT (2).

- **CNA.** Includes a module for monitoring context and KPIs. Moreover, the capability delivery adjustment algorithms are built-in here. The algorithms continuously evaluate necessary adjustments and pass capability delivery adjustment commands to the Capability Delivery Application (CDA) for adapting the service to its application context (3).
- **CDA.** An interface between the CNA and the Enterprise Information System of the organization in order to receive capability delivery adjustment commands from the CNA (3) and to provide the adjustment commands in line with the actual service application context (6).

Positioning itself in line with the CDD approach, this thesis uses the term **capability** as an instrument to realize Business-IT alignment and to bridge the gap between the design of digital services and their actual implementation. As the core proposal of the thesis concerns designing a capability-based context modelling method, it is beneficial to investigate the current state in the field of capability design and development methods. By performing a SLR, next section deals with this topic and reports findings.

4.5.3 *SLR in Capability Design and Development Methods*

This section is taken from the paper "Methods in Designing and Developing Capabilities: A Systematic Mapping Study", which was published in Practice of Enteprise Modelling (PoEM) Conference in 2015 [84].

The notion of capability has received a lot of attention as an instrument to align business and IT in changing environments to enable a competitive advantage. Research in the field of capability management steadily rose during the last decade. However there is a paucity of articles that systematically investigate methods, approaches and procedures developing organization's core capabilities. In terms of systematic literature reviews the contributions focus on capability maturity models. In this section, the results of a systematic mapping study is presented by analysing the research topics, research methods and research activities in methods of the capability design and development. In line with [51], a method is defined as a systematic way of problem solving consisting of *concepts*, *activities* and a *notation*. The concepts specify what should be captured in a model. The activities describe in concrete terms how to identify the relevant concepts in a method component and the notation specifies how the result of the procedure should be documented. In this respect the findings show that the methodological support in capability development does hardly fit into the aforementioned method description. The analysed articles propose steps, procedures, guidelines to design

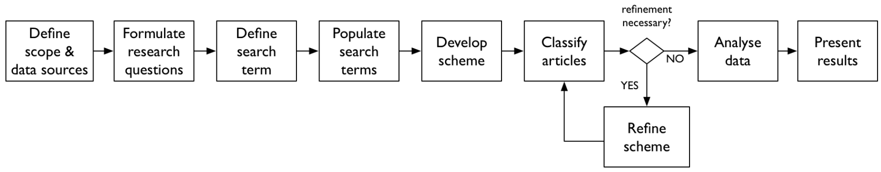


Figure 4.28.: Steps of the systematic literature analysis

capabilities, which only to a weak extent follow the concept-activity-notation structure.

This section is structured as follows: section 4.5.3.1 describes the research approach, which is a mapping study, a specific type of SLR. Then, section 4.5.3.2 presents the research design, i.e. which literature sources are included in the analysis. Following that, section 4.5.3.3 analyses the findings and section 4.5.3.4 concludes the investigation.

4.5.3.1 *Mapping Study and Research Process*

The research approach used during the analysis of the capability development methods is a mapping study, which is a specific type of SLR. A SLR is a review process of prior studies with a structured and comprehensible procedure that aims to accumulate all "existing evidence concerning a treatment or technology" and "identify gaps in current research". Mapping studies are characterized by their wider scope of the study and the generalization of research questions in a broader field [86]. After getting an overview of the research area, by for instance defining the research methods, research designs and research topics, detailed information can be extracted from a set of publications.

In order to classify the findings thoroughly, a classification scheme had to be developed. A classification scheme provides a way to organise and structure the selected papers. Thus the guidelines of Kitchenham [89] were extended by the develop/classify/refine scheme step, as illustrated in Figure 4.28. The selection process of journals and conferences during scope definition was exhibited to provide transparency for researchers who might repeat the analysis by extending the sources or changing the inclusion criteria of journals, conferences or books. After defining the scope and data sources, three research questions (RQ) are formulated, which are answered subsequently in section 4.5.3.3.

- RQ1: Which research methods and research designs are used in the capability development field?
- RQ2: Which topics are under investigation in the field of capability design methods? Is it possible to identify a trend in these topics?

- RQ3: Which methods, steps or approaches are proposed to develop and design capabilities?

4.5.3.2 *Review Design*

This section introduces the literature sources included in the analysis as well as the classification scheme development process. Conducting a SLR requires a thorough selection of data sources that serve as a starting point. To select the literature sources, first A+ and A Journals were identified based on the rankings from [245]. Next, this list was complemented with B Journals from the Business Information Systems sub-discipline. To stabilize the journal selection, the results are crosschecked with the rankings from [246] and the journal selection part is finalized. After that, the list of journals were populated with A and B ranked conferences from [247], with "A" being the highest ranking. As a result we identified a total of 112 journals and 24 conferences.

The main terms used for the initial search were "capability" (in abstract) and "method OR design OR proc*" (in keywords). The keyword terms were populated with additional terms "practice OR step OR modeling OR modelling". Consequently we searched in the selected sources that included the term *capability* in the abstracts and one of the following terms *method, modeling, modelling, proc*, design, step, practice* in keywords. After removing the duplicates and inaccessible articles, the search resulted in a total of 362 journal articles and 178 conference papers published between 2000 and 2014.

The selection of the papers was based on a set of criteria, which is applied during abstract reading. In cases where the exclusion or inclusion was unclear, an additional full-text reading is conducted. First of all, articles are eliminated that did not explicitly address "design and development of capabilities" as their research scope. For instance, if capabilities were proposed only as means to leverage the value of a firm's knowledge or mentioned as enablers of enhanced outsourcing arrangements, then it was excluded. Furthermore we eliminated an article when the term capability was used as a synonym for "ability" or "future", i.e. unrelated to its application in IS. Also the articles were excluded, which use the term capability in the abstract and do not mention it in the narrative text or that mention dynamic capabilities to position their proposals as means to gain competitive advantage.

The main purpose in line with the research questions was analysing the state of the research in fields of capability design and development, in particular where processes/ procedures/ steps/ or methods are proposed to identify/ model/ design business capabilities. Hence articles are included that address the design and development of capabilities in narrower context, i.e. investigate steps, best practices, guidelines, concepts, notations and roles in developing such capabilities. Most of the journal articles explored the relation between the capabilities of an enterprise and its environment, which is an interpretation of capability design in broader context. Still, if the article contributed to capability development method area, then it was included. On the other hand, publications were excluded that investigate how for instance the IT capabilities are interlinked with e-Government service offerings by applying statistical methods and developing hypotheses. After the application of these criteria, a total of 22 journal articles and 23 conference papers resulted for further analysis[22].

To cluster the articles, a classification scheme including three main categories, **research methods**, **research design** and **research topics** was developed. The starting point for the classification in **research design** category was the framework of Alavi and Carlson [248] that on the highest level distinguishes between empirical and non-empirical research. Articles carrying out empirical research capture the essence of research by relying on observation that are supported by data, which is acquired via qualitative (case study, interviews) or quantitative (experiments, surveys) techniques. The research design types are extended with "conceptual articles" and "DSR" articles [85]. Conceptual articles are primarily based on ideas, frameworks, and suggestions rather than on systematic observation. Design science research articles answers questions relevant to human problems via the creation of innovative artefacts, thereby contributing new knowledge to the body of scientific evidence. To be classified as design-oriented, the articles should follow the guidelines provided by [21].

The category **research methods** is created based on the article of Palvia et al. [249], which examined the mainstream journals in MIS research in terms of employed methodologies. The structure is expanded in order to fit our research purpose. We first defined "*qualitative & quantitative research*" as two main research method classes. Then we specified the two method types, *SLR* and *experiments*. Finally *grounded theory* was added as an additional research method, which seeks to develop a theory by analysing gathered data systematically [250].

To structure the **research topics**, the "concept matrix" approach was adapted from Webster and Watson[92], where the articles are structured according to their contribution areas. As illustrated in Figure 4.28, the research topics were refined whenever necessary. Here three main contribution classes were observed. *Motivation* analysed the starting point of the articles, which is mostly reflected in abstracts and state of the art sections. *Investigation* analysed the topics that the papers explore and contribute in, mostly stated in the conclusion

22 The list of investigated literature sources as well as the selected papers can be retrieved from https://drive.google.com/open?id=1Vutjm37qHket83RRTOYNZ-5jpzHz_zhsPeYSKugupLA.

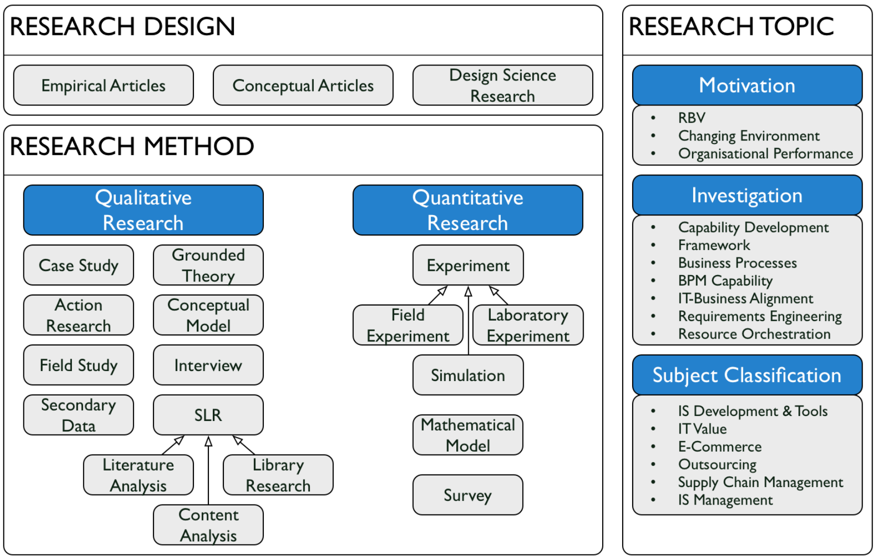


Figure 4.29.: The classification scheme

parts. In line with [249] *subject classification* structured the research endeavour to the more general research subjects in the IS discipline. Figure 4.29 shows the classification scheme, including the research design, research method and research topics as the categories.

4.5.3.3 *Data Analysis*

This subsection answers the research questions formulated in section 4.5.3.1 and analyses the findings.

RQ1: Which research methods and research designs are used in the capability development field?

The "research design" category shown in Figure 4.29 is mutually exclusive, i.e. an article can apply only empirical, conceptual or design science research paradigm. On the other hand, in the "research method" category the articles may be related to more than one method, when for instance conducting a case study after a survey. The analysis of all articles has shown that empirical design is used at most in the design of capabilities (76% of all articles). A remarkable result was the application rate of DSR paradigm, which only took place in 4% of all articles.

When conducting empirical research, 2 of 3 articles based their findings on qualitative research by applying case studies (38%), interviews (26%) and conceptual models (21%). The articles adopting quantitative research use surveys extensively (55%). The structure that these articles follow is i) developing hypotheses to investigate the factors, phenomena, abilities, roles influencing design and development of capabilities, ii) conducting a survey and iii) statistically evaluating if the hypotheses hold. The results of such articles might be quite beneficial when constructing methods for capability design. Surveys are followed by secondary data (36%), where the authors collect business data such as financial reports, documentations, archival materials and published documents. The conference papers extensively use qualitative methods (75%). In fact, only 2% of relevant articles apply quantitative methods solely. The allocation in journal publications seems to be balanced, i.e. 44% of all articles conduct quantitative and 56% qualitative method techniques. In the set of 45 papers, 15 publications combined qualitative and quantitative methods (the exact allocation is 10 journal articles and 5 conference papers). Interestingly 8 of these 15 publications adopt case studies, interviews and analysis of secondary data, which seems to be a research method pattern. 80% of the conference papers combining both qualitative and quantitative methods adopt this pattern.

By allocating 45 papers to three time frames; 2000-04, 2005-09 and 2010-14, we analysed the trend in research methods applied in the publications. In order to do so, we observed the relation of the selected research method to the sum of published articles in the time period. There seems to be a trend in the capability design field concerning the application of secondary data and case studies as a research method. Moreover, articles producing conceptual models based on non-empirical data seem to diminish, the application rate of interviews and surveys remain stable.

RQ2: Which topics are under investigation in the field of capability design methods? Is it possible to identify a trend in these topics?

To determine the research topics we first analysed the titles, abstracts and keywords of the publications and summarized the mentioned terms. Next, a full text reading of 45 papers was conducted to limit the number of terms and include only the main focus and contribution of the respective work. After this we clustered the final terms and classified them into the research topics in line with the developed scheme (cf. Figure 4.29), where an article can be related to multiple topics. The clustered topics include following terms:

- **Resource Based View.** Articles motivating their work based on ”Resource Based View, Dynamic Capability or Competitive Advantage” are categorized here. This topic is used for nearly half of the total works (45%), which clearly addresses the inspiration in the field of capability design and development methods (cf. Figure 4.30.

- **IT Value.** Includes the terms ”IT Capability, ICT, ICT Capability” or ”Leveraging IT”. This topic is analysed in 38% of the relevant articles.

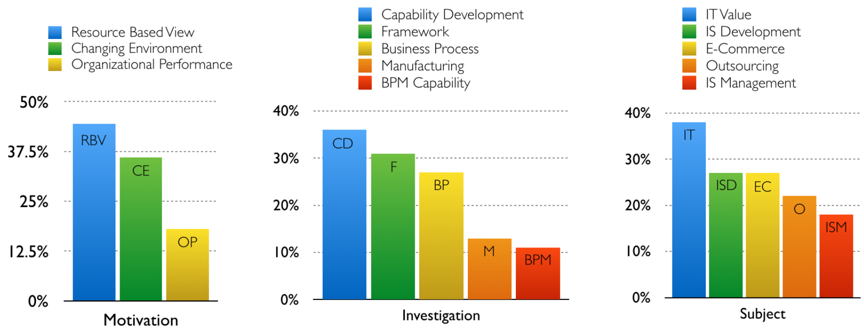


Figure 4.30.: Research topics in capability design

- **Changing Environment.** Includes articles with the terms "Change in Business, Change Management, Growing Enterprises, Business Model Transformation, Evolving Needs, Different Contexts, Unanticipated Changes, Dynamic Business Environment, Developing Countries, Emerging Economies". 36% of articles motivate their work based on this topic.

- **E-Commerce.** Includes the subject terms "e-Service, Electronic Service Delivery, Cloud Computing, Cloud Service, e-Business Strategy, e-Government, e-Business". 27% of the relevant articles deal with e-Commerce topic.

- **IS Development & Tools**. Includes subject terms "Enterprise Modelling, Goal Modelling, Pattern Modelling, BPM, Business Process Design, Business Models, Context Modelling". 27% of the relevant articles deals with this topic, all of which are published in conference proceedings.

- **IS Management.** Includes subject terms "Strategic Management, Strategy Process, Internationalisation Strategy, Strategy Optimisation, Business Strategy Development, Strategic Business".

- **Outsourcing.** Includes subject terms "IT Outsourcing, Business Process Outsourcing, Service Level Agreement, Interorganizational Relations".

In addition to these topics, specific concepts were identified that cannot be structured in the above-mentioned groups, such as "Framework, Capability Development, Business Process, and BPM Capability". Figure 4.30 illustrates the results of the research topic classification including both clustered terms as well as specific topics. For brevity reasons, the topics were omitted which were motivated or investigated in less than 10% of all articles. No trend analysis was conducted for such topics.

The analysis shows that concerning some of the aforementioned research topics it is possible to speak of a trend. Here it should be

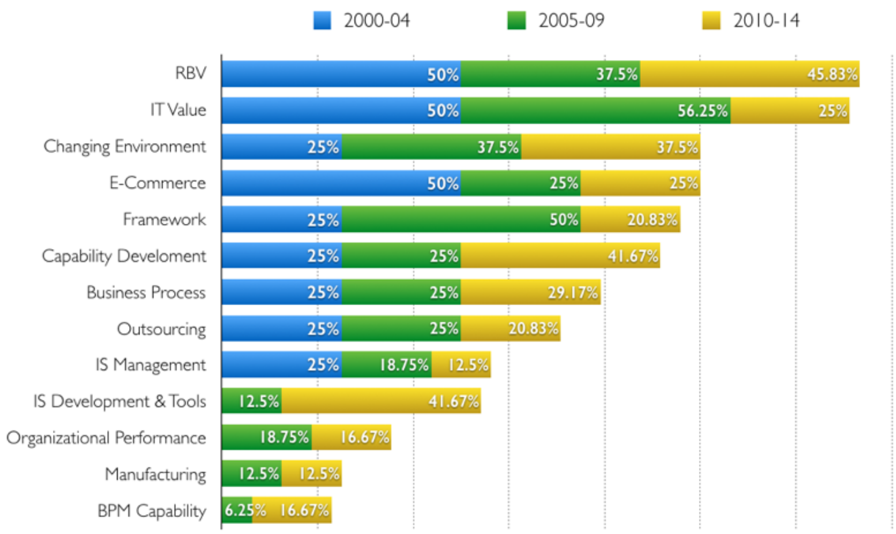


Figure 4.31.: Trends in topics

noted that all three classes (motivation, investigation and subject) are observed together as illustrated in Figure 4.31. The analysis was carried out by simply relating the used terms to the number of published articles in the selected time frame. The trend graphic proves that the contributions are mainly based on three motivation topics, with a positive trend in "Changing Environment" and a slight negative trend in "RBV". Concerning the investigated topics, scholars pay more attention to the "Capability Development" field in the last 5 years and both "Business Process" as well as BPM Capability have a stable course over the observed 15 years. On the contrary the publications proposing frameworks diminish from 2010 to 2014 in the field of capability design. In terms of the subject areas a negative trend was observed in the topics "E-Commerce, IT Value" and IS Management". This may imply that capability design research has reached a certain level of maturity in these subject areas, but still considered to be relevant. Conversely, the topic "IS Development and Tools" gains a recognizable attention, for which we did not find an article between 2000 and 2004. As all the articles covering this topic were published in conference proceedings, we argue that the research trend in capability design is moving lately towards methods, ways, steps, procedures in capability modelling, capability construction as well as integration of capabilities with enterprise modelling. This view is also in line with our findings from two other topic classes, *motivation* (trend in the topic "Changing Environment") and *investigation* (trends in the topics "Business Processes, Capability Development, BPM Capability"). Interestingly only very few work investigate the factors causing changes in the operating environment of the organizations and how they can be tackled in terms of enterprise modelling practices. Conclusively the scholars seem to be interested in *modelling capabilities of enterprises in changing environments, which influence their business processes*. This line of argumentation seems to be appropriate to explain the relevance of capabilities and of this work in the field of digital services, as 27% of the articles concerns this topic (cf. *E-Commerce* in Figure 4.30).

RQ3: Which methods, steps or approaches are proposed to develop and design capabilities?

This research question focuses on the methods for capability design and how they are related to research topics provided in RQ2.

- **IS Development.** The articles providing methods for capability design base on a novel approach in the capability modelling field, namely CDD, which is proposed in [238]. The CDD approach integrates organisational development with IS development by considering the application context and adjusting the solution in line with the dynamic changes. In this connection [239] presents an approach to design capabilities and establishes first cornerstones of capability development method. [36] addresses the stakeholder concerns to be taken into account when developing capabilities and presents a process for specifying requirements. [27] provides an overview of CDD method components, including context modelling, patterns modelling and enterprise modelling parts. Finally [251] uses the CDD approach on a case study and reports feedbacks for the improvement of CDD methodology.

- **E-Commerce.** The capability design methods for adjustable service provision received attention in the e-Commerce field between 2005 and 2009. To exemplify, [252] indicates the need for developing focal capabilities to achieve an e-Commerce adoption and presents a process model to orchestrate the organizational resources in line with the changing business delivery context. However no steps, activities and tasks are defined and the approach lacks notation to model the outputs of the phases. [253] suggests strategies for practitioners how to develop organisational capabilities in e-Commerce field and provides a process model including the key actions to be carried out.

- **BPM**. Notably in the last third of analysed time frame works in the BPM field relate to methods in capability design. [254] and [255] investigate BPM topic from the Dynamic Capability point of view and present a framework, which supports the design of BPM capabilities. The framework consists of three activities, namely sensing, seizing and transformation, which are further elaborated in sub-capabilities. Last but not least [256] offers a method for IT capability-based business process design, which consists of 8 steps. The work describes roles and notations loosely, whereas the important concepts, outputs of the activities are not mentioned at all.

In addition to the above mentioned topics, [257] proposes a process model for the development of capabilities to meet the fast growing business demands. [258] develops a theoretical model for conceptualizing the internationalization strategies of IT vendors, which consists amongst others a capability-building process. Regarding both articles however, the processes cannot be applied solely as a capability design method since the roles, goals, concepts and notation is not defined. Moreover, the latter contribution analyses the capabilities of IT service vendors in emerging economies, which remains too specific. To sum up our findings, the CDD approach provides amongst the investigated publications the most comprehensive methodological support to design enterprise-grade capabilities. Apart from the CDD, the analysed approaches:

- address which factors should be taken into account when designing capabilities,
- show how they relate to subject under study,
- provide means for capability evaluation, such as maturity models,
- do not address the integration of capabilities with enterprise modelling,
- propose steps, procedures, guidelines to design capabilities that are decoupled from enterprise objectives.

4.5.3.4 *Summary of the SLR in Capability Modelling Methods*

We performed a mapping study in the field of research in capability design and development methods by following the guidelines of [89] and [92]. In line with the conference and journal rankings in [245], [246] and [247] a search term was applied to 112 journals and 24 conference proceedings. A number of criteria were defined to include and exclude the articles in the final set. As a result a total of 45 articles were classified into a scheme, i.e. applied **research design**, used **research methods** and investigated **research topics**. To analyse the results and to identify trends we defined three time frames, namely 2000-2004, 2005-2009 and 2010-2014. The trend calculation was done by relating the used terms to the number of published articles in the selected time frame. For instance, the topic business process was investigated in 25% of the papers that are published between 2000 and

2004. In doing so we aimed to hinder the effect of the increase on the number of articles through the years.

Obviously using a different setting for the time frame and including more conferences, journals and other works would make it possible to examine wider perspectives. Another limitation is the total number of articles (45), which is few to draw more general conclusions. This drawback is balanced by the detailed description of the research process, which hopefully encourages researchers to extend the investigation based on this setting. Nevertheless, the analysis provided a starting point to classify research topics, research methods and activities in the area of capability development and design. Following summarizes the findings of the work.

Research Method & Design. Empirical research is used extensively in developing and designing capabilities. More than a half of articles adopting quantitative research conduct surveys and follow a structure, namely i) developing hypotheses to investigate the factors, phenomena, abilities, roles influencing design and development of capabilities, ii) conducting a survey and iii) statistically evaluating if the hypotheses hold. Their results can be used when engineering a method for developing and designing capabilities. There seems to be a trend in the capability design field concerning the application of secondary data and case studies as a research method. On the other hand DSR is applied scarcely, which is a certain motivation for applying it in this thesis to close this gap.

Research Topics. The topics related to enterprise modelling, BPM, Business Models are only analysed in conference proceedings. The articles investigating capabilities are motivated by Resource-based View (RBV) and the focus moves towards "changing environment" lately. However, being a fundamental argumentation for the application of capabilities, the number of publications towards investigation of what types of changes might exist and how they can be tackled from an enterprise modelling point of view remain quite moderate. Moreover, the focus in capability research seems to be on 3 topics, namely *enterprise modelling*, *e-commerce* and *changing environments*. This correlation is also reflected in this thesis and establishes the core of the proposed artefact.

Methods. The term "method" is used synonymously with "process, procedure" or "step". Except for the CDD approach we were not able to identify a comprehensive method including stakeholder goals, actors, notations, important concepts and activities to be executed when designing capabilities. The methodological support is scarce and limited to the activities or procedures. Moreover, most of the articles present evidence on how capabilities interact with the subjects under study, such as service quality, customer satisfaction, success factors, knowledge management etc. but do not provide further information on how to model such capabilities. Hence, we argue that researchers could in the future propose methods that systematically support modelling of capabilities and their integration with enterprise modelling practices.

In a nutshell, the findings show that the research in capability design methods i) adopts empirical research, mostly in form of case studies and surveys ii) investigates development approaches and frameworks, mainly motivated by RBV and iii) requires additional work on the support of capability modelling, not only in terms of proposing procedures, but also enabling an integration with enterprise modelling practices in general.

4.6 CONCLUSIONS AND SUMMARY

This section briefly documents the most important findings introduced in Chapter 4.

Services and flexibility

The information society is transforming into the digital society. Information Systems should adapt to the new conditions, which determines the extent, to which an enterprise reaches its objectives. Continuously changing business environment demands flexible information systems that are easy to modify and maintain. In the thesis the focus is narrowed down to design and implementation of digital services. For this, we distinguish digital and non-digital services, as shown in section 4.2.2. The term digital service is described as the IT-based design and provision of (business) services (or *solutions*), mainly focusing on the related business processes and enterprise objectives to exchange value. That the digital services are interpreted as a socio-technical aspect had important implications for this work, e.g. the need for Business-IT alignment when designing services and taking contextual constraints into account (cf. section 4.2.1).

Not much work have been identified concerning the flexibility enhancements in digital services. We screened the feasibility of transferring proposals from the neighbouring fields. In that sense, we found approaches, studied mostly from the BPM point of view, i.e. the solutions focused on enhancing the adaptability of the processes that underlie digital services. We presented the shortcomings of the proposals and continued with our solution approach, which is modelling the application context of digital services in a systematic way.

Context modelling

Context is a widely used term, not only in computer sciences but also in other disciplines, such as social and cognitive sciences. Hence various definitions of context arise in the literature. The thesis proposes to model the context surrounding the delivery of a business. In line with [174] it defines context as "any information characterising (i.e. changing, influencing) the provision and design of a digital service that fulfils enterprise goals in a changing environment". Furthermore the notion encompasses the information characterizing the situation in which a digital service should be provided, which is the focus of attention according to Brézillion and Pomerol [185].

The state of the art analysis showed that context modelling and context-based systems are a popular topic in contemporary research with a lot of different context definitions and application examples existing. Proposals for context modelling perceive context to be of physical nature, the context of an enterprise and its operations lack scholars' attention. Bauer's work supports this finding by stating that the physical world is the most discussed dimension, whereas the activity dimension concerning the variables influencing and surrounding a task is only very little mentioning. In this respect, of the many different context categories, "proceduralized context" is the most relevant one for this thesis, since developments in this category focus on information characterising the situation of a person or an object during performing a task. This understanding could be a suitable basis to characterize the assumed or desired situations or states of digital services in different application contexts, as we have shown that digital services are offered process based and changes in the environment should be reflected in the activities that are affected from them.

None of the context modelling methods analysed in section 4.4 is suitable to reach the aim pursued by the thesis. Hence, the different context representations proposed have been used as inspiration to develop context models. Furthermore, most work focuses on the conceptualization of context, i.e. what elements context typically consists of and how to represent context models. A method for context modelling showing what steps to take and how to identify relevant context elements has not been proposed yet. In a nutshell, the shortcomings of the methods for context modelling can be summarised as follows:

1. Approaches assume in most cases that the contextual information is known. Although having a procedure for context modelling, they fail to show how to elicit contextual information in a systematic way.

2. Methods lack important elements, such as notation, tools required to model the context, the prerequisites to use the method etc., which would enhance their practical applicability.

3. Methods that rely heavily on formalisms are hard to be accepted by the stakeholders. Moreover, the authors that propose formal approaches admit that the stakeholder perceptions are still important, i.e., it is not possible to reach to a complete and unique context model.

4. Methods are prepared for the use of certain stakeholder roles. However, the contextual factors need to be represented in an

understandable and acceptable way to everyone involved in the design of digital services.

5. Methods are of monolithic nature and do not support different ways of working.

Capability modelling

Capabilities are frequently used in strategic management and IS domains to emphasize gaining and sustaining competitive advantage in changing environments. In this thesis, we applied the term **capability** as an instrument to realize Business-IT alignment and to bridge the gap between the design of digital services and their actual implementation. After introducing CDD approach as a model-based solution for capability management, methods for designing and developing capabilities are investigated. One important result of this investigation is that the research trend in capability design is moving lately towards methods, ways, steps, procedures in capability modelling, capability construction as well as integration of capabilities with enterprise modelling. Nevertheless, only very few work investigate the factors causing changes in the operating environment of the organizations and how they can be tackled in terms of enterprise modelling practices. Conclusively the scholars seem to be interested in *modelling capabilities of enterprises in changing environments, which influence their business processes*. Taking the relevance of capability research in e-Commerce area and lack of work integrating capability and service research streams, it is fair to argue that our proposal to apply capability-based solutions in the field of digital services can make a contribution to the scientific body of knowledge.

Part II

SOLUTION DESIGN

5

DECOM: A CONTEXT MODELLING METHOD

This chapter introduces the main DSR artefact, the context modelling method, which represents the core of the thesis. However, before detailing the method, section 5.1 will discuss the notion of "method" and the approaches in method engineering. The output of the section should help the reader to understand how the context modelling method is structured in the thesis. Following a selected method conceptualization framework, the remainder of the chapter explains each method component in detail.

5.1 METHOD ENGINEERING FRAMEWORK

This section describes the notion of "method" and shows the constituent elements of a method (cf. section 5.1.1). Section 5.1.2 represents the method conceptualisation framework of Goldkuhl [51], based on which the context modelling method was developed.

5.1.1 *What is a "Method"?*

In very general terms, a method describes a systematic procedure for problem solving including the required aids and resources. Problems can be characterized as the discrepancy between an as-is and a to-be situation [259].

Methods often are considered as prescriptive since they are supposed to provide guidance for problem solving or for performing complex tasks. Constituent elements of methods are actions, artifacts, constructs, notations, and actor roles [259, 260, 261]. Moreover, a method should be tool supported [262]. [129] provide a more general overview on methods and state that methods should represent three aspects; processes, products and people. Processes concern the work that must be done and encompass the activities. Product aspect includes the resources that needs to be used or produced during the processes, such as models, documents or software systems. The people aspect is related to the organizational structures that perform the tasks by creating and consuming products, such as roles and teams.

Method development is usually is a complex process since methods have to be grounded in solid experiences, elaborated with an adequate level of detail and ideally validated in many application cases in order to reach a sufficient maturity level [263]. Hence the creation of modelling methods is regarded as an engineering task.

5.1.2 *Method Engineering*

Method engineering represents a structured framework in which methods can be designed, constructed, and adapted. In the IS discipline, the notion of method engineering has been established to adress all activities concerned with the creation of methods in general and (conceptual) modelling methods in particular [262]. [264] defines method engineering as ”the engineering discipline to design, construct, and adapt methods, techniques, and tools for the development of IS”.

Method engineering is a continuous, evolutionary process [265]. [262, p. 12] states that such process consists of three phases, i.e. *method requirements engineering*, *method design* and *method implementation and evaluation*. The first phase is related with the activities that are used to explicate the problem and analyse constraints (cf. section 3.5 and section 3.6.2). The second phase is the actual method construction, as will be detailed in the next sections. The final phase includes the activities that are used to demonstrate, implement, test and evaluate the designed method (cf. Chapter 6). This method life cycle is in line with the DSR procedure followed in this work (cf. section 2.1.3.).

In a context where the organizations are in a constant seek of balance and work methods should be organized flexible to support various application scenarios [45], it is not recommendable to construct monolithic methods. A method needs to be purpose-fit and adapted to the particular needs and characteristics of its user. An often acknowledged approach to construct configurable methods is using the *situational method engineering* techniques [266]. With this approach, methodologies can be assembled from pre-existing method components, whereby a method component is a small, reusable piece of information about a very specific aspect of a methodology [129]. In terms of conceptual method development, components refer to independent items that can be aggregated to form a new artifact and they provide a partial solution to a defined problem. [267].

Another way to construct adaptive methods is proposed by Goldkuhl and colleagues [51]. Here, methods can be assembled from multiple individually identifiable parts, *method components*, which are referred to as ”method fragment” or ”method chunks” in situational method engineering [145]. Goldkuhl and colleagues state that a comprehensive method description should describe the perspective, framework, cooperation principles and all method components, including procedures, notations and concepts.

The context modelling method applies the method conceptualization framework proposed by Goldkuhl and colleagues. To streamline the method application, Goldkuhl's framework is slightly adapted in operationalization. [263]. First, we use the term *Purpose* instead "Perspective" and *Overview to Method Components* instead "Framework". Second, we refine the procedures of a method component, which is an aggregation of one or more steps. A step consists of input, objective, activity, output and tool support. Lastly, we assume that a method component can include method components, which can be described in the same structure as a complete method. The parts of the method conceptualization framework used to engineer the context modelling method in this thesis is described in the following. Also note that the remaining structure of this chapter reflects the method documentation template developed according to Goldkuhl and collegues' method engineering framework, which was used in CaaS project [167]. The framework is illustrated in Figure 5.1.

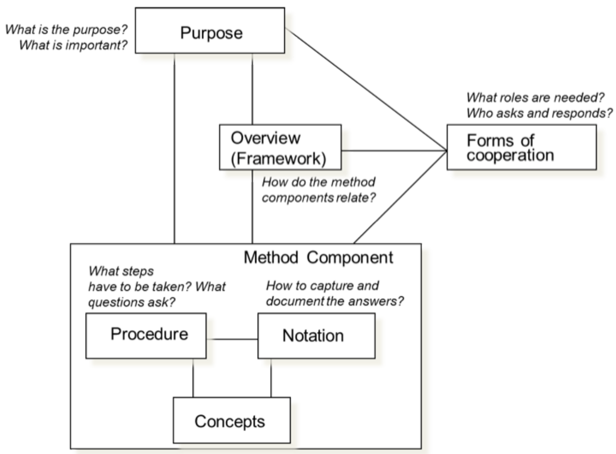


Figure 5.1.: Method components according to [51]

- Purpose: Every method has to clearly state, what the purpose of the method is, e.g. what modelling or problem solving task is supported by the method as well as the preconditions for using it.

- Overview to method components: A method usually consists of different method components and each method component may consist of sub-components. This part has to describe, which method components or sub components are included in the method and how they are interrelated, i.e. which components are to be used and under what conditions, as well as the sequence of the method components (if any), alternative ways of working. Moreover, important concepts and notation will be introduced here briefly.

- Forms of cooperation: Many modelling tasks require a range of specialist skills or cooperation between different roles. These necessary skills and roles must be described, along with the division of responsibilities between the roles and the form of cooperation. The cooperation form also includes who will take responsibility for each task or method component, and how the collaboration will be organized.
- Method components: A method component should consist of concepts, notations and a procedure.
  - The *concepts* specify what aspects of reality are regarded as relevant in the modelling process, i.e. what is important and what should be captured in a model. These relevant concepts should be named and explained in the method component.
  - The *procedure* describes in concrete terms how to identify the relevant concepts in a method component and inform the method users about the actions to be performed as well as its orders. It may also cover prerequisites and resources.
    - *Steps* define groups of activities.
    - *Input* describes the required information forming the starting point of the step.
    - *Objective* explicates how the step contributes to the overall goal of the method.
    - *Activities* are the atomic tasks to be performed to fulfil the goals.
    - *Outputs* are the results produced by the activities.
    - *Tool* support addresses the available tools to document the outputs.
  - The *notation* specifies how the result of the procedure should be documented. As a rule, this must provide appropriate expressions for each concept and for the potential relationships between them. In graphic notations, these are the symbols to be used (such as BPMN, Event-driven Process Chain (EPC), ER etc.).

5.1.3 *Documentation of the Context Modelling Method*

In order to prepare for a uniform or at least similar way of describing the different method components, a template for documenting method components was created. The template is based on the aforementioned method conceptualization framework and defines structure and content of the method documentation. The structure of the template is shown in Figure 5.2.

Template for Documenting the Method

1. Introduction
2. Purpose and Preconditions
3. Forms of Cooperation
4. Overview to Method Components
5. Method Component (one section for each method component)
    a) Concepts
    b) Procedures (for each step, the following structure is used)
        i. Input
        ii. Objectives
        iii. Activities
        iv. Output
        v. Tools
    c) Notation

Figure 5.2.: Template used for documenting the context modelling method in the thesis

5.2 INTRODUCTION TO DECOM

Enterprises exist in the context of their dynamically changing environments. There are many constraints, which the enterprises should be taking into account when designing and delivering their services or products. To name a few, external constraints are the changes in customer requirements, regulations or service deployment environment, whereas the internal constraints may relate to the staff schedule, change of task priorities and delay factors. Such constraints have a strong impact on the design and delivery of services. We name all relevant information that may influence the design and delivery of such services as contextual factor.

This observation is especially relevant for digital enterprises. As stated in [13], most of the traditional approaches for designing and delivering products and services in this digital world seem outdated and incapable to address this fast changing environment of digital users. In this respect scholars already call for new methods in digital enterprises, i.e. *enterprises offering digital services* [17].

Digital enterprises are enterprises possessing digital resources and providing an important share of its services digitally. The important emerging feature of digital enterprises is a sensing ability. Also, as digital services are intangible and favour user-specific, flexible solutions, digital enterprises should possess the ability to collect the right information from *business* sensors, evaluate the service application context and adapt the service provision accordingly. As discussed in detail in Chapter 3 and 4, we need a context modelling method integrated within enterprise modelling in order to understand context and configure digital services. The approach that will be proposed in the next sections is a first step towards this direction and introduces the digital enterprise context modelling method, or shortly deCOM.

Throughout the introduction of method components, the reader will be supported with a running example from a fictional company called *Fun Factory*. The aim will be enhancing the understandability of the respective parts of the method, by applying its concepts in shortly explained practical settings. For the readers who want to elaborate on the method application as well as know about its benefits, two more use cases with various detail levels demonstrating the application of deCOM will be provided in the appendix.

5.3 PURPOSE AND PRECONDITIONS OF DECOM

The purpose of the context modelling method is to provide a systematic help to solve the following problems documented in Chapter 3 by satisfying the functional requirements motivated in section 3.6.2.2.

- Defining and identifying the business context in an environment, in which the digital enterprise deploys a digital service (FREQ5).
- Modelling the business context, when providing digital services (cf. FREQ3, FREQ7).
- Relating the context to the actual business processes underlying the digital service and to the business goals to reach an alignment among the stakeholders (cf. FREQ4).
- Supporting the design of adaptable digital services in changing environments (cf. FREQ1, FREQ6).

The use of the context modelling method starts from a number of preconditions[1].

- The method user needs to be acquainted with conceptual modelling and preferably with enterprise modelling.
- The method components benefit from the initial definitions of the capabilities. If there are none, then these could be defined during the context modelling activities.
- The business goals to be achieved by offering the digital service are specified and modelled. These goals help to identify required context elements. If no goal models are available, then the MC F should be used to develop them (cf. section 5.6).

1 These are not "hard preconditions" that need to be fulfilled before method application. The preconditions are rather recommendations to for using the method efficiently.

- The business service related to the capability is defined, i.e. business process models exist specifying the service. The business process models are needed for identifying variation points and dependences to context elements. If no business process models are available, then the MC B should be used to develop them (cf. section 5.8).

5.4 FORMS OF COOPERATION

This section informs the method user concerning the roles performing the activities defined in deCOM. CDD methodology defines stakeholders included in the design of enterprises from capabilities point of view. As deCOM is a capability-based context modelling method, it adopts the roles defined in CDD methodology, which are explained in the following [244, pp. 21].

- Capability analyst: analyses information about capabilities and their expected operating context. From this analysis, they predict the evolution of the context and take advantage of these predictions by providing new services or improving existing services.
- Method engineer: a person who has knowledge about deCOM and can tailor it for requirements specific to an organization.
- Business service manager: is responsible for management strategies, for changes in business and to identify opportunities for capitalizing on these changes. Usually her consultancy is required to set the scope and complete context models (e.g. prioritize context elements and relate them to capabilities) as she has extensive knowledge concerning the market and change needs.
- Business analyst: a person who designs and analyses the business models as well as proposes changes to these models. Her expertise is required in deCOM when contextual factors are investigated in respective enterprise models.
- Solution engineer: configures and carries out business solution implementations, such as the implementation and configuration of an IT system support.
- Business service operator: aims to follow best practices for achieving the delivery of services to the customers. Benefits from the context models as the capability delivery is automatically adjusted to the current situation.
- Solution architect: works closely with solution engineers to ensure proper implementations. Solution architect is the link between the needs of the business and the solution engineer and helps to analyse contextual factors.

- Capability provider: responsible of providing capabilities, i.e. process-based digital services which are adaptable to changing contexts, to the client.

The stakeholder roles allocated to the context modelling activities are illustrated in a RACI chart. RACI is an abbreviation for Responsible-Accountable-Consulted-Informed. *Responsible* role executes the work and ensures the completion of it. *Accountable* role delegates the role to the responsible role. *Consulted* role is the person, whose expertise is required to complete the work. *Informed* role must be notified about the status of the work and the results. The rows in Table 16 represent the activities performed in the method and the columns show the roles performing them.

5.5 OVERVIEW TO METHOD COMPONENTS

deCOM differentiates between seven method components, each of which can be applied depending on the information set that the method user has. This chapter clarifies when to apply which method component and defines whether the MC is optional or mandatory. First, we explain the MCs shortly in the following. We follow the sequential order illustrated in Figure 5.3.

- **MC F** - Goal models are used for describing the goals of the enterprise along with the issues associated with achieving these goals. By applying this method component at the very beginning, the method user aims to establish a consensus on what the enterprise wants to reach. Eliciting goals of an enterprise will help in further stages of method application to understand, why certain business processes are required and what motivates them. This understanding helps the method user when analysing context in the business processes. MC F is conducted only if no goal models are available, i.e. it is an optional method component (see Figure 5.3). Section 5.6 details this method component.

- **MC A** - This MC sets the scope of the method application area, prepares the enterprise for its application and selects the service based on a number of criteria. The application of the MC A is is mandatory. Section 5.7 describes this method component in detail.

- **MC B** - We opt the view that the factors influencing variability in service provision should be analysed to identify contextual information. This MC primarily focuses on the analysis of business process models to identify gateways and process variants. The MC consists of two steps. The application of Step 1 is skipped, if the business processes of the respective service

Table 16.: RACI Chart

	Capability analyst	Method engineer	Business service manager	Business analyst	Solution engineer	Business service operator	Solution architect	Capability provider
Establish context modelling project	R	C	A				R	C
Select the service	I	C	A	I		C	I	R
Identify organizational processes	I	C	A	R		C/I	A	C/I
Model operational processes		C		R	I	C		A
Identify gateways	I	C		R		C	A	
Identify process variants	I	C		R		C	A	
Analyse factors & goal fulfilment	A	C		R		I	A	C/I
Analyse dependency	A	C	C	R		C	A	
Create a context element	A	C		C			R	C/I
Define how to measure each element	I	C			R		C/I	
Define capability	R	C	I			I	A	R
Select context elements	A	C	C				R	C/I
Define context element ranges & indicators	A	C	C				R	C/I
Develop and link context set	A	C	C				R	C/I
Select context providers	C/I	C			R		A	C
Add calculations	C/I	C			R		A	
Add adjustments	C/I	C			R		A	
Prepare for goal modelling	C	R	A	I			C	
Gather information		R	C/I				C/I	C/I
Conduct modelling session		R	I					
Analyse and refine goal models	C	R	C				C	I
Present the results to stakeholders	I	R	C	I			I	I
Develop and refine goal models	C	R						
Collect data related to service provision	I	C	C			R		A
Extract change factors		C	A	R			C/I	C/I
Compare findings with change factors	I	C	A	C			R	C

are already modelled. The application of Step 2 is mandatory. Section 5.8 describes this method component in detail.

- **MC C** - This mandatory MC identifies factors in business process models that cause variability, analyses dependencies between them, elicits context elements and defines mechanisms on how to measure them. If the process models have to be designed during method application, then the method user should apply both C and G[2] (see Figure 5.3). In case the process models are already developed and available, application of G is advisable[3], but not mandatory. Method component C is detailed in section 5.9

- **MC D** - This MC, which is detailed in section 5.10, is mandatory and designs the context of the selected service by defining permitted values. Also, this is the first MC that motivates the term *capability*.

- **MC E** - Prepares the context model for operational use, i.e. adds calculations and specifies which variants are implemented, how the processes are adjusted at runtime. The application of this method component is optional and only then recommended, if the resulting context model needs to be implemented in a system. The method component is rather for advanced deCOM users and detailed in section 5.11.

- **MC G** - Provides techniques to analyse textual data to support the context element elicitation activities in MC C. This is an optional method component, i.e. if the method user already has enough material to analyse or knowledgeable about fact elicitation techniques, the MC G can be skipped. Section 5.12 elaborates this method component.

The recommended sequence of the method components and their interrelation are illustrated in Figure 5.3. In total, four possible paths exist to proceed with the method:

1. Neither goal nor business process models are available: There may be situations, where business services are only described informally[4] and no formal enterprise models exist. One important remark is that deCOM has a limitation regarding the usage

2 This is useful, since the gained knowledge during business process modelling can be used to directly find contextual factors or at least can help to develop their initial understanding.

3 It is recommended as textual data can also provide valuable information complementing the information included in business process models.

4 This is true, if the enterprise is offering part of its services digitally. Informal descriptions may include customer specifications, policies, guidelines, service level agreements, documents explaining the organizational processes, the structures, roles, task allocations, handling instructions, best practices etc.

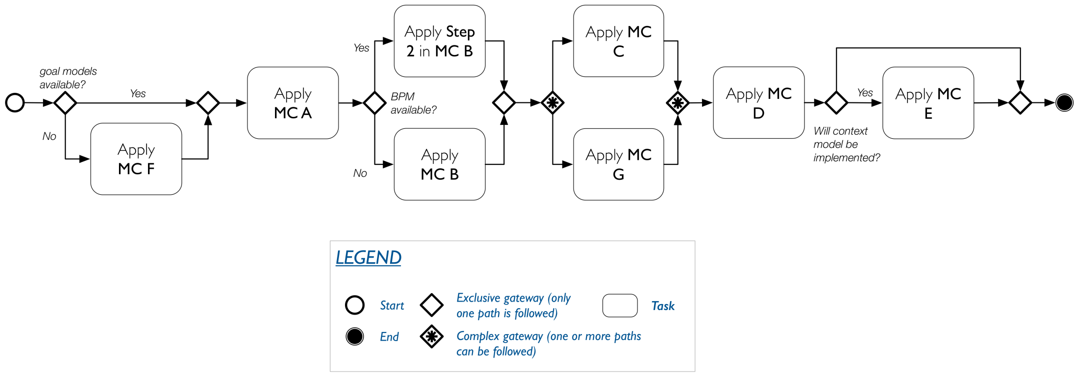


Figure 5.3.: Method components and their relation (illustrated in BPMN)

of the term "enterprise models" here and interprets it as **goal** and **business process** models. This follows from "capability-oriented thinking" of deCOM[5]. In such cases, the sequence of the method components is **F - A - B (apply fully) - C - (G optional) - D - E (optional)**.

2. Only goal models are available: If the business process models are not available but only goal models are, then the sequence of the method components is **A - B (apply fully) - C - (G optional) - D - E (optional)**.

3. Only business process models are available: If the business process are available but no goal models, then the sequence of the method components is **F - A - B (apply only Step 2) - C - (G optional) - D - E (optional)**.

4. Both goal and business process models are available: In such situations, the sequence of the method components is A - B (apply only Step 2) - C - (G optional) - D - E (optional).

As mentioned in section 5.2 earlier, examples from a fictional company *Fun Factory* will be provided to demonstrate the method application. Next, we show how the method user selects the most appropriate path before starting with context modelling activities.

5 A capability is understood as a *context-aware digital service* that helps fulfilling the enterprise objectives and implemented by the business processes. The definition emphasizes the existence of *goal models* to ensure the object fulfilment and of *business process models* to identify and extract the relevant context. After applying the method, it is not *services* any more, what the enterprises offer, but rather *capabilities*, which provides an integral view of what a service does (business process models), why it is done (goal models) and how it should be adjusted in changing situations (context model). Still, we will use the term "(digital) service" in the method components, until we begin explaining method component D. Then, we will refer to the term "capabilities".

Example

Fun Factory decides to apply deCOM. The method user investigates the suitable path to follow.

"Fun Factory" provides services to the companies operating in the attractions industry. Fun Factory operates in highly dynamic conditions, its clients offer an environment that provides amusement, entertainment, excitement, competition and year round activities. They plan to apply deCOM for a context-supported design of their services, which should be adapted to various scenarios; such as highlighting new leisure activities depending on the weather or calendar of events in the town.

After the kick-off meeting, the method user finds out that Fun Factory did not model goals, though there are plenty of documents, where enterprise objectives are detailed. The business processes of Fun Factory in contrast are formally documented with BPMN. As a result, the method user decides to apply the path F - A - B (apply only Step 2) - C - (G optional) - D - E (optional).

In the upcoming sections, each method component will be introduced based on the template provided in Figure 5.2, i.e. the core structure will follow the sequence *concept-procedure-notation*. The procedure is made up of step(s), each of which consist(s) of the input, objective, activities, output and necessary tool support. The procedure of respective method components will be illustrated as depicted in Figure 5.4.

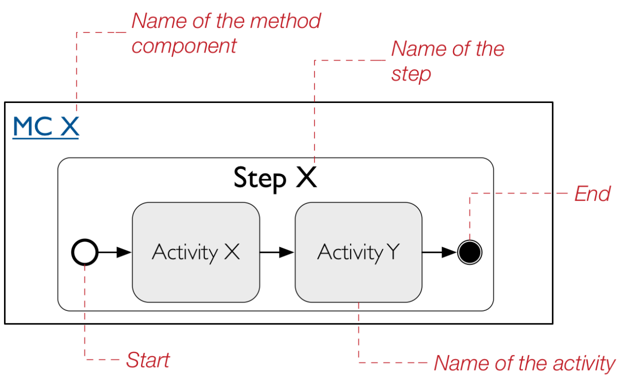


Figure 5.4.: A legend for illustrating the procedures

The structure of the context is represented within the refined CDD meta-model (see Figure 5.5) on a generic level. The meta-model builds the basis for specific context models that support system designers in their decisions which context variables to integrate in a particular digital service [183]. Consequently, the concepts used in deCOM and the relationship between them are also illustrated in the meta-model. The concepts are explained in the respective method components. The figure should only serve for introductory purposes.

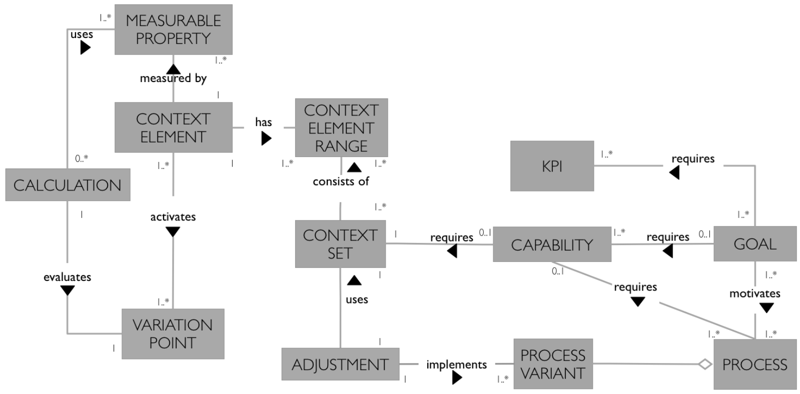


Figure 5.5.: Concepts used in deCOM represented in a meta-model, adapted from [35]

deCOM uses a number of notations for modelling business context:

- It adopts the context modelling notation (see Figure 5.6), which is designed and evaluated in the course of the EU-FP7 project CaaS [263]. The visual notation is integrated to the CDT, which is a tool developed for this project.
- It adopts the BPMN[6] for modelling business processes.
- It adopts the goal modelling notation proposed in the For Enterprise Modelling (4EM) method [268].

Beginning with the next section, we now introduce each method component in detail.

5.6 METHOD COMPONENT F: GOAL MODELLING

This method component is to a large extent adapted from goal modelling sub-component of 4EM method [268]. The goal models form the framework with which the relevance of processes are obtained. In other words, the goals are related both to the organizational and operational processes. This is why the method user should first model the enterprise goals before capturing the business processes.

5.6.1 *Concepts*

The important concepts used in MC F are explained in Table 17.

6 http://www.omg.org/spec/BPMN/2.0/

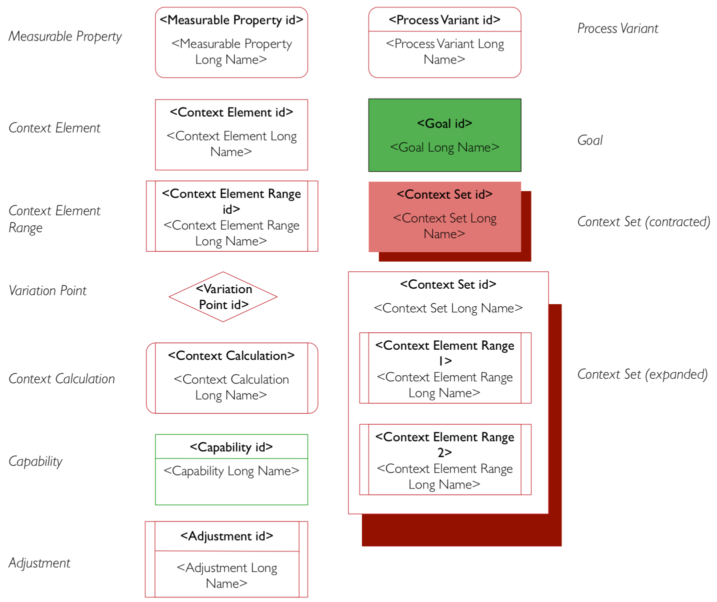


Figure 5.6.: Context modelling notation used in deCOM

Table 17.: The important concepts used in MC F

Concept/ Term	Explanation
Goal	Desired state of the enterprise that is to be,attained [268]. Goals describe what the enterprise and its,employees want to achieve or to avoid. They may be expressed as a measurable,set of states, or as general aims, visions or directions

5.6.2 *Procedure*

deCOM adapts the procedures from the 4EM process model [268, p. 151]. Depending on the project budget and available resources, the method user is allowed to select one of the two possible steps (Step 1A or Step 1B).

The procedure supports participatory[7] or conventional approaches. deCOM recommends to model enterprise goals by applying a participatory approach (see Step 1A below and Figure 5.7-A). However, situations may arise, where the project budget is limited or the contextual factors have to be analysed rather fast. In such cases the procedure is slightly adapted and simplified, which is described in Step1B and shown in picture Figure 5.7-B.

7 The *participatory* approach involves stakeholders in the decision-making and problem solving process, which increases the participants' acceptance and commitment [269]. In the conventional approach, the goal models are developed by the method user itself based on interviews, observation or workshops, with no participation by those involved in the enterprise.

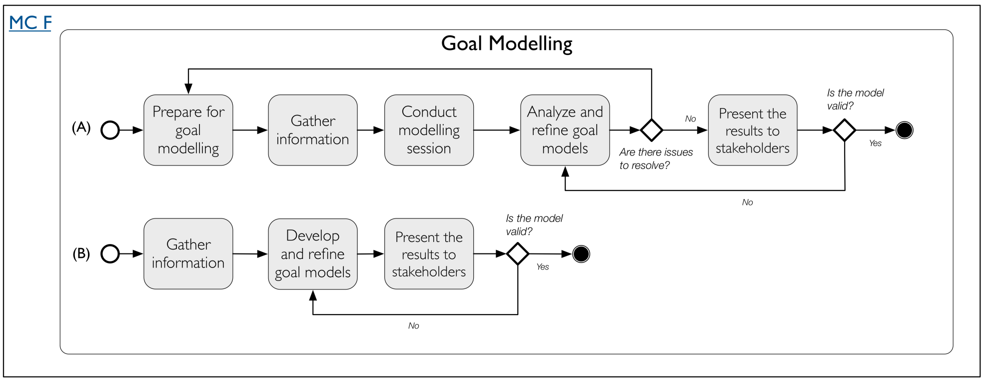


Figure 5.7.: Participatory (A) and conventional (B) goal modelling procedures

Step 1A: Participatory Goal Modelling

Input

- Organization's vision and strategy
- Stakeholder wishes and requirements, existing policies and standards
- Existing enterprise models (if any), IT architecture

Objective

- To reach a consensus on what the enterprise and its employees want to achieve, or to avoid, and when
- To describe the goals of the enterprise along with the problems associated with achieving these goals
- To have an understanding of what motivates organizational processes (discussed in section 5.8 in detail)

Activities

The following activities are performed sequentially. Iterations are highly recommended.

a) Activity 1: Prepare for goal modelling

Goal modelling is conducted in a participatory fashion. The "stakeholders" become designers working towards a common set of goals. For this purposes, this activity plans resources required for modelling enterprise goals and prepares for goal modelling in a team as follows:

- Set the budget and time frame for the modelling task.
- Schedule one mandatory and one optional modelling session, define the issues that are going to be addressed in them as well as the expected outcomes.

- Indicate relevant domain experts to be involved in the modelling sessions.
- Communicate the aim of the project with stakeholders, gain trust and establish neutrality.

b) Activity 2: Gather information

- Search the essential enterprise data related to the *enterprise strategy* (balanced scorecard, policy documents).
- Interview modelling participants in order to:
  - learn more about their views on the objectives and problems,
  - give an overview on and agree about what needs to be achieved in modelling sessions.

c) Activity 3: Conduct modelling session (see also Guideline 1).

- Introduce the session to the participants.
- Include everyone in the session and stimulate ideas.
- Build the structure gradually and refine it during the session.

Guideline 1: Best practices for conducting a participative modelling session

A series of best practices and guidelines for a participative modelling sessions are provided in the 4EM method [268]. To name a few:

- Avoid beginning modelling with long explanations of abstract concepts
- Make sure that everybody participates in the modelling process.
- Give a brief introduction on the sessions agenda as well as the ground rules for modelling.
- Build further on each other's thoughts .
- The objectives are related to the enterprise itself and its rationale, i.e. information system goals and its technical requirements are not reflected in goal models.

d) Activity 4: Analyse and refine goal models

- Refine the models in terms of their presentation, layout and content.

- If there are issues that needs to be resolved (conflicting goals, unclear statements) go back to Activity 1 and perform the second modelling session. If not, continue with the next activity.

e) Activity 5: Present results and validate

- Stakeholders identify whether there are issues that are not resolved and require further development. If this is the case, then Activity 4 is revisited and the model is refined. If not, then the goal model is ready for use.

Output

- A goal model consisting of the objectives of the enterprise as well as the problems that hinder achieving it. Thanks to the participatory approach, there is a consensus among the stakeholders on what the enterprise wants to achieve.

Tools

- CDT is recommended[8]. Otherwise, any modelling tool incorporating the deCOM stencils[9] can be used (e.g. Visio, OmniGraffle), as it adopts the goal modelling notation proposed in 4EM method.

Step 1B: Conventional Goal Modelling

Input

- This step assumes the same inputs as Step 1A.

Objective

- To describe the goals of the enterprise along with the problems associated with achieving these goals, where the budget is limited and/or the contextual factors have to be analysed fast
- To have an understanding of what motivates organizational processes

Activities

Following activities are performed sequentially (see Figure 5.7). Iterations are highly recommended

a) Activity 1: Gather information

8 The current version of the CDT can be downloaded from https://drive.google.com/open?id=0B-RMdeoAg4L1XzA5YWM3aHhIdDA

9 The stencils can be downloaded from `https://drive.google.com/open?id=0B_qy9WuXXyDidjhHZ2F1RWxoalE`

- Search the essential enterprise data related to the enterprise strategy (balanced scorecard, policy documents).
- Identify the relevant stakeholders who are directly involved in decision making and goal formulation at pertinent level of the organization.
- Interview those stakeholders to gain additional information regarding the enterprise objectives.

a) Activity 2: Develop and refine goal models

- Build the structure gradually, if possible by using a modelling tool (see also Guideline 2).
- Refine the models in terms of their presentation, layout and content.

Guideline 2: Useful questions for modelling goals

To develop goal models, the method user may ask herself following questions [268, p. 99]:

- What are the strategies of the enterprise? (These should be reflected in goal models)
- Which regulations, rules, laws and conventions are relevant?
- How can a particular goal may be made more specific and more relevant to the selected service scope?

c) Activity 3: Present results and validate

- Stakeholders identify whether there are issues that are not resolved and require further development. If this is the case, then Activity 2 is revisited and the model is refined. If not, then the goal model is ready for use.

Output

- A goal model consisting of the objectives of the enterprise as well as the problems that hinder achieving it[10].

Tools

10 The resulting goal model in a conventional case will probably be different than a goal model, which is developed in a participatory fashion. Nevertheless, it will suffice to understand why certain processes are required. This understanding helps the method user when analysing context in the business processes.

- CDT is recommended[11]. Otherwise, the method user can model within MSVisio® or OmniGraffle® and use the deCOM stencils[12].

Example

Fun Factory models the enterprise objects formally.

The method user starts the project by applying Method Component F. Here, she performs Step 1B with the justification that "the available budget is limited, the management staff documented the objectives clearly". She models the high priority goals of Fun Factory and validates them with the domain experts as follows (note that the aim is to keep the example models as simple as possible. Hence the goal models do not include problems, weaknesses etc. and they do not claim completeness). The result is illustrated in Figure 5.8.

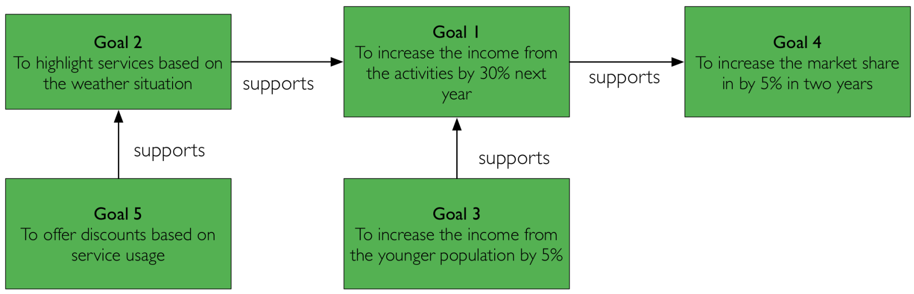


Figure 5.8.: A fragment from Fun Factory's goal model

5.6.3 *Notation*

The modeller should use the goal modelling related parts of the deCOM notation, which is adopted from the 4EM method and shown in Figure 5.9.

5.7 METHOD COMPONENT A: SCOPE ANALYSIS

In this method component, the method user sets the scope by establishing the modelling task as a project (define the problem, state the goal, communicate the improvements gained with the application of deCOM etc.). A model is generalized representation of a piece of reality, with only relevant real-world properties taken into account during modelling. For the purposes of deCOM, the real world properties mainly refer to the objectives and business processes of an enterprise.

11 The current version of the CDT can be downloaded from https://drive.google.com/open?id=0B-RMdeoAg4L1XzA5YWM3aHhIdDA

12 The stencils can be downloaded from https://drive.google.com/open?id=0B_qy9WuXXyDidjhHZ2F1RWxoalE

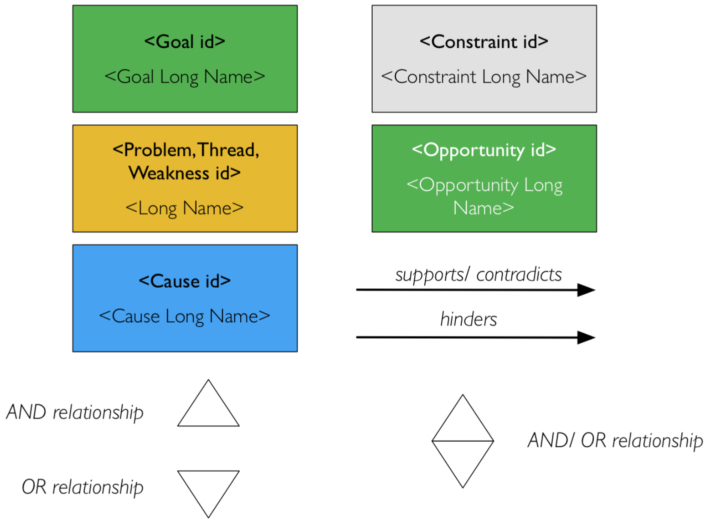


Figure 5.9.: Goal Modelling Notation used in deCOM, adapted from [268]

Table 18.: The important concepts used in MC A

Concept/ Term	Explanation
Service	Capabilities or competencies that one person, organization, enterprise or system provides for another. In this MC, we refer to **digital services**, i.e. services that are provided based on digital assets and require IT in its creation and delivery, each time the term *service* is used

A general consensus between the project stakeholders is an important prerequisite for a successful method application. After this, the service that needs to be designed context-aware is selected. The service selection can depend on various factors, such as optimizing the services with high process costs or managing services that frequently change and require the adjustment of business processes. Adhering to [41], we call such factors *service enhancers*. deCOM differentiates between four service enhancers, time, automation, flexibility and cost. It is possible to extend the list with other enhancers that are perceived as important from the enterprise point of view.

5.7.1 *Concepts*

Method component A uses the concepts illustrated in Table 18 and mentioned in section 5.7.2.

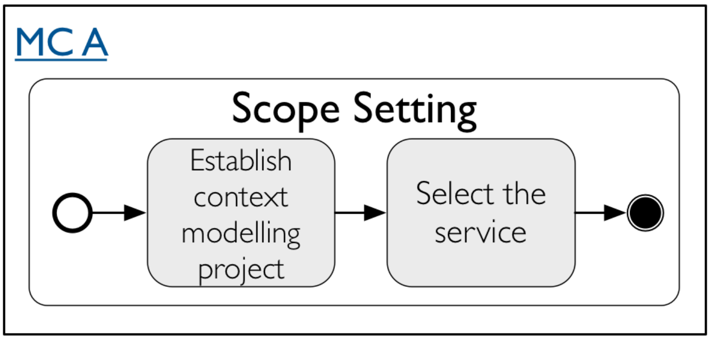


Figure 5.10.: The procedure of the MC A

5.7.2 *Procedure*

The method component A includes a single step "Scope Setting", which is depicted in Figure 5.10.

Step 1: Scope Setting

Input

- Objectives of the enterprise, as formulated, modelled and agreed upon in the MC F
- Service descriptions and service portfolio of the enterprise.
- Secondary data including customer specifications, policies, guidelines, service level agreements, documents explaining the organizational processes, the structures, roles, task allocations, instructions, best practices etc.

If the secondary data is not enough for scoping, additional information should be obtained by conducting interviews and workshops with respective roles in the enterprise.

Objective

- Reaching a consensus with the stakeholders regarding the outcomes of the method application.
- Setting the scope of the service, which should be designed context-aware.

Activities

The following activities are performed sequentially. Iterations are recommended.

a) Activity 1: Establish the project [268].

- Define the problem with the organizational actor(s) that benefit(s) from its solution (problem owner).

- Discuss the expected outcomes, boundaries and likely ways of solving it.
- State the goal(s) explicitly that the context modelling method supports.
- Communicate the project benefits with related stakeholders and get approval (see Guideline 3). These can be adapted in line with the enterprise goals.

Guideline 3: The aspects for highlighting the benefits of method application

- The method application creates value that contributes to the overall success of the enterprise.
- The resulting context models are going to save costs by improving the process execution.
- The enterprise will be able to configure its services faster and expand into new markets easier, which necessarily enhances competitive advantage.
- Explicating context requires a thorough analysis of business processes. This will ensure up-to-datedness of the process models.
- The context modelling method will provide a way to manage variability issues in business processes.
- The context models will show what parts of the service should be flexible. That such information is represented on a model level makes it easy to communicate with the stakeholders, which are influenced by such flexibility.

b) Activity 2: Select the service

This step can be skipped, if enterprise objectives or problem definition in the aforementioned activity already addresses the service, which needs to be designed context-aware.

- Identify a service that fulfils the enterprise goals and satisfies the following Service Enhancer (SE)s:
  - SE1-Automation: Identify services that have a potential of automation or are largely automated. Automating a service may promise a high level of quality compared with non-automated services, since they do not rely on human effort.

Table 19.: An example of the service selection matrix

	Automation	Time	Flexibility	Cost
Service 1				
Service 2				
Service n	x	x	x	x

  - SE2-Time: Identify services that aim to reduce the time and effort spent by the client or focus on client's time and effort optimization.
  - SE3-Flexibility: Identify services that require more frequent change than others.
  - SE4-Cost: Identify services, where the failure of provision causes high process costs or where the co-production of the value with the customer is highest.

- Create a matrix with services on the left column and the service enhancers on the upper row (see Table 19).
- Mark the services that fulfil the aforementioned enhancers. Select the service that satisfies all four enhancers (see Table 19 for an example).
- Reach an agreement with the stakeholders about the selection, i.e. the selected service is going to be designed context-aware at the end of method application. Use the created matrix and adapt it, if necessary.

Output

- A tabular representation including the services and the service enhancers (service selection matrix).
- Selected service, which should be designed and provided context-aware upon the agreement with stakeholders.

Tools

- In this step no specific tools are required. Anything can be used for tabular representation of the service matrix.

5.7.3 *Notation*

No specific notation is required in this method component.

Example

Fun Factory establishes the context modelling project.

Fun Factory has a management software for theme parks and leisure centers, based on a set of applications integrated into a single data system. To a large extent, the business processes are modelled and implemented as workflows in the system. However, the system does not have the capability to promote leisure activities depending on the **current context of each client**, i.e. offering discounts for outdoor activities when its usage is below average would not be possible. deCOM will support the company to identify the business factors that influence which leisure activity to promote for what type of clients and under what circumstances. This will be termed as "business context"of Fun Factory. The resulting model will adjust the workflows implemented in clients system and adapt the tasks to the service application context. This selection is supported by the "service selection matrix". Although the method user does not have to use "service selection matrix" in this case, (because the expressed problems and goals of method application clearly defined what service to take), the matrix served double check purposes (see Table 20). Promoting and advertising services i) have a potential of automation, ii) focus on offering the right service for the client and save her time, iii) are under high influence of environmental factors and iv) incorporate high proportion of customer co-production.

Table 20.: Service selection matrix in the Fun Factory case

	Automation	Time	Flexibility	Cost
Promotions & Advertising			x	
Ticket Desk Operations		x		x
Shops & Games	x	x	x	x

5.8 METHOD COMPONENT B: PROCESS MODELLING & VARIABILITY ANALYSIS

In this method component, the modeller identifies certain elements in business processes, which will help her to form the context element in MC C. The main idea is that business context of a digital service can be extracted after analysing the reasons, factors, drivers, influences etc. that cause changes in the execution of the workflow, as "variations cannot be explained in isolation from contextual factors" [212] and digital services are provided process based (cf. section 4.2.3). For this, availability of the business process models of the respective service is a prerequisite.

Table 21.: The important concepts used in MC B

Concept/ Term	Explanation
Process	See *operational process*
Gateway	Instruments to represent join and split behaviour of the flow of control between activities, events and gateways
Process Variant	Adaptations or adjustments of a master process to specific requirements caused by the changes in the context
Operational Processes	Series of activities that are performed to achieve a particular result. In this work, we use the term "process" or "business process" instead operational processes [270]
Organizational processes	High-level processes that are typically specified in textual form. Organizational processes determine the operational processes and they realize business goals [270]
Activity	In line with BPMN community, an activity is defined as smallest business-related element of a process and do not possess any further subordinate elements
Workflow	An automated business process that is used for service implementation

5.8.1 *Concepts*

Method component B uses the concepts illustrated in Table 21 and mentioned in section 5.8.2.

5.8.2 *Procedure*

The method component B includes two steps "Business Process Modelling" and "Process Model Analysis", which are depicted in Figure 5.11.

Step 1: Business Process Modelling

(Skip this step, if business processes of the respective service are already modelled.)

Input

- Selected service in MC A.
- Goal models representing the objectives of the enterprise.
- Secondary data including information about the organizational processes, policies, guidelines, service level agreements and instructions.

Objective

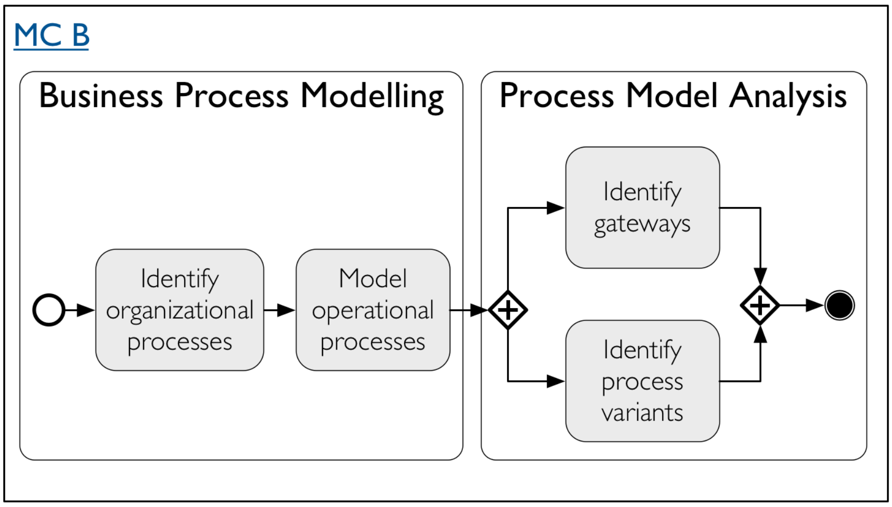


Figure 5.11.: The procedure of the MC B

- Supporting the method user on business process modelling activities.
- Documentation of the business processes on a textual level leaves room for different interpretations of solution implementation. Their formal modelling in contrast solves this problem and allows for unambiguous interpretations.
- By modelling the processes, a higher degree of formality should be reached. A low degree of formality hinders the automation of the tasks.
- Creating a basis for the method user to analyse variability (see the next step).

Activities

The activities are performed sequentially (see also Guideline 4).

a) Activity 1: Identify organizational processes.

Organizational processes are the highest level in the process hierarchy. They help realizing the enterprise objectives and strategies.

- Analyse secondary data comprising of the information about service provision process and task allocation. The method user may also use the data gathered in MC F.
- Analyse goal models and extract organizational processes.

b) Activity 2: Model operational processes required for service implementation.

- Transform the textual descriptions of organizational processes to smaller activities with certain sequence manually[13].
- Enrich the models with the information extracted from goal models.
- Discuss resulting process models with stakeholders and update those when necessary.

> **Guideline 4: Recommendations for modelling business processes [268]**
>
> - Remember that a business process model describes processes of the business area, and not systems or organizational units. In our case it relates to the provision of the selected digital service.
> - *Organizational processes* are easier to understand, since they are represented on a higher abstraction level. If they are too generic and do not contain information about digital service delivery, they should be decomposed to *operational processes*, which often includes variations related to the service provision context.
> - Following questions may help for modelling business processes:
>   - Which organizational processes are there, or should be there, in order to manage the organisation in agreement with the goals?
>   - How should the business processes, tasks, etc. be performed (workflows, process models)?
>   - Why is this process needed and what is its relationship to the other processes?
>   - How are the processes related to organisational actors?

Output

- Process models of the selected service, both on organizational and operational level

Step 2: Process Model Analysis

(This is a mandatory step.)

Input

- Process models of the selected service

13 Although methods exist that support business process modelling, deCOM does not favor a specific one.

- Textual descriptions of processes

Objective

- The aim is to analyse business process models to identify possible variations. The main motivation is that such variations in the business process models arise due to the factors, from which *context elements* are extracted [212]. Simply stated, contextual influence may be traced back by analysing the variability in business process models.

Activities

The Activity 1 and 2 are performed sequentially (see also Guideline 5). Iterations are mandatory, since we investigate both *operational* and *organizational* processes.

a) Activity 1: Identify gateways.

- Highlight all labelled gateways (gateways with conditions) or gateways with labelled paths in the business process models.
- Create a table with two columns. Enter the number of the gateway in the first column and condition expression in the second column (see Table 22).
- Gateways with same conditions and same diverging paths are considered identical.

Example

Gateways in Fun Factory case are highlighted

As explained earlier, the business processes of Fun Factory are already modelled and stored in the ERP system. We will not go into the details of each process model and each gateway. Nevertheless, a simple example of gateways captured in the operational processes is illustrated in Table 22.

Table 22.: An example of tables capturing the gateways

Gateway	Condition
GW1	Important events in the calendar?
GW2	Temperature above 15 degrees?
GW3	Service booking below average?
GWn	...

b) Activity 2: Identify process variants

A process variant refers to the adapted versions of a certain process due to any of the following reasons: new technologies, governmental rules, organizational context or adoption of new standards.

Guideline 5: Variability identification in organizational and operational processes

- Usually, it is a straight forward task to identify variability in organizational processes, since these exhibit a high level of abstraction, contain fewer model elements and include happy flows.
- On the contrary, identifying variability in operational processes may require more efforts and a higher number of iterations.
- It is probably easier to perform Activity 1 with consolidated business models. In a consolidated business process model, all possible variations of a process are represented in the same model, including all branches and activities. An example of this is given in Figure 5.13.

In Activity 1, the focus was on the identification of gateways to investigate variability. However, process variability does not have to be represented only by the gateways. For instance, a business process model might be adapted by adding and/or removing activities to/from them[14]. By both examining the variation points and process variants we make sure that deCOM explicates variability elements in a business process model.

- Highlight process variants both on operational and organizational level.
- Number the process variants.

Output

- Process variants and gateways in the business process models of the selected service.
- The output should be documented in tabular form.

Tools

- Any tool incorporating a module for business process modelling, preferably the CDT.
- Anything can be used for tabular representation of gateways.

14 As an example, before promoting a leisure activity during good weather, the task "calculate wind speed" is executed (see Figure 5.12A). This is a process variant, although there is no gateway behind the task. This is a solely design decision of the process modeller, which we cannot influence.

Example

Process Variants in Fun Factory case

Depending on a number of input data, such as the precipitation, temperature and wind speed, the system obtains the value of weather (good or bad). Based on this calculation, specific leisure activities can be promoted. Figure 5.12 shows an example of two process variants (A and B) reflecting how to proceed in both cases.

The consolidated view of these process variants are provided in Figure 5.13. As will be mentioned in Guideline 6, our experience shows that it is easier to identify gateways in consolidated business process models. Note that the task "pre-calculations" in Figure 5.12 is generic and comprises of the tasks that are modelled before the first gateway in the consolidated process model view.

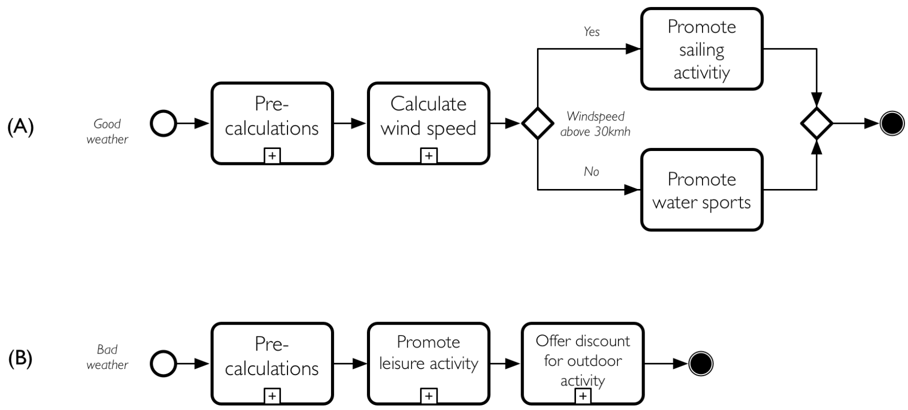


Figure 5.12.: Process variants in Fun Factory case

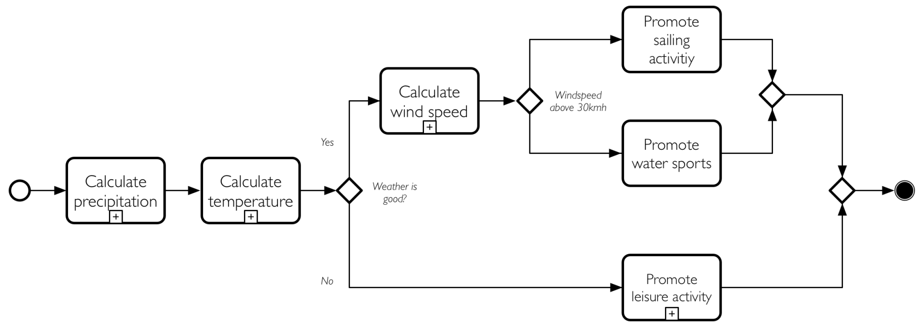


Figure 5.13.: Consolidated view of the process variants for leisure activity promotion

5.8.3 *Notation*

deCOM adopts the BPMN for the execution of Step 1 in this method component. Step 2 does not require applying a notation.

Table 23.: The important concepts used in MC C

Concept/ Term	Explanation
Factor	Drivers that cause variations in the process models, such as varying expectations of the stakeholders, changing user needs, technology advancements, scheduling constraints, market demands etc. An analysis of such factors aids to design a context element
Context	Any information characterizing (i.e. changing, influencing) the provision and design of a digital service that fulfils enterprise goals in a changing environment [174]
Context Element	Context entities that affect the service design and provision by causing variability. The context entities are always related to the enterprise goals (as opposed to the "factors")
Measurable Property	Attribute of a context element that helps to measure its value
Variation Point	A specific gateway incorporating locations of variations in a business process model that influence the enterprise goals. All variation points are gateways, but not all gateways represent a variation point. Variation points are decisive for identifying context elements

5.9 METHOD COMPONENT C: CONTEXT DESIGN

deCOM assumes that the business context can be explicated by analysing the variability in business process models. In this method component, the reasons, drivers, influences (in short, *factors*) for change in relevant business process models are elaborated. These factors will establish the basis to create the *context elements* that affect the service design and provision.

5.9.1 *Concepts*

Method component C uses the concepts illustrated in Table 23 and mentioned in section 5.9.2.

5.9.2 *Procedure*

The method component C includes two steps "Context Element Elicitation" and "Context Element Design", which are depicted in Figure 13.

Step 1: Context Element Elicitation

Input

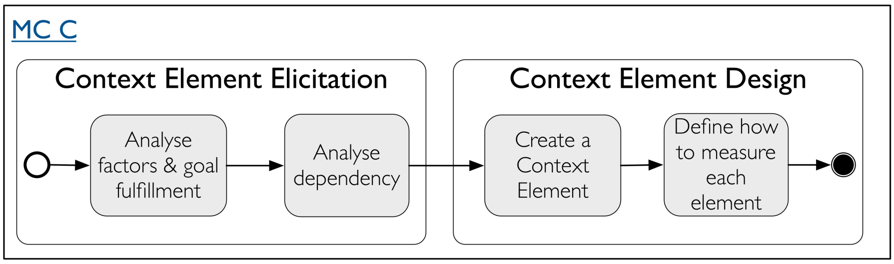


Figure 5.14.: The procedure of the MC C

- Process models of the selected digital service
- A view of process variants and/or a tabular list of gateways that are identified in the MC B

Objective

- The main assumption of deCOM is that the contextual influences may be traced back by analysing the variability in business process models. In this step, the factors (the reasons, drivers, influences causing a change in service provision) are elaborated, which will establish the basis to create a context element.

Activities

The activities may be performed sequentially or in parallel. Iterations are highly recommended.

a) Activity 1: Analyse factors & goal fulfilment

- Take the list of the gateways identified in the last step of MC B and the process variants.
- Add the column "gateway analysis" to the table. (Please check Guideline 6 on how to proceed for the **process variants**)
- Study each gateway by asking the following questions:
  - What is the reason for this gateway to exist?
  - Does the reason relate to the enterprise objectives? Is it reflected or represented in the goal models?
  - Is the reason too generic in a sense that a different enterprise would anyway consider it when offering similar services? Or is it specific?
- Add the column "factor" to the table.
- Derive the exact factors from your analysis, document them in "factor" column.

- Add the column ”goal fulfilment” to the table.
- Analyse how those factors influence goals. They may have weak or strong contribution to goal fulfilment (see Table 24 for an example).
- Discuss the findings with domain experts and validate the factors.

Guideline 6: The activities may be altered for non-consolidated business process models

- Consolidated process models consist many gateways, since they incorporate all possible path executions in one single model. It is a fact that creating consolidated business process models is a complex and time-consuming task. An alternative to consolidated models are the models that represent each process variant separately. In such cases, you have many business process model fragments and most likely they do not incorporate those gateways that are relevant for context identification. In such cases, you should adapt Table 24 as follows:
  - Rename the *Gateway* column as *Process Variant*.
  - Rename the column *Gateway Analysis* as *Process Variant Analysis*.
  - Add a new column named *Gateway* after the *Goal Fulfilment* column .
- Following rule applies, when mapping the process variant numbers to the gateway numbers:
  - Map each factor to *exactly* one gateway. Assume that there are two rows in the table, corresponding to two process variants (PV1, PV2). The factors influencing the execution of the first variant (PV1) is ”regulation”. The second variation (PV2) is required due to the factors ”regulation, financial status and market size”. In that case, the method user should end up with documenting three gateways, *regulation* (GW1), *financial status* (GW2) and *market size* (GW3).

Example

Analysing the factors and their goal fulfilment

In the business process models of Fun Factory, we assume that there are six gateways, which we do not represent graphically, but still analyse why these are required, how their evaluation contributes to the enterprise goals.

Table 24.: An example of factor and goal fulfilment analysis.

Gateway	Condition	Gateway Analysis	Factor	Goal Influence
GW1	Important events in the calendar?	The reason for this gateway to exist is .... It is not reflected in goals model and it does not relate to service provision	Capacity utilization prediction	Weak
GW2	Temperature above 15°?	The reason for this gateway to exist is .... It is reflected in goals model AND/OR directly relates to service provision	Weather analysis	Strong
GW3	Precipitation over 60%?	The reason for this gateway to exist is .... It is reflected in goals model AND/OR directly relates to service provision	Weather analysis	Strong
GW4	Service booking below average?	The reason for this gateway to exist is .... It is reflected in goals model AND/OR directly relates to service provision	Capacity utilization	Strong
GW5	Wind speed over 30km/h?	The reason for this gateway to exist is .... It is reflected in goals model AND/OR directly relates to service provision	Weather analysis	Strong
GW6	Weather is good?	The reason for this gateway to exist is .... It is reflected in goals model AND/OR directly relates to service provision	Weather analysis	Strong

b) Activity 2: Analyse dependency

- Filter and eliminate factors in the table that have a weak contribution to goal fulfilment.
- Create a taxonomy between the gateways of remaining factors to identify dependencies (cf. Figure 5.15).
  - Resolving a gateway may resolve another gateway, although the evaluation of its condition expression does not directly influence a goal. Use *contributes_resolving* association between those gateways (see Fun Factory example below).
  - Resolving a gateway may determine, whether another gateway is needed. Use *depends_on* association (directed from the latter to the prior) between those gateways (see Fun Factory example below).
- Create a separate table and select the gateways which have "*strong contribution*" association to goals. Rename those as *variation points* (according to the example in Figure 5.15, the gateway *GW4* should be renamed as *VP1*).
- Validate the results with the domain experts.
- Note that, if you only have separately modelled process variants, you do not have to consolidate them to perform this activity. Instead, extract the factors that cause modelling such variants and treat them as *gateways*. After that, analyse dependency.

Output

- A table including the gateways, list of factors, their analysis and contribution to goals
- Dependency analysis as modelled in Figure 5.15
- Variation point(s)

Tools

- Anything can be used for tabular representation of change factors.
- Any tool incorporating a module for business process modelling, preferably the CDT, to view the business process models.

Example

Dependency analysis of the factors that influence the gateway evaluation in Fun Factory case.

The method user filters out the gateways that are evaluated by the factors, which have a weak goal influence. Then she creates a taxonomy between the remaining gateways. GW2 and 3 are executed to obtain whether the current weather is good or not. As such, they "contribute to resolving" of GW6. GW5 is only then executed, when the weather is good. This is why there is a "depends_on" relation between them. GW6 and GW4 relate to company goals and has a strong contribution. Figure 5.15 depicts the dependency analysis.

deCOM allows highlighting the most important gateways in the context model. These are termed as "variation points" (see Guideline 7). Consequently, Table 25 renames the gateways with strong and direct goal contribution as *variation points*.

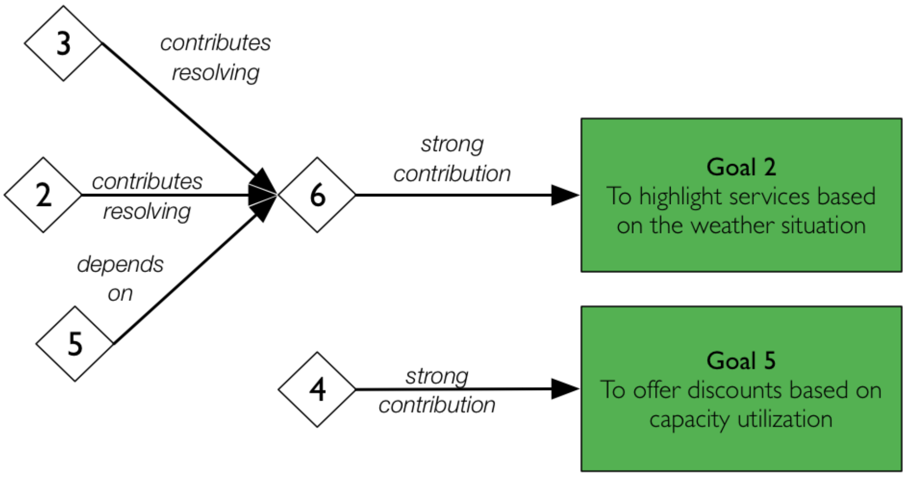


Figure 5.15.: Dependency analysis in Fun Factory example

Table 25.: Renaming the gateways as variation points

Gateway	Variation Point
GW6	VP1
GW4	VP2

Step 2: Context Element Design

Input

- Analysis of factors & goal fulfilment
- The dependency analysis

Guideline 7: Understanding the role of variation points

- Different than a decision point (represented by standard gateways), the branches of a variation point is always relevant for the service delivery and their execution contributes to the enterprise goals. As such, they are represented in context models.
- Variation points are not *generic* but often characteristic for process execution. On the contrary, *standard* gateways are expected to be used in all kind of situations and they can appear in all possible process models.

Objective

- Designing the entities (context elements) that affect the service design and provision and related to enterprise goals.
- Defining how those entities are measured.

Activities

The activities may be performed sequentially or in parallel.

a) Activity 1: Create a Context Element

- Select the variation points resulting from the dependency analysis.
- For each variation point, check the factor associated with it.
- For each factor, create an entity "context element".
- Repeat this for all variation points.

b) Activity 2: Define how to measure each element

- Identify how the values of context elements are obtained. These are called "measurable properties" (see Guideline 8).
- Refine the context elements into atomic entities if necessary (see Guideline 8).
- Model the entities as measurable properties.

Output

- An initial context model including the context elements and measurable properties. The context model incorporates all factors that cause changes in the digital service provision.

Tools

- Anything can be used for tabular representation of change factors.
- Any tool incorporating a module for context modelling, preferably the CDT, to model the business context. Also, the method user can model within MSVisio® or OmniGraffle® and use the deCOM stencils.

5.9.3 *Notation*

The modeller should use the context modelling notation, which is illustrated in Figure 5.6.

Guideline 8: Refinement of a context element

- The analysed factors can be refined into atomic entities by observing what actually affects the service provision. For example, a company called "Dermott Sails" hires paddle boats in all type of weather situations, except for when the temperature is lower than 15 degrees. Hence, the context element will probably be "temperature" rather than weather. On the other hand, a competitor in that sector called "Meridian Sails", hires the boats when the weather is good and defines good weather as "low precipitation with temperature over 20 degrees". In this case, the context element will probably be "weather" which is measured by the precipitation and temperature.
- Check the factor and goal fulfilment analysis table. If there are factors, which have a weak or strong but indirect influence on goal fulfilment, then these may be used as measurable properties or context element ranges.

Example

Designing the business context in Fun Factory case

The method user checks the dependency analysis model as well as the factor and goal fulfilment table. The two dominant factors seem to be the "weather analysis" and "capacity utilization". Based on these factors, she creates two context elements.

How should these context elements be measured? What could be relevant to obtain the value of "weather"? For this, the method user looks into the outputs of Step 1 and identifies temperature, precipitation and wind speed as entities to measure the value of the context element "Weather". For the second context element, she finds out the service booking rates can be obtained from the system.

The initial context model including two model elements is illustrated in Figure 5.18.

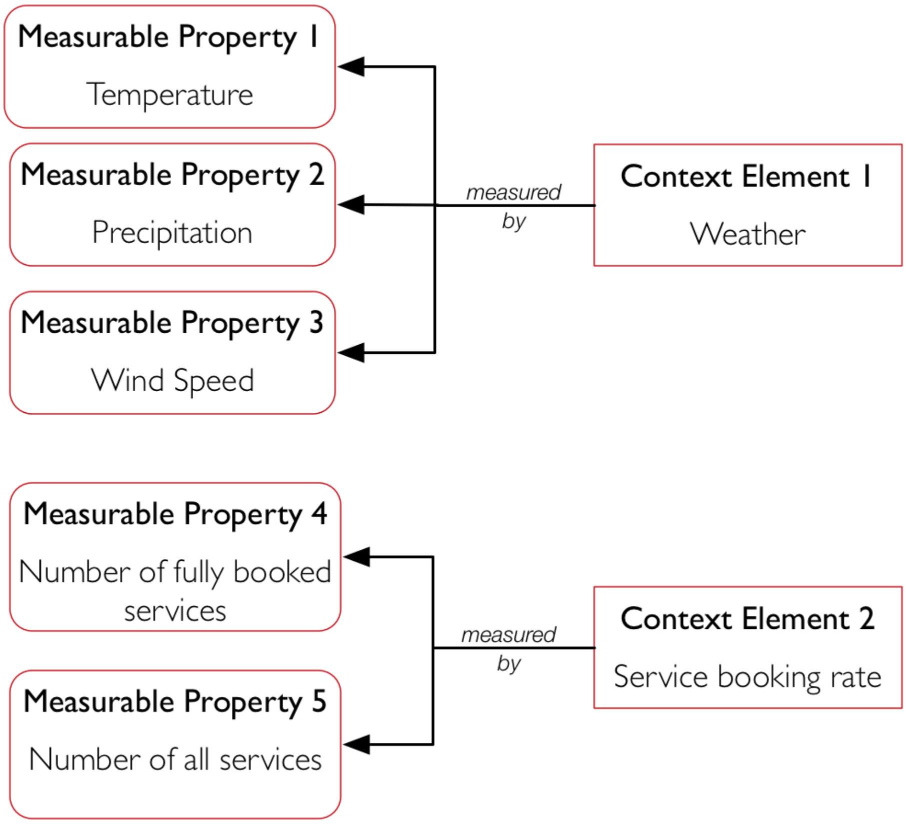


Figure 5.16.: Initial context model of Fun Factory example

5.10 METHOD COMPONENT D: CAPABILITY DESIGN

This method component i) introduces the term *capability*, ii) defines value ranges of the context elements and iii) collects them in a context

Table 26.: The important concepts used in MC D

Concept/ Term	Explanation
Capability	Context-aware digital services that are related to the enterprise goals and implemented by the business processes[15]
Context Set	A container for context elements that are relevant for design and delivery of a specific capability. This container includes defined value ranges of a context element
Context Element Range	Boundaries or permitted values for a specific context element and for a specific context set, where the delivery of capability is active or inactive (i.e., context-aware digital service is provided in a certain way or not provided at all)

set. The modeller is expected to have a better view of the context, goals and business processes in this stage, hence the term *capability* is used for the first time in this method component. The notion is explained and shortly discussed in the following sections.

5.10.1 *Concepts*

Method component D uses the concepts illustrated in Table 26 and mentioned in section 5.10.2.

5.10.2 *Procedure*

The method component D includes one step "Context Set Design", which is depicted in Figure 5.17.

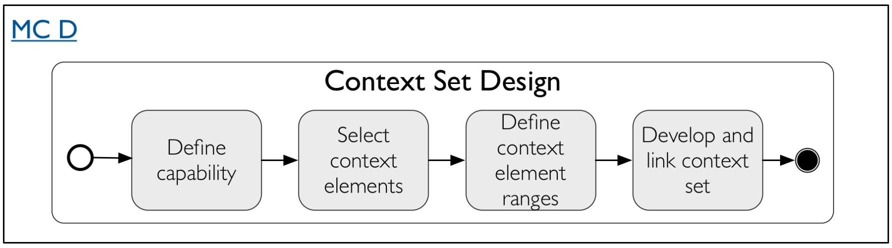


Figure 5.17.: The procedure of the MC D

15 From this moment on, deCOM suggests using the term "capability" rather than the term "service". After completing this method component, it will be "capabilities" what the enterprises offer, i.e. digital services that are put in a context and which are easy to configure. Doing so, enterprises aim to be more agile and flexible in ever-changing environments, in which they operate. This is different from what a "service" does. A service is not always related to enterprise goals in a sense that service models do not capture enterprise goals. Moreover, a service is per se not context-aware and hence not flexible.

Step 1: Context Set Design

Input

- The initial context model resulting from the previous method component, including the context elements and measurable properties.

Objective

- Establishing a connection between the goals, business processes and business context (by using the concept of ”capability”)
- Extending and refining the context model before preparing it for operationalization

Activities

The activities are performed sequentially. Iterations are recommended.

a) Activity 1: Define capability

- For the relevant service, explicated goals, designed business process models and context models, find the most proper ”capability” definition (see Guideline 9).
- The defined capability is in a sense context-aware expression of the selected service. The method user should communicate the definition with stakeholders and reach an agreement about it.

b) Activity 2: Select context elements

- The context elements are already in the context model. In this activity, the relevant context elements for the defined *capability* are selected.
- Validate the suitability of context elements for this capability with domain experts.

c) Activity 3: Define context element ranges

- Define the permitted values for selected context elements by taking capability delivery into consideration (also see 8).

d) Activity 4: Develop and link context set

In the context model:

- Connect context elements with their ranges.
- Put all the ranges in a context set.

Guideline 9: Recommendations for capability definition

- A capability can share the same name with a service. However, the difference is in their content. A capability is an enhanced digital service in a sense that:
  - its relation to enterprise goals are clear and expressed on a model level,
  - it can be offered, delivered, provided in different environments, since it is context-sensitive,
  - the change factors influencing the variability are well-documented and reflected in context models. Hence, they can be communicated easily with different experts participating to the design and delivery of the digital service.

  Services do not always satisfy such properties, which is why we urge the term "capabilities" (see also Footnote 15 and a detailed discussion in section 1.1).
- In a context model, the term capability is used as a central concept to link different model perspectives, such as goals, application environment and operational processes.

- Connect the context set with the defined capability.
- Connect the capability with goals and processes.

Output

- *Capabilities*, which are basically context-aware digital services that fulfil one or more enterprise goals by implementing operational business processes.
- Extended and refined context model with additional concepts. Note that the model in this level only conceptually specifies how a capability is adjusted in line with its delivery context. It is yet not ready for an implementation.

Tools

- Any tool incorporating a module for context modelling, preferably the CDT, to extend and refined the modelled business context. Also, the method user can model within MSVisio® or OmniGraffle® and use the deCOM stencils.

5.10.3 *Notation*

The modeller should use the context modelling notation, which is illustrated in Figure 5.6.

Example

Capability definition at Fun Factory allows for a holistic view

Fun Factory now possesses the capability of offering the digital service ”Weather and capacity-based leisure activity recommendation”. The capability definition requires associating three integral views, goals model, context model and a business process model. The capability definition may change and the context configurations may be altered to adapt to a new situation. For instance, during summer season, the measurable property ”temperature” can be removed from a client’s system operating in middle Europe, since it affects the weather situation only little. This may allow for more efficient calculations with less input data.

The business context of Fun Factory is modelled in Figure 5.18.

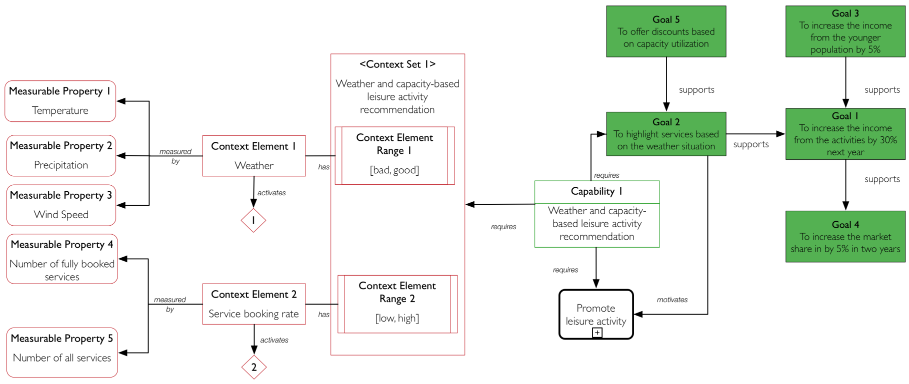


Figure 5.18.: Fun Factory’s context model including capability, as a connector of all three views

5.11 METHOD COMPONENT E: PREPARATION FOR OPERATIONAL USE

The execution of this method component is optional and only recommended for the cases, where the resulting context model should be implemented, e.g. in a workflow automation system. Consequently, we do not illustrate the Fun Factory case in this method component. The reader should be directed to the detailed cases introduced in Appendix A and B.

5.11.1 *Concepts*

Method component E uses the concepts illustrated in Table 27 and mentioned in section 5.11.2.

Table 27.: The important concepts used in MC E

Concept/ Term	Explanation
Context Provider	The source, from which the data for calculations of context value are gathered. This can be a web service or an information system
Calculations	Codes implemented in Java or MathML to determine the value of a context element by using its measurable property. Calculations use Measurable Properties and evaluate Variation Points
Adjustment	Codes implemented in Java or MathML to support decision making, whenever the business process requires resolving a variation point. Adjustments are associated to Context Sets and implement Process Variants

5.11.2 *Procedure*

The method component E includes one step "Design Binding", which is depicted in Figure 5.19.

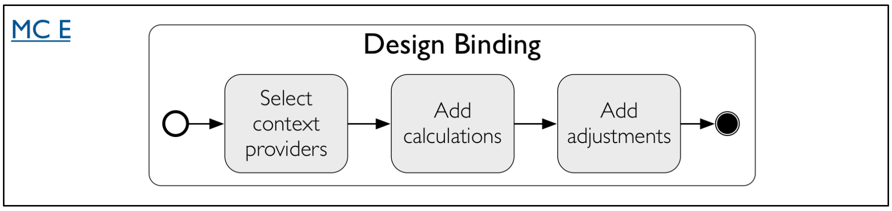


Figure 5.19.: The procedure of the MC E

Step 1: Design Binding

Input

- The context model produced in MC D

Objective

- Adding specifications and bindings to the context models
- Preparing it for the operational use, which would be the first stage in the implementation phase

Activities

The activities can be performed in parallel.

a) Activity 1: Select context providers

- Identify the sources which provide data to obtain the values of context elements by calculating the measurable properties.

b) Activity 2: Add calculations

- For each context element, specify the mathematical operations to define the values of context element ranges.
- Connect the calculations to the measurable properties and variation points.

c) Activity 3: Add adjustments

- Specify the decision logic to adjust the capability delivery according to the application context.
- Connect the adjustments to the context set and process variants.

Output

- A context model which is prepared for operational use. The resulting model cannot be implemented as it is, further specifications are needed, e.g. Input Data Association (IDA)s. deCOM does not support such implementation aspects.

Tools

- CDT or another Eclipse-based tool which can import the resulting context model from MC D and extend it with calculations, providers and adjustments.

5.11.3 *Notation*

The modeller should use the context modelling notation, which is illustrated in Figure 5.6.

5.12 METHOD COMPONENT G: FACT ELICITATION

[271] claims in his article "content management professionals estimated that 85% of the information in companies is stored in . . . an unstructured way, mostly as text documents". Based on this assumption, the method user gathers and analyses data in this step related to the selected service.

The application of this method component is **optional**. Although deCOM recommends to apply it, method user can skip this method component if she is already experienced in fact elicitation techniques.

5.12.1 *Concepts*

Method component G uses the concept illustrated in Table 28 and mentioned in section 5.12.2.

Table 28.: The important concepts used in MC G

Concept/ Term	Explanation
Secondary Data	Informal descriptions such as customer specifications, policies, guidelines, service level agreements, documents explaining the organizational processes, the structures, roles, task allocations, handling instructions, forms, manuals, reports, best practices as relevant sources of information for the construction of conceptual models

5.12.2 *Procedure*

The method component G includes one step "Text-based Fact Elicitation", which is depicted in Figure 5.20 .

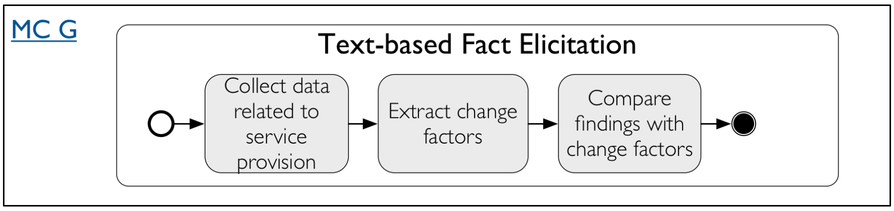


Figure 5.20.: The procedure of the MC G

Step 1: Text-based fact elicitation

Input

- Selected service from MC A
- Goal models from MC F
- Business process models from MC B
- Secondary data

Objective

- Collecting detailed description about the service provision, including the role of the service consumer (client, customer), tasks of the service provider as well as agreements between two partners[16].

16 During goal modelling in MC F, most probably the documents are analysed, which give an overview on a strategic level. One cannot expect that such documents give a detailed view on the selected service. Hence, the aim of this method component is **not** to collect enterprise data, as performed in MC F, but rather collect **operational** data related to business processes and service provision.

- Creating a knowledge base and extracting data, which may help for eliciting context elements or updating the table created in MC C, Step 1.

Activities

The activities are performed sequentially. Iterations are recommended.

a) Activity 1: Collect data related to service provision

- Find and analyse secondary data related to the selected **service**. The documents should consist of instructions which are written informally comprising of the information about the process of service provision and allocation of tasks. The textual documents can include policies, reports, forms, manuals, handling instructions etc. (see Guideline 10).

b) Activity 2: Extract change factors

- Focus on parts of the textual descriptions, where different variations for a service provision are required.
- Check the relevancy of the factors by determining their influence on the business process models.

c) Activity 3: Compare findings with the change factors

- Use the table of factors & goal fulfilment analysis[17] created in MC C, Step 1.
- Update the table when necessary.

Output

- Textual information collected from the analysis of secondary data about the **selected service and related processes**. This output might help to identify additional context elements or limit the existing ones.

Tools

- In this step no specific tools are required

5.12.3 *Notation*

No specific notation is required in this method component.

17 Reminder: This table incorporates the change factors, reasons, drivers etc. causing variability in the respective process models as well as their influence to the enterprise goals.

Guideline 10: Documents to investigate for fact elicitation

- Ask for the following documents in the enterprise:
  - Organisation charts
  - Policy manuals
  - Job descriptions
  - Service descriptions
  - Reports
  - Documentation of existing services
- The written documents may not include the latest information. So the method user has to assure up-to-datedness of the documents.

5.13 SUMMARY

This chapter details the capability-based context modelling method, deCOM, which is engineered following Goldkuhl's method conceptualisation framework [51]. The framework is slightly adapted in its operationalization, i.e. the terms "Perspective" and "Framework" are renamed as "Purpose" and "Overview to Method Components". Also, the concept of procedure is detailed in a way that it consists of steps and activities which consume an input to produce an output. Experiences gained during method engineering are briefly discussed in Chapter 7.

deCOM is engineered component oriented and includes a total of seven method components. Basically, each method component follows the concept-procedure-notation structure of Goldkuhl's framework. The method explicitly defines who does what, who should be informed about the results of activities and who should support the roles under consideration, as illustrated with a RACI chart in Table 16. Also, it provides the method users with appropriate modelling tools, notations and guidelines. Depending on the available knowledge in the enterprise as well as the level of envisioned enhancement with regards to digital service adaptation and flexibility, it is also allowed to apply only parts of deCOM for context modelling purposes. For instance, one can exclude method component F (goal modelling) if the respective organisation already has mature and well-defined objectives represented in goal models. Different paths to proceed with the method exist, as explained in section 5.5. Consequently, deCOM is modular, the modulariy is supported by low coupling (method has optional and mandatory parts) and high composability (method provides different entry points to the user). As deCOM is a DSR artefact, its utility must be demonstrated via well-executed evaluation activities, which is the focus of the next chapter.

Part III

SOLUTION VALIDATION

6

ARTEFACT EVALUATION

DSR is concerned with creating purposeful artefacts to solve real world problems by contributing to scientific knowledge. According to the DSR Guidelines, the utility of the design artefact and the rigorousness of its design process should be shown via appropriate evaluation methods. Hence, *artefact evaluation* is an essential part of any DSR project, as discussed in section 2.1.3. This chapter details the activities that are performed to evaluate deCOM. Section 6.1 introduces the procedure and the framework used for evaluating the artefact. Section 6.2 instantiates this framework and details a total of six evaluation episodes, each adopting a different research method and evaluating various characteristics of the method. Section 6.3 summarises the findings and concludes the chapter.

6.1 DESIGNING THE EVALUATION

As introduced in section 2.4.3 and illustrated in Figure 6.1, FEDS follows a four-step procedure to frame the evaluation activities. In the following subsections these steps are performed and the outcomes are discussed.

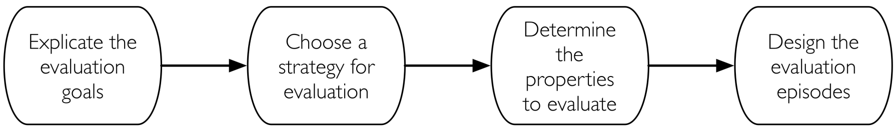


Figure 6.1.: Evaluation design procedure in FEDS, in line with [52]

6.1.1 *Explicate Evaluation Goals*

The first step in the procedure proposed by FEDS regards goal explication, i.e. what does the researcher aim by performing the evaluation activities. For that, FEDS identifies four competing goals, which have been explained in section 2.4.3.

The methods are designed to improve performance of a task, which can be reached by increasing the efficiency (by reducing the inputs of the task) or effectiveness (by improving the quality of outputs) [102].

Expressed in FEDS terminology, this means that the evaluation of deCOM should focus both on the Effectiveness and Efficacy of the artefact (cf. Figure 2.12). Hence, the **Actual Efficiency**, the **Actual Effectiveness**, the **Intention to Use** and **Perceived Efficacy** should be measured rigorously, latter of which will be further divided into evaluation properties as depicted in Figure 2.13 and detailed in section 6.1.3.

6.1.2 *Choose a Strategy for Evaluation*

FEDS proposes four evaluation strategies (cf. Figure 2.10), each of which focuses on different evaluation purposes (e.g. formative/ summative) and adopts different evaluation paradigms (artificial/ naturalistic). Formative evaluations are usually performed to identify areas of that need improvement, whereas summative evaluations aim to evaluate the "final" artefact. In terms of evaluation paradigms, it is recommended to use naturalistic settings for evaluating effectiveness of an artefact in real use. The artificial evaluation should be adopted when the goal is assessing the efficacy of an artefact.

Concerning deCOM, we argue that major design risk is user oriented (e.g. "user needs to learn the method") rather than being technically oriented (e.g. "computational requirements to run the tools recommended by the method"). Furthermore, considering the industrial network built during the CaaS project, it was perceived to be relatively cheap to have real users in their real context for evaluation purposes. Consequently, we opted to use the *Human Risk & Effectiveness* evaluation strategy, i.e. evaluation methods that produce empirically-based interpretations to improve the characteristics of the artefact (formative evaluation) should be applied in artificial settings, which allows for a few false starts. Then, the evaluation should be scaled up rather fast to the more realistic settings (naturalistic evaluation) in the upcoming method versions to create shared meanings of the artefact in different contexts (summative evaluation).

6.1.3 *Determine the Properties to Evaluate*

In this stage, the evaluation perspectives are further enriched by evaluation properties. For this purposes, FEDS proposes a number of *candidate evaluand properties*, which are illustrated in Figure 6.2[1]. Furthermore, Venable and collegues conceptually define the relationship between the utility properties, which was shown in Figure 2.13. We associated these properties with the evaluation constructs proposed

1 The illustration is taken from the slides of the workshop *Design Science Research: A Hands-on Tutorial* by John Venable, Jan Pries-Heje and Richard Baskerville at ECIS 2016, Istanbul Turkey and used with their kind permission. John Venable, Jan Pries-Heje and Richard Baskerville hold copyright.

Hevner et al (2004)	The Five "E's" (Checkland and Scholes, 1990)	Mathiassen et al (2000, based on the ISO standard 9126)	Levels of granularity (Sun and Kantor, 2006)
• Utility • Quality • Efficacy • Functionality • Completeness • Consistency • Accuracy • Performance • Reliability • Usability • Fit with the organisation • Style • Other	• Efficiency • Effectiveness • Efficacy • Ethicality • Elegance	• Useable • Secure • Efficient • Correct • Reliable • Maintainable • Testable • Flexible • Comprehensible • Reusable • Portable • Interoperable	• Whether the individual item was retrieved • Whether the task-at-hand was completed • Whether the completed task had a valuable impact on the goals-at-hand
	Technology Acceptance Model (Davis, 1989)		**Other**
	• Perceived usefulness • Perceived ease of use		• Ease of learning • Response time

Figure 6.2.: Candidate evaluand properties in FEDS

in MEM [102], the result of which is shown in Figure 6.3. Definition of the properties and their relationship helped us to plan the evaluation episodes. Note that the causal relationships that are conceptual and not yet empirically tested are represented with the dotted arrows.

- Actual Efficiency: The effort required to apply a method.
- Actual Effectiveness: The degree to which a method achieves its objectives.
- Perceived Ease of Use: The degree to which a person believes that using a particular method would be free of effort. Perceived ease of use is determined by Actual Efficiency [102].
- Perceived Usefulness: The degree to which a person believes that a particular method will be effective in achieving its intended objectives. Perceived Usefulness is determined by Actual Effectiveness and by Perceived Ease of Use [102, 272].
- Maintainability: The degree, to which a particular method can be maintained in order to cope with a changed environment and meet new requirements.
- Understandability: The degree, to which a particular method is comprehensible. Following the conceptual taxonomy of Venable and colleges (cf. Figure 2.13), we assume that higher Understandability rates contribute to Ease of Learning, which increases the rates concerning Perceived Ease of Use.
- Ease of Learning: The degree, to which a particular method can be thought to a group of potential method users. We assume that Ease of Learning contributes to Perceived Ease of Use.
- Flexibility: The degree, to which the method can be tailored for use in different settings. We assume that Flexibility contributes both to Perceived Ease of Use and Perceived Usefulness.

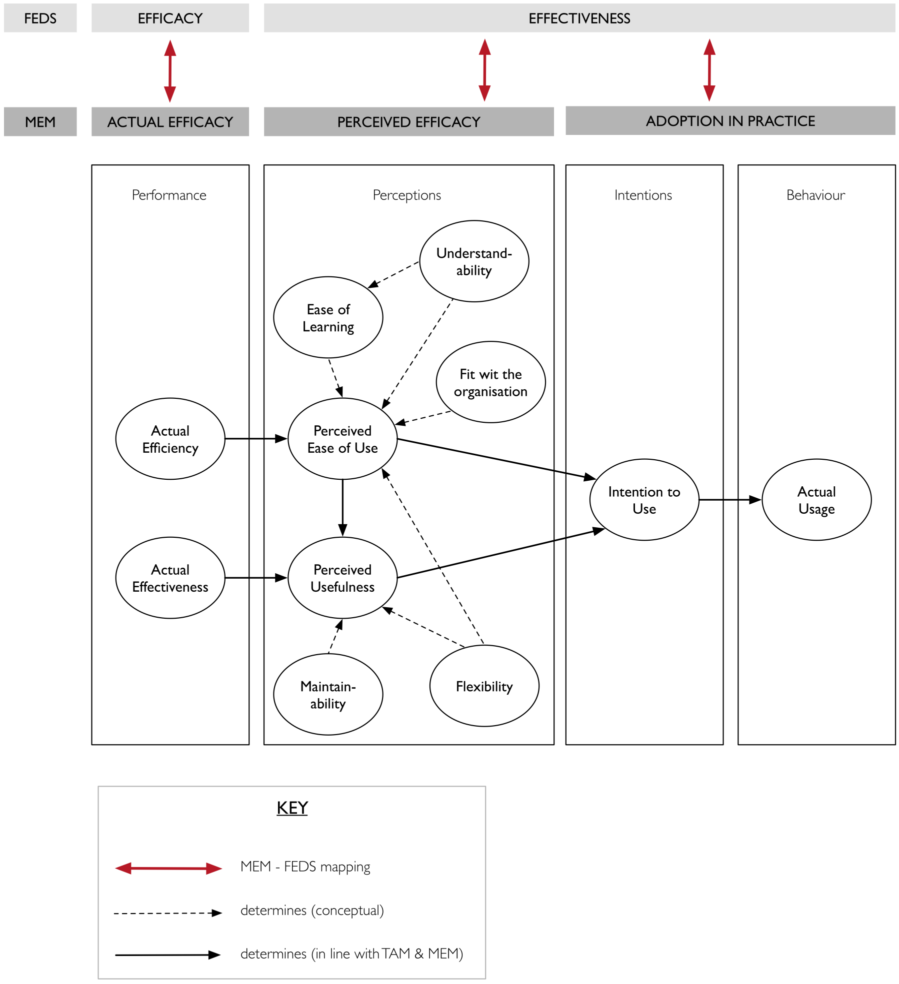


Figure 6.3.: The relationship between the evaluation properties, following [102, 272] as well as the conceptual work introduced during a FEDS Workshop

- Fit with the organisation: The degree, to which a particular method is applicable in an organizational setting. We assume that a better fit with the organisation can help acceptance of an artefact in a real setting and hence define a positive association to Perceived Ease of Use.
- Intention to Use: The extent to which a person intends to use a particular method. It is jointly determined by its Perceived Ease of Use and Perceived Usefulness [272].

6.1.4 *Design the Evaluation Episodes*

This stage details the evaluation cycles and plans the number of iterations required evaluate the purposeful artefact. For each episode, the researcher should prioritize the properties to evaluate and de-

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
1,2, …,n	• Formative • Summative	• Artificial • Naturalistic	• Criteria-based • Focus Group • Client Feedback • …	• Perceived Ease of Use • Understandability • Actual Efficiency • Perceived Usefulness • …	• FREQ X • NFREQ Y

Figure 6.4.: Tabular template used to describe the evaluation episodes

fine when particular episodes will be conducted, in what way and by whom. Depending on the situation, changes may be required during the execution of evaluation activities. Planning in that stage helps to have an idea of cost, skills needed, time the evaluation episode will take and access needed, etc.

To give an overview of the designed stages, we developed a tabular template which is shown in Figure 6.4. The first column "#" gives a unique ID to each evaluation episode. The 2nd and 3rd columns "Functional Purpose" and "Paradigm of Study" determine the aim of the respective evaluation episode and its paradigm (e.g. real, non-real users). The 4th column determines the methods used to evaluate the artefact. The 5th column documents the properties of the method that are subject to evaluation. Finally, the 6th column shows the requirements, which are related to the episode, i.e. whether the method version fulfils certain requirements.

To support the researcher with appropriate methods to evaluate the design artefact, FEDS provides a 2x2 matrix, in which the evaluation methods are mapped to the evaluation strategies. The method selection framework is depicted in Figure 6.5. Following "technology rules" are defined for selecting an evaluation method [273].

- Action Research: Used, if the researcher has access to real user/-client and they like to participate in formative design.
- Focus Group: Used, if the researcher needs detailed information about personal and group feelings, perceptions and opinions as part of the formative design.
- Field Experiment: Planned, if it is important to have a setting where real users will behave more naturally as part of researcher' s formative design.
- Collect Client Feedback: Used, if the researcher has access to clients that are using a (prior) version of the design artefact.
- Criteria-Based Evaluation: Used, if the researcher has some criteria that need to be lived up to.
- Scenario Analysis: Used, if situations can be forecasted within a decision tree.
- Case Study: Performed, if the researcher has a real user for the artefact that applies the artefact for a real problem.

	Formative	Summative
Naturalistic	• Action Research • Focus Group • Field Experiment • Collect Client Feedback	• Case Study • Participant Observation • Ethnography • Phenomenology • Quantitative Survey • Performance Measures
Artificial	• Criteria-based Evaluation • Scenario Analysis	• Mathematical or Logical Proof • Lab Experiment • Simulation • Testing

Figure 6.5.: Evaluation method selection framework, in line with [273]

- Participant Observation: Used, if applying the artefact requires tacit knowledge that cannot be explicitly expressed.
- Ethnography: Selected, if the use of the artefact requires deep knowledge and long-time use.
- Phenomenology: Used, if the user intentionality and the structures of consciousness as experienced from the first-person point of view are important.
- Quantitative Survey: Used, if the researcher needs statistical evidence, e.g. in the summative evaluation.
- Performance Measures: Collected, if the researcher has access to clients that are using a version of designed artefact.
- Mathematical or Logical Proof: Used, if the final design can be expressed using mathematics.
- Lab Experiment: Used, if final design can be evaluated in an experiment e.g. because a natural setting is risky or expensive to use.
- Simulation: Used, if the interaction between different roles is important in relation to the summative / final design and/or a simulation can be build on a computer.
- Testing: Used, if the design is (partly) coded.

Six individual evaluation episodes have been designed to evaluate the artefact. As stated earlier, the output of an evaluation episode provides at the same time a valuable input to the forthcoming method version. In other words, *Method Version 1* (shortly deCOM v1) is the evaluand in *Evaluation Episode 1* (shortly EE 1) and the results of the EE 1 are integrated into the design cycle of deCOM v2. Figure 6.6

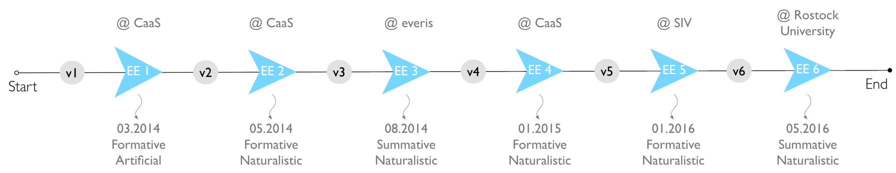


Figure 6.6.: Designing the evaluation episodes

illustrates the evaluation episodes (arrows denoted with "EE") and the method versions (circles denoted with "v"). The illustration also depicts where the evaluation took place (tagged with "@") and includes information about the date, as well as the evaluation characteristics. Following section details each evaluation episode by providing information about the evaluation context, participated stakeholders, received feedback and improvement needs.

6.2 EVALUATING THE METHOD

6.2.1 *1st Evaluation Episode*

In this episode, method version 1 (shortly deCOM v1) was subject to evaluation (cf. Figure 2.6). The evaluation episode 1 (shortly EE 1) is basically the same step with the demonstration activity in a DSR cycle and the purpose of the EE 1 has been already introduced in section 2.1.3.4. To summarize, the aim was testing the feasibility of deCOM v1 in a selected case that represents the explicated problem, i.e. its *actual effectiveness*. CaaS technical meeting organised in March 2014 in Rostock was selected as the platform for performing evaluation activities. The meeting's agenda consisted of a slot, in which deCOM v1 was introduced by the author and discussed with the participating stakeholders.

The EE 1 has a formative-artificial character and adopts the criteria-based method and expert opinion. The enterprise modelling experts discussed deCOM v1 and checked whether it fulfils the requirements FREQ 1 (documentation of procedures for context elicitation), FREQ 2 (description of important concepts and meta model support), FREQ 3 (provision of a graphical notation), FREQ 5 (ability to identify the context when designing digital services) and NFREQ 1 (supporting different ways of working with an adaptable, modular method). The design decisions concerning the EE 1 is illustrated in Figure 6.7.

Results of the evaluation episode

The discussions based on the satisfaction degree of the aforementioned requirements led to the conclusion that deCOM v1 should be updated. In line with the gained feedback, the important concepts that the method user needs to be acquainted with had to be speficied and aligned with the CaaS meta-model (cf. Figure 4.26). Based on the classes in the capability meta-model, important concepts in the procedures are highlighted and explained. Here, also the results of

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
1	Formative	Artificial	Criteria-based Expert opinion	Actual Effectiveness	FREQ 1 FREQ 2 FREQ 3 FREQ 5 NFREQ 1

Figure 6.7.: 1st evaluation episode

the literature reviews are used to include additional concepts such as "variation aspect" or "variation point", which extended the capability meta-model. In order to represent such concepts, a graphical notation was developed and then evaluated based on Moody's principles [274] and tools are introduced, which the method user needs to model the context. To define the relationship between the concepts, the associations in the meta-model were used. Moreover, the tools are introduced, which the method user needs to model the context. To create the basis for a modular method, each dimension in deCOM v1 (e.g. *Find Variations, Design Context* in Figure 2.6) was restructured as a separate method component. Following this, the generic procedures are refined as steps, which comprise of the activities, input(s), objective(s) and output(s). Furthermore, tool support required to execute the steps is added to the method. The steps are related with the relevant aspects of reality, i.e. *concepts*, which can now be modelled with the provide notation.

The activities to update the method to a second version included two researchers, an enterprise architect and a knowledge worker. This helped to clarify the concepts that the method uses and to identify initial skills required when applying the method. Also, by observing the modelling activities of the business stakeholders in the participatory modelling sessions, the researchers could propose guidelines on how to develop enterprise models. Examples of this were the produced goal models, mostly with ambiguous and hardly measurable objectives and business process models with various granularity levels. The resulting method version "deCOM v2" is shown in Figure 6.8.

6.2.2 *2nd Evaluation Episode*

The 2nd evaluation episode used formative-naturalistic methods and included the practitioners and the enterprise modelling experts in the evaluation activities. To gather feedback concerning how the method works in real settings, action research was applied, where the real user (practitioners) also participated to the formative design. As the results helped to improve the characteristics of the method, the evaluation activity is of formative nature. The design decisions of the EE2 are shown in Figure 6.9.

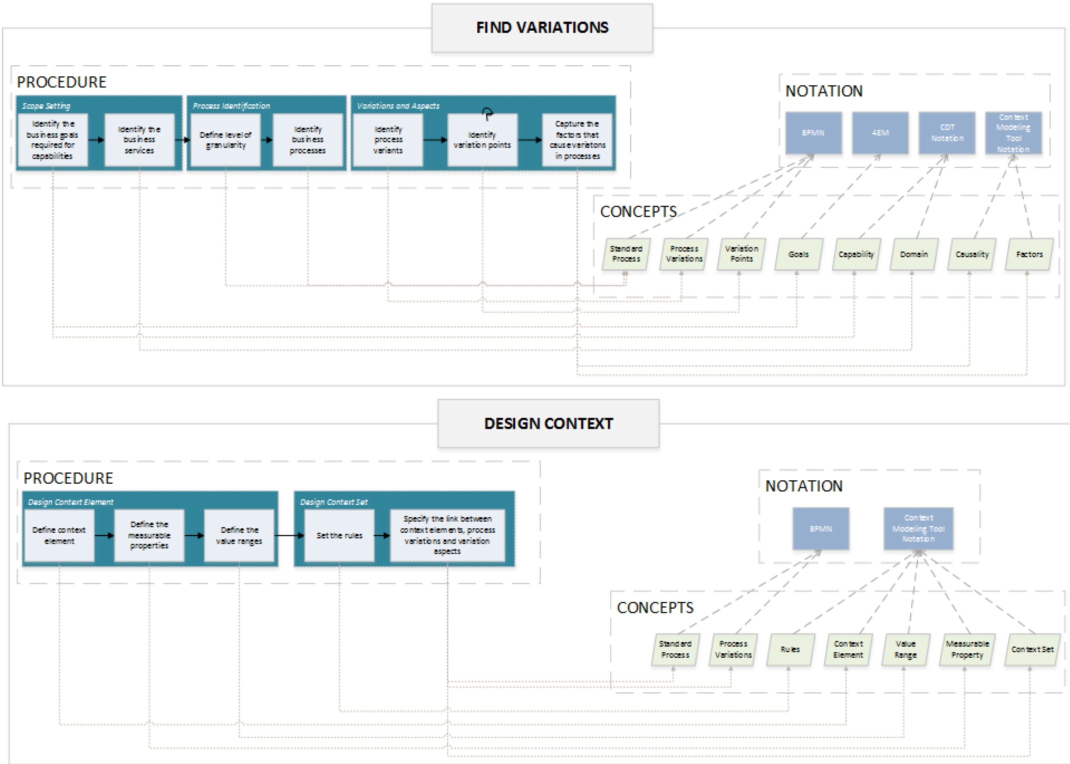


Figure 6.8.: Method components in deCOM v2

Results of the evaluation episode

An appropriate platform to perform the evaluation activities was a plenary meeting performed in CaaS context on May 2014. During the meeting, deCOM v2 was presented to the audience, which involved real users from everis, SIV.AG and FreshTL as well as the enterprise modelling experts working in the project. Regarding the perceived usefulness and fit with the organisation, general consensus was that the terminology used by the method was appropriate, the procedures were easy to follow. Nevertheless, initial concerns were raised for a clear separation between various stages that the method covers, e.g. scope setting, variability analysis and operationalization.

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
2	Formative	Naturalistic	Action Research	Perceived Usefulness Fit with the Organisation	FREQ 1 FREQ 3 FREQ 4 NFREQ 1

Figure 6.9.: 2nd evaluation episode

In order to incorporate the evaluation results into deCOM v3, the author was involved in the supervision of a master thesis, in which deCOM v2 was optimized and extended [275]. A total of three researchers and one business analyst from everis participated to the design sessions. First of all, deCOM v3 elaborated the scope setting activities by providing alternative ways to identify enterprise goals. Second, activities related to the analysis of the factors causing variability are removed from the scope setting step. Third, activities addressing the business process variability are added, the variation points are now explicitly shown in process models. Fourth, to provide support for operationalization, a new method component is designed. Fifth, an initial proposal is made towards the classification of context elements as "atomic" and "composite". Last but not least, new procedures ("define context rule") as well as new concepts (e.g. "atomic context element" [200]) are added to this version. The resulting method version "deCOM v3" is shown in Figure 6.10.

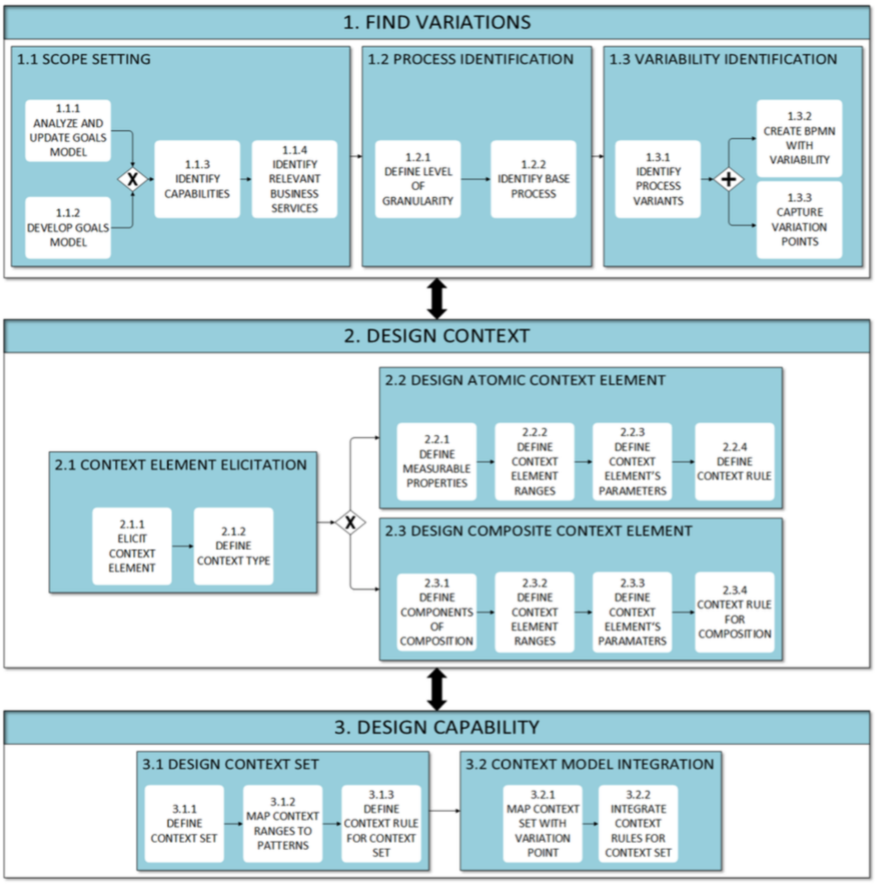


Figure 6.10.: Method components in deCOM v3, taken from [275]

6.2.3 *3rd Evaluation Episode*

The 3rd evaluation episode adopted single case study approach to gather feedback from the method application in a naturalistic setting to identify earlier risks in use. Since the method was evaluated in the course of a master thesis with the participation of everis, the evaluation is rather summative and not ex-post. The design decisions for EE3 are shown in Figure 6.11

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
3	Summative	Naturalistic	Case Study	Perceived Usefulness Perceived Ease of Use Understandability	All requirements, except for FREQ6 and FREQ7

Figure 6.11.: 3rd evaluation episode

Results of the evaluation episode

The company stakeholders involved in the evaluation activities stated that the method provides an effective solution for analysing a business service's contextual influence and enhances the communication of the contextual influences to the stakeholders. The method was perceived to be easy to use and to understand, nevertheless the stakeholders asked for additional guidelines to identify key concepts better. Such change request related to the fact that during the method application, the client identified all possible gateways as variation points and all sub-processes as process variants. This caused confusion in the identification of the contextual factors, i.e. everything related to the resolution of the gateways were elicited as context elements, without considering its effect on service design and enterprise objectives.

The results of the EE 3 were used as an input to update the method to its 4th version. Related activities included a researcher, enterprise modelling experts and an enterprise architect. The result was deCOM v4, which provides guidelines to identify what constitutes a context element and how to distinguish it from other information objects. To enhance the simplicity, in deCOM v4 the concepts and steps related to atomic and composite context are removed, instead the model primitive "Context Type" should be used to classify such elements. Further guidelines are documented to identify variability and variation points in the business process models. To support the understanding of what a context element is, the context identification steps are extended and grouped into a single method component. In other words, method component *Capture Context Element* focuses on the elicitation and identification of the context elements and is decoupled from the context design activities. This possibility was not given in deCOM v3 (cf. method component *Design Context* in Figure 6.10). Moreover, the context modelling notation is specified, i.e. pictograms for developing context models are provided to the method user.

Now that the method user can model the context, the need for implementing it grew. However, the *design capability* method component in deCOM v3 focusing on the context operationalization proved to be insufficient for this purposes, i.e. the clients did not know how to represent the business rules and how to model the adjustments in line with the application context. As a result, the 4th method version

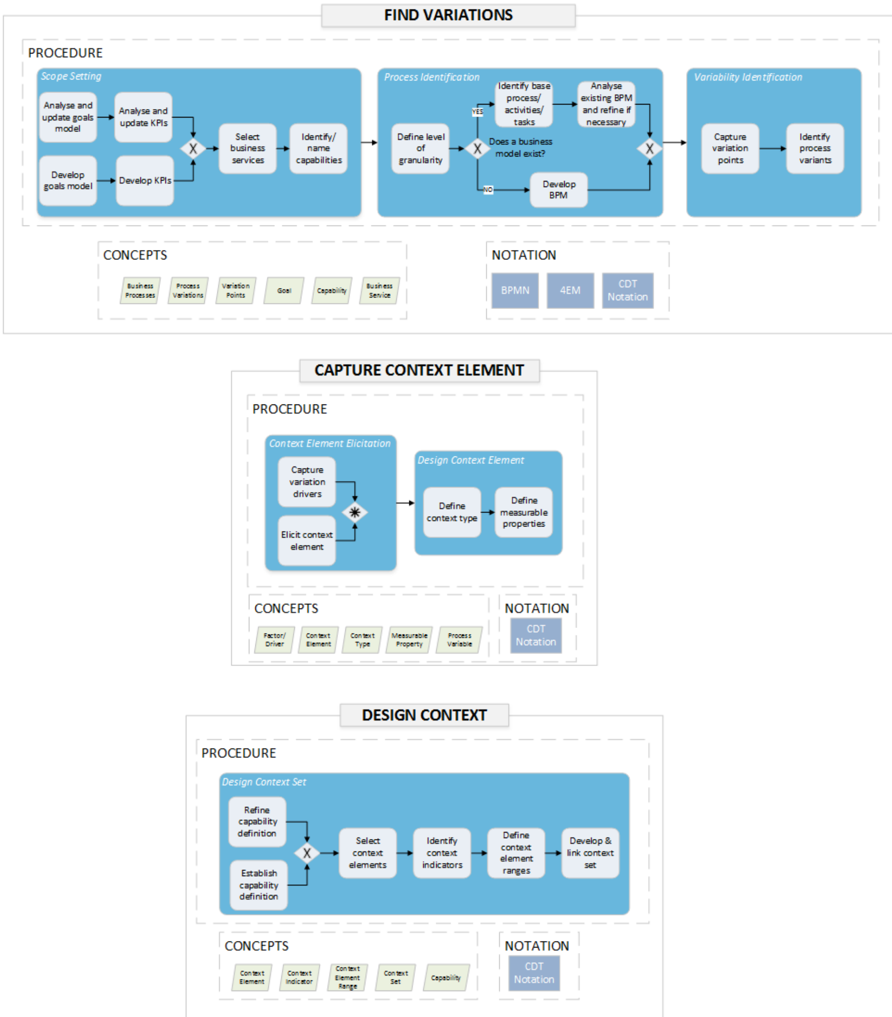


Figure 6.12.: Method components in deCOM v4

focused only on the early design phases and removed the runtime related aspects, which should be addressed in the further versions. deCOM v4 is shown in Figure 6.12

6.2.4 *4th Evaluation Episode*

EE 4 was formative-naturalistic and collected client feedback. The evaluation venue was another CaaS meeting that was scheduled to discuss the technical aspects of the CDD methodology, which includes deCOM as a low-level method component. Similar to the EE 1, the meeting's agenda consisted of a slot, in which deCOM v4 was introduced by the author and discussed with enterprise modelling experts and software engineers. By this time, the method has been applied in the use cases of the industrial project partners. Consequently, another stream of client feedback was gathered from users' experiences. The characteristics of EE 4 are summarized in 6.13.

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
4	Formative	Naturalistic	Client Feedback	Perceived Usefulness Fit with the Organisation Flexibility	FREQ 2 FREQ 4 FREQ 5 FREQ 6 NFREQ 2

Figure 6.13.: 4th evaluation episode

Results of the evaluation episode

The results of the EE 4 pointed out to mainly two change requests. The first one concerned the need for operationalizing the context models. The method could not cope with the run-time aspects, hence rules and preconditions for implementing a context model were necessary. The second change request is related to the different application scenarios of the context modelling method. We observed that the industrial partners had different enterprise models that had been developed before the method application. For instance, one partner offered business services in the utility industry and has already modelled business processes that are implemented to offer such services, whereas the other partner had established goal models. The extent, to which such enterprise models can be reused for eliciting and modelling context should be increased.

The results were incorporated into deCOM v5, which is shown in Figure 6.14. In this new version, a new method component *Prepare for Operational Use* is added, which specifies the preconditions and rules before implementing a context model (e.g. context sources and calculations of raw data gathered from them). Furthermore, based on the input provided by the use case partners, the method was enriched by complementary guidelines related to the identification of context elements and variation points.

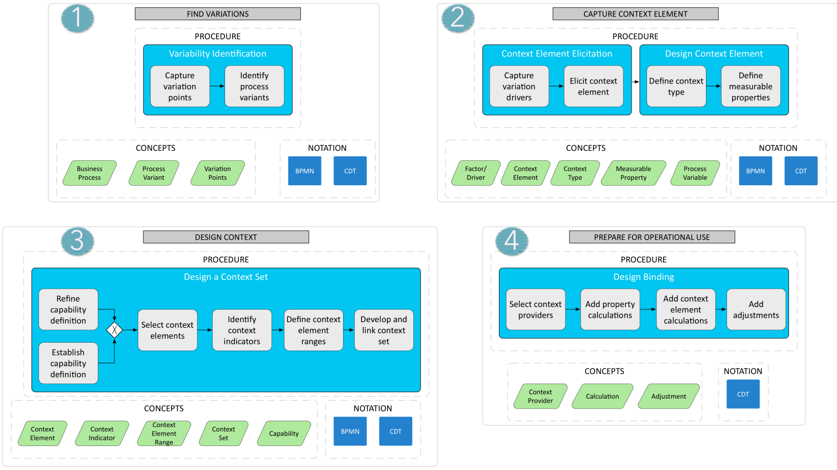


Figure 6.14.: Method components in deCOM v5

As mentioned earlier, the method should make use of various kinds of enterprise models to support the potential ways of working in the organisations (cf. NFREQ1). For this, the two steps, *scope setting* and *process identification*, are removed from the method component *Find Variations*. Both of these steps supported the enterprise modelling activities and included guidelines for goal modelling as well as business process modelling. Consequently, removing the enterprise modelling related parts added a new prerequisite to use the method, which is the availability of enterprise models. If goal models are available, starting point for the context modelling should be the analysis of the hierarchies in such models. If business process models are available, starting point of the context identification and modelling should be a process underlying a business service under consideration. If none of them are available, deCOM v5 recommends to use 4EM, a method for enterprise modelling focusing both on the objectives and processes of an enterprise [268].

6.2.5 *5th Evaluation Episode*

The EE 5 consists of two evaluation cycles. In the first cycle, deCOM v5 was evaluated from perspectives of perceived usefulness and perceived ease of use by performing TAR during a collaborative working week with SIV within the premises of CROZ[2] in Zagreb Croatia. The second evaluation cycle addressed the value creation perspectives and investigated the benefits of the method use (cf. section 6.2.5.2). The characteristics of EE 5 are summarized in Figure 6.15.

2 Evaluating the artefact in CROZ's premises helped the author to observe the technical limitations of deCOM v5.

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
5	Formative	Naturalistic	Technical Action Research Client Feedback	Perceived Usefulness Perceived Ease of Use Fit with the organisation Maintainability Ease of Learning Actual Efficiency	All requirements

Figure 6.15.: 5th evaluation episode

6.2.5.1 *First Evaluation Cycle - Technical Action Research*

Research Problem Analysis

Regarding the proposed procedure when performing TAR (cf. Figure 2.9), the first step determines the conceptual framework subject to evaluation and lists the properties of the evaluand (deCOM v5) by asking knowledge questions. Moreover, it defines the population, for which the solution could be useful [59]. In the context of the EE5, the output of the research problem analysis step is documented as shown in Table 29.

Table 29.: Documentation of the research problem analysis step

Conceptual Framework	In this evaluation episode, deCOM is considered as a conceptual method for providing context-aware and flexible BPO services in utilities industry. The method integrates consists of a tool environment for context modelling
Knowledge Questions	- Fit with the enterprise landscape: Does deCOM v5 fit with the SIV? In what parts are the improvements needed? - Ease of use: Is deCOM v5 easy to use? - Method and the tools: Do the tools recommended by the method support the way of working as described by deCOM v5? - Goal contribution: Does deCOM v5 contribute to the goals of SIV? In other words, can deCOM v5 help the client to offer context-aware BPO services?
Population	The population only includes SIV as a digital enterprise offering BPO services in utilities industry

Research Inference Design

In the *Research Inference Design* step, the researcher - company relations are established. This necessarily triggers the *client engineering cycle* of the TAR procedure (cf. Figure 2.9) [59]. The client acquisition process (*Acquisition of Objects of Study*) was documented as follows.

- The client, which has to be an industrial partner in CaaS, should provide the researcher with a use case. The solution generated by applying deCOM should aim to improve that use case.

- The artefact can be customized in line with the client needs, i.e. the client defines the parts of the framework which he is interested to use.
- To support the aforementioned objective, the client should be able to work closely with the researcher to make the required arrangements for the working environment and the artefact customization.
- deCOM should be validated case based. For this, the client provides the up-to-date version of the use case.
- Validity of Object of Study (OoS)
  - Based on these objectives, the analogic inference design is selected, which in our case generalizes the explanations by the architectural similarity[3].
  - The other researchers can use the report to construct or select a similar OoS.
  - The people are informed that they will be studied and they are aware that they can stop at any time without giving reasons.

The prearrangements for the working environment were enriched with the tasks of the client (the enterprise architect from SIV.AG) and the researcher (the author). The researcher models the context and the required adjustments of the clearing case, whereas the client focuses on the implementation of the models in the respective environments. The aforementioned tasks should not have strict boundaries, i.e. the client should also participate to the modelling process and provide feedback, e.g. whether the models that are developed by applying deCOM v5 contributes to the SIV goals or whether the concepts are easy to understand. Both the client and the researcher provide feedback to CROZ regarding the bugs and improvement possibilities of the tools.

The preliminary agreement was adapted to the circumstances during the working week. For instance, instead over an external host, the CCP was ran in a virtual environment and the CNA ran both in the client's and researcher's modelling environments, which did not have any effects on the validation. The adaptations were realised only after the client's approval.

Research Design Validation

The research design validation task in the *empirical research cycle* is coordinated with the treatment validation task from the *client engineering cycle*. In the engineering cycle, the researcher reaches a mutual agreement with the client that the treatment plan will help them

3 An analogic inference is always case based. In the architecture similarity, the inference can be expressed as "in cases with an architecture like this, it is plausible that this explanation is true" [59]. A simple architectural view related to the use case is given in Figure 3.4.

to reach their objectives. This at the same time validates that this research design helps the researcher to answer the knowledge questions [59].

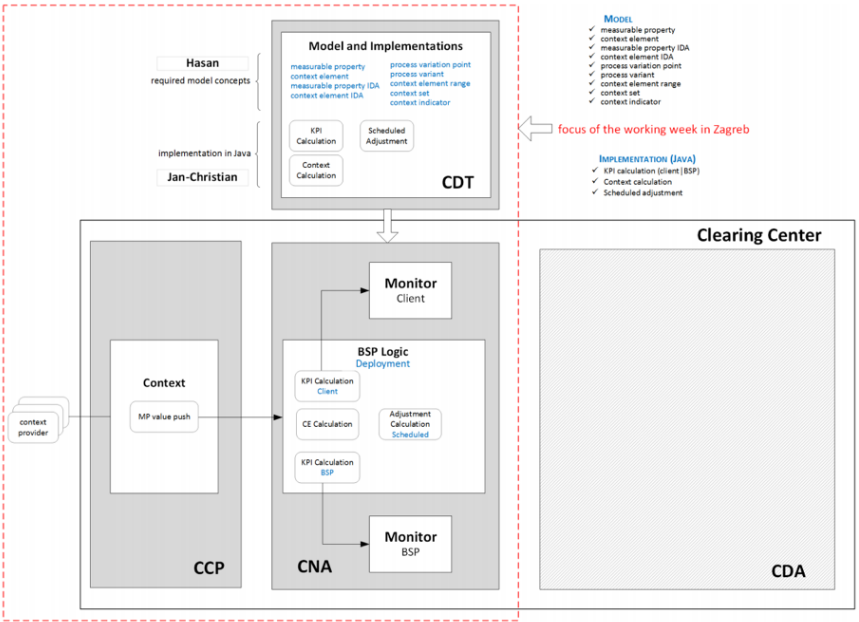


Figure 6.16.: The validated treatment plan

After customizing the artefact to the needs of the use case, we agreed upon the treatment plan with the client. The treatment plan illustrated in Figure 6.16 was created by SIV (client) and by UR (researcher), which was communicated, confirmed and also validated by CROZ. The *model and implementations* part directly concerns the application of deCOM v5. The other part, *clearing center*, is related to the implementation of the context model developed after applying the method. Moreover, before visiting the premises of CROZ, an initial proposal concerning the evaluation activities was prepared and communicated between the collaborating partners. Following agreements were reached regarding the collaborative week:

- The CDD methodology is not applied as a whole. Instead, the context modelling (deCOM v5) and adjustments modelling components are applied, which are currently required by the use case.
- The CNA[4] is fully used in its latest version, without any limitations and it runs in the client's environment. However, the parts of the CDT are used that suffice to model the context and the adjustments.

4 CNA is a module which is responsible for monitoring context and adapting the service to changing situations.

- The CCP is run over an external host in PTIN's[5] premises.
- The CDA[6] and its interaction with the context model are not subject to evaluation.

Research Execution

An enterprise architect from SIV.AG and the author visited the premises of CROZ and worked for one week collaboratively on the modelling, implementation, deployment and test of the SIV application case clearing center[7]. The efforts concentrated on the validation of the requirements related to the context modelling method component of the CDD methodology (or in other words, deCOM v5) as well as the CDD environment, including their interoperability.

Results of the first evaluation cycle - Data analysis

deCOM v5 was applied to the *Dynamic BSP Support* use case and its impact has been elicited. This concerned in particular the specification of the context models and adjustment models, the refinement of the method procedures and the method concepts, the deployment of the message clearing service and observation of their behaviour in changing situations. At the end of the each working day, the client and the researcher analysed the effects in test cases, discussed the achievements, problems and next activities, evaluated the benefits and trade-offs, which were documented by the researcher. An example of such trade-off analysis is shown in Table 30. Moreover, partner CROZ was included in such meetings to elicit the impact of the changes in the tool environment.

Following results were achieved after evaluating deCOM v5 in the collaborative working week:

- Does deCOM v5 fit with SIV? - The context model representing a solution to the *Dynamic BPO use case* during the working week in Zagreb proved that deCOM fits into the existing enterprise landscape of SIV. Yet, further refinement of the concepts are required, a new element - Context Indicator Calculation - should be added to the meta-model to fulfil SIV's requirements.
- Is deCOM v5 easy to use? deCOM is tailored for the needs of the enterprises that intend to become context-aware and adaptive. This requires engineering of a comprehensive method with a number of method components and a tool environment for capability design and delivery. As such, deCOM was not

5 PTIN is an industrial project partner in CaaS project, which is responsible for the development of the CCP. CCP is basically a platform which captures data from external data sources, such as sensing hardware and social networks. This data should further be processed to assess the context of a business service.

6 CDA is an interface between the CNA and the Enterprise Information System of the organization in order to receive the adjustment commands from the CNA and to provide them to the system in line with the actual service application context.

7 The case was termed as *clearing center* during the collaborative working week, which refers directly to the *Dynamic BSP Support* application case introduced in section 3.3.3.

Table 30.: Evaluation of the benefits and trade-offs

	Explanation	Benefits	Trade-offs
1st solution	Context Element Range (CER) represents every possible range of a Context Element (CE)	The capability model is only created and deployed for once. For each client, the capability manager selects in CNA, which CERs apply for the deployment at hand.	Requires an update on the meaning of a context element range. Moreover, for each CE, the modeller has to design two Measurable Properties (MP)s, which is to some extent a redundancy problem. To exemplify, the current type of the exceptional message is collected from the MP message type ProMo and the supported values from the MP message type contract. Such a setting requires also the monitoring of the MPs from two different providers, namely the ProMo and the contract management system.
2nd solution	CERs are specified values and include information about the client's contract. They do not cover all possible values of a CE.	The MPs provide the required data from the system (ProMo) and context calculations/ adjustments compare, if the provided values are in the defined ranges or not. Hence, the redundancy problem regarding the MPs is solved; contractual data values are represented in CER and values coming from the message is represented by MPs.	Every time the permitted ranges change, the capability designer has to go into the model and update it. In addition to that, there has to be a different capability model for each client since their CEs would assume a different range. Last but not least, currently there is no possibility to pull the values of CER from the contract management system (a provider), which would eliminate the aforementioned shortfalls.
3rd solution	Combining the 1st and 2nd solutions. The approach requires modelling MPs redundantly as in the 1st solution but uses the concept of CER to represent the supported values, i.e. the CER are specified values and include information about the client's contract. They do not cover all possible values of a context element.	No updates are needed in the meaning of the CER concept. Moreover, in the future, the CCP can parse the permitted ranges from the contract management system, so that the related MPs are directly parsed from the agreement.	The MPs are redundantly modelled. The modeller has to redesign the ranges each time they change and redeploy the capability.

perceived to be easy to use, and hence additional and easy-to-follow instructions are needed.

- Method and tool integration The results of the use case execution activities showed that deCOM v5 and recommended tools work together successfully. By applying the design and adjustment related components of context modelling method, a capability-based context model supporting a dynamic clearing behaviour was designed in the CDT by the researcher and the client. To test the model correctness, the model was deployed to the CNA with specific parameters. The CCP pushed the current values of the context elements, which are related to the deployed service and its state (whether the dynamic clearing is supported for SIV's respective client's exceptional message) was successfully monitored in the CNA.

- Does deCOM contribute to the application case related goals of SIV? - deCOM helped the client to offer context-aware BPO services. From a conceptual point of view, deCOM helps SIV to reach its use case related goals. An example of this is shown in Figure 6.17[8]. The context model created after method application is deployed to adapt the behaviour of the clearing service at runtime. This is only possible, if the factors influencing such adaptation (or shortly, the *contexts* are known, explicated and modelled systematically.

6.2.5.2 *Second Evaluation Cycle*

This subsection is to a large extent taken from "Deliverable 2.3: BPO case validation report for the CaaS approach" of CaaS project [120].

The second evaluation cycle focussed on the value creation perspectives and investigated the benefits of applying the CDD method and environment for SIV. As deCOM is an integral part of the CDD method and enabler of context-aware service design, we argue that the gained benefits can also be partly attributed to it. Moreover, the fact that applying deCOM and in particular motivating the "capability thinking" and "context-aware adaptation" initiated the way of certain improvements, which will be documented in this section. Summarized, eliciting the adaptable parts of a service and representing it in a context model allowed to be capable of offering flexible services in the utility industry.

Against this background, we collected client feedback to evaluate the actual efficiency and observed how understanding and modelling of context improved the way of working. The approach taken was to compare the situation of the clearing service before context modelling

8 Please note that the illustrated context model adheres to the meta model used during the 5th method version.

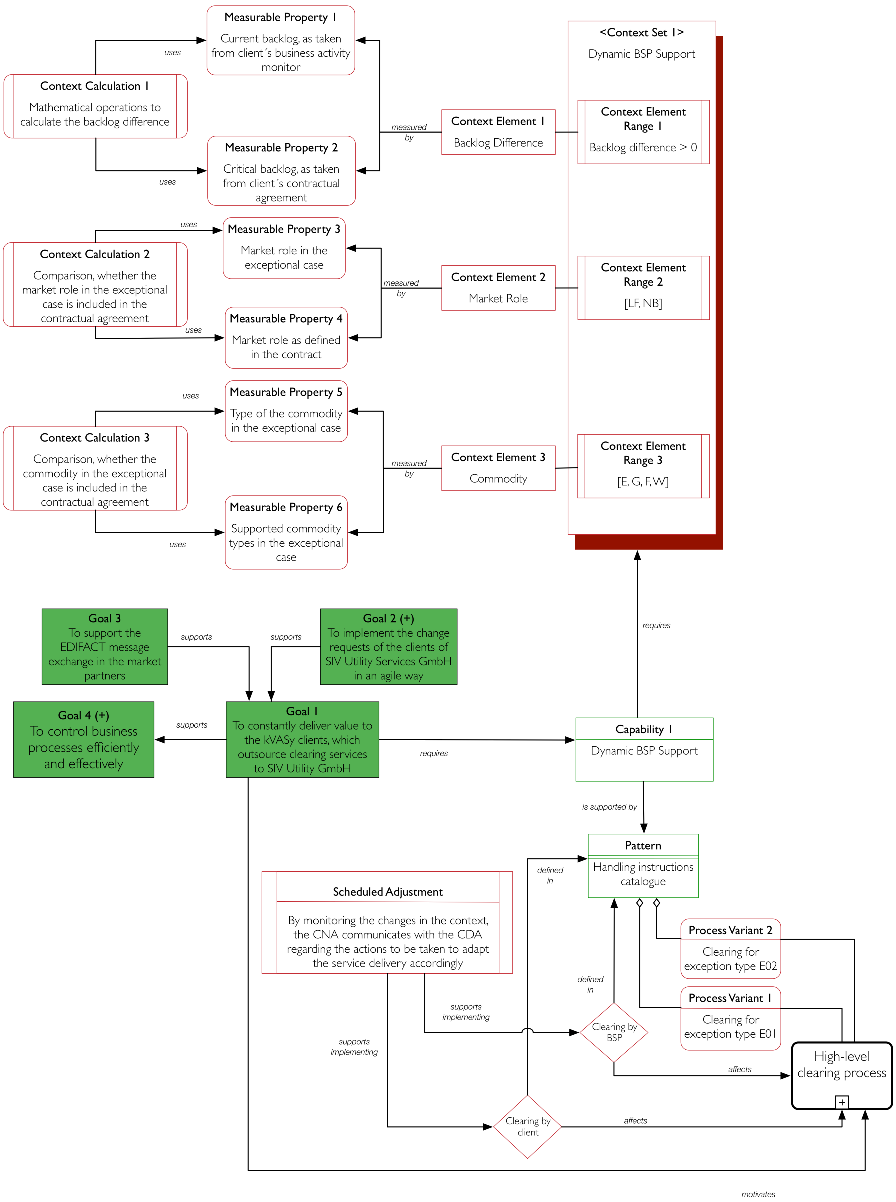


Figure 6.17.: Context model of SIV's use case

and the situation after the use of deCOM v5 and implementation of changes resulting from the context model. More concrete, we compared the process of setting up the clearing service for a new client, operating and maintaining it "before" and "after" applying CDD in general and deCOM in particular.

A suitable instrument to measure the benefits is to analyse the benefits from a strategic, informational, transactional and transformational perspective [276]:

- Strategic benefits exist if an investment in IT (in this case, implementing the tool environment and using deCOM) is made to gain a competitive advantage and increase market share, usually in established business areas. One of the characteristics is that the technology and methodology is used in a new way for the industry at the time of investment.

- Informational benefits can be assumed if improvement in the information infrastructure for control, planning or other management tasks is achieved, i.e. there is an informational advantage due to the new IT technology or methodology as compared to the situation without it.

- Transactional benefits typically are connected to automation or at least semi-automation of tasks within an enterprise. This type of benefit usually is connected to cutting costs and reducing time required for processes or tasks.

- Transformational benefits are achieved by IT-related organizational transformations which lead to new business models and substantial changes in value creation and propositions. Such organizational transformation can materialize in new skill levels, organizational learning, and industrial or company processes and structures.

The followed approach was the investigation of four benefit aspects with regards to changes in SIV's clearing service design and implementation process[9]. For this purposes, the process for setting up the clearing service for a new client (a) with CDD implemented and (b) without CDD. However, the main focus was put on the context modelling part of the CDD, which is basically deCOM v5. The main question prepared for this evaluation cycle was:

- Q1: From a context modelling point of view, which changes have been observed in terms of setting up, operating and maintaining the clearing service for a new client with CDD implemented and without CDD? This question was tackled from 4 different aspects:

9 The process of designing and implementing clearing services was analysed in section 3.3 and illustrated in Table 4.

– What are the strategic benefits for SIV from the "capability-thinking", i.e. designing and implementing context aware clearing services?
– What are the transactional benefits?
– What are the informational benefits?
– What are the transformational benefits?

Results of the second evaluation cycle

For investigating the potential benefits, we compared the different activities of both processes and analysed these differences from the perspective of potential benefits. Table 31 summarizes the results of this analysis by documenting the changes in each activity and identifying the benefits related to the use of deCOM v5.

Table 31 shows that the introduction of CDD and deCOM result in strategic, transactional, and informational benefits for SIV. Identification of factors that affect delivery of the clearing service and representing these factors in a context model was the starting point to further standardize the service offering. This standardization is manifested in contract templates and standard processes, and in the automation of labour-intensive activities in the clearing process. The navigation between different standardized processes is specified by the adjustment algorithms in the capability model and facilitated by the CNA. This adds an additional monitoring and control level to the management of BPO services, which leads to improved flexibility. Nevertheless, it should be noted that deCOM only provides introductory support on the modelling of adjustment algorithms.

Summarizing the EE 5

To summarize the 5th evaluation episode, we observed a number of benefits by the method application and to some extent by the implementation of the resulting context models. First, deCOM provided a solution for analysing a business service's contextual influence. As it fit with the organizational landscape, the solution allowed for creating standardized contract templates and configurable processes, which both use parameters identified in the context model. Second, the resulting context models increased the rate of automation in the clearing processes and reduced the time and effort for adapting a business service to a new delivery context. Third, the method enhanced the communication of the contextual influences with the stakeholders that participate to the business service design and implementation via a well-integrated tool environment. The main drawbacks concerned the perceived ease of use and comprehensibility; initial results indicate the need for improvement in the next method version. The findings of EE5 were incorporated into deCOM v6, which is the final method version introduced in Chapter 5 in detail.

Table 31.: Changes in SIVs clearing service design and implementation process, adapted from [120]

Phase	Activity without CDD/ with CDD	Change due to CDD	Role of deCOM in change	Benefit
Negotiation	Initiation / Initiation	–	–	–
	Creation of client-specific handling instruction /Definition of Contract Parameters	Machine-readable contract that can be edited by the client once he/she is logged on to the portal	Modelling the contractual parameters and enabling its deployment to the portal	Informational benefits due to better overview on overall contractual obligations
	Handling instructions for client approval /Definition of Process Parameters	Introduction of standard processes which have been automated	The ability to control the process variants with context related parameters	Strategic benefits due to increased control of contract and process variants
Preparation	Access to client ERP and technical configuration /Configure CDA	Substantial change in way of working	–	–
	Study process description/ Configure CNA	Substantial change in way of working	–	–
	Assignment of staff to client / Assignment of staff to clearing tasks	More flexibility in the assignment of knowledge workers	The ability to monitor the changes in the context of knowledge worker and to respond to customer demands promptly	Informational benefits due to better overview on current situation Strategic benefits due to increased flexibility
Operation	Decide on clearing /Decide on clearing	Automation based on contract parameters	The task to be automated is selected depending on the current context	Transactional benefit due to automation
	Clearing /Prepare clearing	One part of clearing process (which is very labour-intensive) was automated		Transactional benefit due to automation
	Clearing /Clearing	Manual part of clearing was reduced		–
Maintenance	Regulation-induced: implementation change /implementation or configuration change	If change can be tackled with existing parameters and processes: Simplified adaptation due to standard processes and contract parameters	If changes are context dependent: Modelling the existing parameters as context elements	If change can be tackled with existing parameters and processes: Strategic benefits due to shorter adaptation time and less efforts
	Client-requested: implementation change /configuration change	Simplified adaptation due to standard processes and contract parameters	Enables to define a contractual template, including documentation of standard processes	Strategic benefits due to shorter adaptation time and less efforts

6.2.6 *6th Evaluation Episode*

The assigned resources to the EE 6 were larger compared to other episodes and its design was subject to detailed activities since it was the final evaluation episode. The whole evaluation cycle was performed in the course of a bachelor thesis, which had the core task of ″evaluating deCOM's effectiveness and efficiency by conducting experiments in a master course″. The objective was to measure whether the method works in a real environment (and not to improve the characteristics of the method). During the evaluation activities real users performed context modelling tasks. In that sense, EE6 was summative-naturalistic. Evaluation properties, research methods and contributions to requirements are depicted in Figure 6.18.

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
6	Summative	Naturalistic	Observation Questionnaire Interview	Actual Effectiveness Perceived Ease of Use Understandability Ease of Learning Flexibility Perceived Usefulness Maintainability Intention to Use	All requirements

Figure 6.18.: 6th evaluation episode

Research methods

Concerning the research methods used for evaluating the artefact, we applied observation, questionnaire and interview techniques. The *observation* was selected as it is particularly suitable for the cases, where the investigation focus is on the behaviour of evaluands encountering with a new artefact. This technique is also appropriate, if information can not be gathered by questioning [277]. The assignment depicted in Figure 6.19 was given to the students that required producing context models by applying deCOM. By measuring the correctness and informative value of the resulting context models, we used the observation technique to measure the actual effectiveness of the method. For the *questionnaire* part, an online survey was designed to collect quantitative data, which is shown in Appendix D.1. Finally, we designed a semi-structured *interview* including a number of questions directed to the students performing the assignment tasks. The benefit of using an interview guide was that both the author of the thesis as well as the bachelor candidate were in the position of conducting the interviews with different groups by eliminating the risk of individualizing the questions and minimizing the discrepancies in the investigation.

1 Assignment Description

Your task: Context Modeling

Issued:03.05.2016 Completion Until: 10.05.2016, 08:00 (CEST)

Expected time for completing all tasks: 3 hours

Please work in groups of **2 students** on this assignment

Objectives

- To develop skills in business context modelling
- To gain practical experience with the **D**igital **E**nterprise **C**ontext M**o**deling **M**ethod (deCOM) and reflect your observations via an online survey and a follow-up interview

Task 1

Your first task is to model the business context of *AutoPhar*, a digital enterprise offering business process outsourcing services, by applying deCOM. Please capture the context models in one the following three ways and submit them to hasan.koc@uni-rostock.de (with subject header "deCOM in BPO case") until 10.05.2016, 08:00 (CEST) at the latest.

- Pen and paper
- MS Visio (Windows) (deCOM stencil available)
- OmniGraffle (MacOS) (deCOM stencil available)

You are recommended to consider following remarks, when working with the assignment:

- Analyse the starting situation at AutoPhar. Depending on your analysis, you need to first find out which branch of deCOM should be selected.
- What is the business context of AutoPhar? What cause changes in their service provisions? Do the changes influence their goal fulfilment?
- If information should be missing in the use case description (chapter 2), you are allowed to make assumptions regarding the missing part.

Task 2

Your second task is to evaluate deCOM in an online survey until 10.05.2016, 08:00 (CEST) at the latest. The survey includes questions to measure the understandability, ease of use and usefulness of deCOM. The link will be provided to you by the lecturer via mail.

You are also kindly asked to document your reflections and observations during method use. Did you understand the concepts? What problems did you encounter during method use? Do you think that the method can help the enterprises to identify and model their business context? This is a preparation for the discussion and interview, which will be performed in the upcoming lecture.

Expected Results

- Context model of *AutoPhar* from Task 1 (submission to hasan.koc@uni-rostock.de, with subject header "deCOM in BPO case")
- Filled in questionnaire from Task 2 (responses are captured in EvaSys automatically)
- Reflections and observations from Task 2 (to be discussed in the lecture on 10.05.2016)

Figure 6.19.: Assignment description

6.2.6.1 *Experiment Design*

To design the experiment, we needed to define an audience in the first place. For this, the students of Rostock University studying Business Informatics on a master level and participating to the course "Enterprise Modelling Applications" were chosen. According to the campus management system of the university[10] a total of 16 students were subscribed to the course. The author of this thesis planned to perform three 90-minute lectures in English, spanning to two weeks, in which context modelling basics and deCOM v6 would be intro-

10 http://studip.uni-rostock.de

duced[11]. The lectures were designed based on the following procedure:

- Communicate the general objectives with the students, which should be fulfilled after each lecture.
- Briefly discuss about the notion of context in IS.
- Show the overview of the method, i.e. the method components, its purpose and prerequisites as well as the notation.
- Introduce the mandatory method components in detail, i.e. what concepts are used, which activities are performed, which outputs are produced and how.
- Define a running example and show the method application after each component by using the showcase.
- Introduce a short use case after presenting all of the mandatory method components. Group the students to model the case based on the provided example. Discuss the results by showing the solution slides.
- Introduce the optional method components.
- Demonstrate the method application in an industrial case from CaaS project.

After the first week's lecture, the students should be provided with an assignment task, where they develop context models based on a fictional use case. Following this, an online questionnaire should be spread to the students over the evaluation system of Rostock University, *EvaSys*[12]. This web-based tool allows the user to get detailed analysis about the results of a survey. The questionnaire uses a five point Likert scale. The meanings of the values on the scale are as follows: 1 - Totally disagree, 2 - More likely disagree, 3 - Uncertain, 4 - More likely agree, 5 - Totally agree.

6.2.6.2 *Performing the Experiment*

The experiment started on 03.05.2016 with two lectures, each of which took 90 minutes and included 15 students. General objectives of the lectures were defined as follows:

- To introduce a method for context modelling in digital enterprises
- To learn and apply the method in fictional use cases

11 To be more specific, two lectures were planned on 03.05.2016 and one lecture on 10.05.2016.
12 https://evasys.uni-rostock.de/

Table 32.: Survey questions

Evaluation Property	Nr.	Question
Understandability	1.1	deCOM explains the actions to be performed as well as their order in a comprehensible way
	1.2	The relationship between the method components in deCOM are clearly shown
	1.3	The component-oriented structure of deCOM helped me to understand the method better
	1.4	I had problems regarding the understandability of the method
	1.5	deCOM explains the important concepts unambiguously
	1.6	The meta-model provided by deCOM helped me to understand the method better
	1.7	The guidelines provided by deCOM helped me to understand the method
	1.9	The examples in the method handbook helped me to understand deCOM
Ease of learning	1.8	I think it is hard to learn deCOM
Perceived ease of use	2.1	deCOM is easy to use since it informs the method user what step to take next
	2.2	Due to its complexity, it was difficult to apply deCOM to the homework assignment
	2.3	After attending the workshops and reading the method handbook, I feel competent to use the method in further use cases
	2.5	Overall, I think deCOM is easy to use
Flexibility	2.4	I believe the method is flexible, i.e. it can be adopted according to the information set prior to the context modeling task
Perceived usefulness	3.1	Using deCOM would make it easy to communicate contextual influences of a digital service with related stakeholders
	3.4	Overall, I find deCOM helpful to model business context
	3.5	Overall, I think deCOM provides an effective solution for analyzing contextual influence in a digital service
Maintainability	3.3	Because of its component based structure, I believe deCOM is easy to maintain
Intention to use	3.2	If I need to model business context in the future, I intend to use deCOM

- To evaluate a DSR artefact which is
  - used (partly) in CaaS project
  - core of a PhD thesis
  - core of a bachelor thesis

In the first and second lectures, the author of this thesis (the *lecturer* in that case) introduced the notion of business context as well as the overview and purpose of deCOM v6, followed by an in-detail presentation of the mandatory method components. The application of each method component was demonstrated separately in the exemplary case "Fun Factory", which is detailed on page 196 of this thesis. Upon presenting the mandatory method components, a short and fictional use case was given to the students, based on which they modelled the business context by using deCOM v6 (see Appendix A for this use case). Afterwards, the solution slides were shown and the students were engaged into discussions with the author. Here, the author responded questions from the students and checked their models.

At the end of the second lecture, the lecturer introduced the assignment tasks which were then sent to the students and expected to be completed until next week's session[13]. The assignment included two tasks, as shown in Figure 6.19[14].

- Task 1: Modelling the business context of *AutoPhar*, a fictional enterprise in pharmaceutical industry. For this task the students are recommended to work in groups of two.
- Task 2: Evaluating the method via an online survey. For this task, the students are asked to work as single individuals. Moreover, conducting the first task was not considered to be a prerequisite to participate to the survey. The survey questions and the properties subject to evaluation are shown in Table 32.

In the third lecture, which found place a week after the first two lectures, the author of the thesis introduced the optional method components and role of context modelling in the CDD. Following that the method was demonstrated in SIV's application case, which was detailed in section 3.3.3. The third lecture was finished by gathering initial feedback from the students concerning the understandability and usefulness.

The first task has been performed by nine students with varying qualities, both in content and used notation. The response rate to the survey after the first week was even lower, since only seven students participated to the survey at that time. The lecturer thus announced an extension of the deadline and invited them to fill in the survey with an email. At the end of the second session, the lecturer asked the students whether they were willing to participate to a semi-structured interview by informing them about the content and required interview duration. Only 8 students accepted to perform the interview, which were divided into 4 teams consisting two students. The lecturer interviewed Team 1 and Team 2, members of which were ex-

13 Performing the tasks described in the assignment was not obligatory.

14 The whole assignment can be download from http://bit.ly/2fTbmWT.

change students and did not speak German. Members of the Team 3 and Team 4 were interviewed by the bachelor candidate, all of which were German-speaking students. To minimize the discrepancies and the risks, we prepared a semi-structured interview and recorded the conversations with smartphones. Following questions were directed to the interviewees.

- Q1. Have you ever heard about context modelling or context modelling methods before?
- Q2. How much time did you require to complete your home assignment?
- Q3. Did you do the home assignment alone or with a fellow student?
- Q4. How did you interact with deCOM method handbook, lecture slides and the examples? We would like to investigate, how you identified the information that was relevant for you to model the case.
- Q5. Did you encounter any problems during the application of deCOM in the assignment?
- Q6. Would you like to give us further recommendations on how to improve the understandability and ease of learning of deCOM?

As the students were not obliged to participate in the evaluation activities and tend by nature to spare a minimum of their time for an evaluation, designing a semi-structured interview allowed us to use the limited time in an efficient manner. In the following, the results of the survey, interview and the modelling task will be discussed.

6.2.6.3 *Experiment Results*

Survey Results
The questionnaire from the online survey was responded by 12 of 16 students with a response rate of 75%. Every participant answered each question - except for question 3.1, where only eleven responses were given. For analysing the quantitative data, three statistical means were possibly fitting. The first value is the *mean value*, also known as arithmetic average calculated by dividing the sum of all values by the number of values. The mean value is not suitable for analysing data from ordinal scales. The second value is *median*, which is the central value of an ordered list of all collected data. The third one, the *modal* value, is used to analyse the mostly responded value on the scale. In the context of data analysis from ordinal scales, model values deem suitable, as it prevents the analysis from the influence of

statistical outliers. Since the scale on the questionnaire is an ordinal scale, the modal value is used for analysing the collected data. Nevertheless, for the sake of completeness, we also calculated the mean value and median.

Table 33.: Results of the survey

Evaluation Property/ Nr.	Mean	Median	Modal
Understandability	3,5	4	4
1.1	3,3	4	4
1.2	3,7	4	4/5
1.3	3,6	4	4
1.4	2,9	3	4
1.5	3,4	3,5	3/4
1.6	3,2	3	4
1.7	3,7	4	4
1.9	4	4	4
Ease of learning	2,8	3	2/3
1.8	2,8	3	2/3
Perceived ease of use	2,8	3	3
2.1	3,3	3	3
2.2	2,4	2	4
2.3	3	3	3
2.5	2,6	2,5	2
Flexibility	3,3	3,5	4
2.4	3,3	3,5	4
Perceived usefulness	3,	3	4
3.1	3,5	4	4
3.4	3,3	4	4
3.5	3,1	3	3
Maintainability	3,6	3,5	3
3.3	3,6	3,5	3
Intention to use	2,4	2,5	3
3.2	2,4	2,5	3

Table 33 summarizes the values. The overall modal value of a property is calculated by the same procedure as in each question: Count how often each answer option was chosen in each question, which investigates the property. Sum these amounts. The highest amount (most chosen answer option of the whole property) is the overall modal value. Note that the results were mirrored in case of a negated question. For instance, Q 2.2 investigates the ease of use and received the value 4, i.e. the respondents agreed that "it was difficult to apply ..." (cf. Table 33). However, when calculating the overall value of Perceived Ease of Use, this respond is mirrored as "2", i.e. "it was not easy to apply ...". The following part reports the survey results, which are categorised into the evaluation properties.

Understandability. The Understandability of the method was investigated by eight questions, i.e. Q 1.1 to 1.7 and Q 1.9. Based on the modal value calculations, which returned the value 4, we found out that deCOM v6 is more likely easy to understand. Especially the component-oriented structure (Q1.3), the guidelines provided by the method (Q 1.7), the meta-model (Q 1.6) and the examples in the method handbook seem to be helpful for understanding the method (Q 1.9). Following that, it is possible to argue that the method handbook is a very helpful resource for understanding deCOM. The respondents stated that the method is described in a comprehensible way and the relationships between the method components are clearly shown (Q 1.2). Furthermore, deCOM v6 provides the method user with a clear procedure (Q 1.1). On the other side, even the meta-model increases the likeliness of understandability, the method is perceived to describe the concepts somewhat ambiguously (Q 1.5). This may be the reason why the participants likely agreed on having problems regarding the method understandability (Q 1.4). Another assumption may be that although the method is comprehensible, it is not completely effort-free to understand it. The questions and responses are depicted in Figure 6.20.

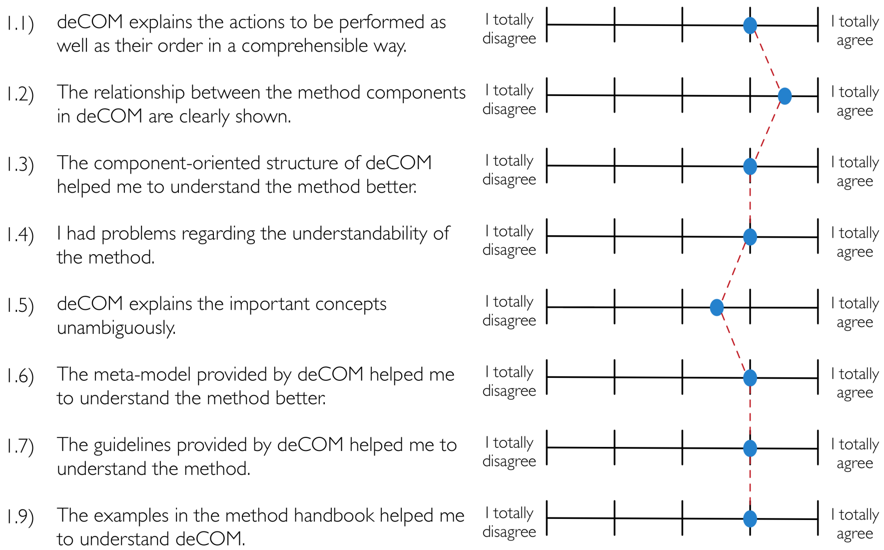


Figure 6.20.: Modal values for *Understandability*

Ease of Learning. The Ease of Learning was investigated by only one direct question (Q 1.8[15]). The modal values are 2 and 3, which shows that the participants were either uncertain regarding the learning aspects or agreed that it is rather easy to learn the method. It is difficult

15 *I think it is hard to learn deCOM*

to derive a clear conclusion from these values, though it is fair to say that in worst case scenario, the method is not perceived to be too hard to learn, whereas it requires some effort to acquire knowledge about it.

Perceived Ease of Use. This property was investigated by four questions, Q 2.1, Q 2.2, Q 2.3 and Q 2.5. The overall modal value of this property is 3. After analysing the responses in detail, we found out that the participants tend not to agree that deCOM v6 is easy to use (Q 2.5). This finding is also confirmed in Q 2.2, where the participants agree that it was difficult to apply the method to the homework assignment (Q 2.2). After attending to the workshops (the aforementioned three lectures) and reading the method handbook, the respondents are not sure whether they are competent to use the method in further use cases (Q 2.3).

We observed an interesting result in Q 2.1, which investigated the extent, to which the procedures contribute to the Perceived Ease of Use. The respondents seem to be unclear concerning this aspect, although in Q 1.1 they agreed that the method explains the actions to be performed and their order, i.e. the *procedure*, in a comprehensible way. This leads to the conclusion that procedures are explained in an understandable way, however, understanding a phenomenon does not necessarily mean perceiving it as *easy to use*. Another way of thinking could be that the users were uncertain how to interact with the method handbook and its step-by-step guidance, and thus they perceive it is not easy to use the method. The modal values concerning the Perceived Ease of Use are depicted in 6.21.

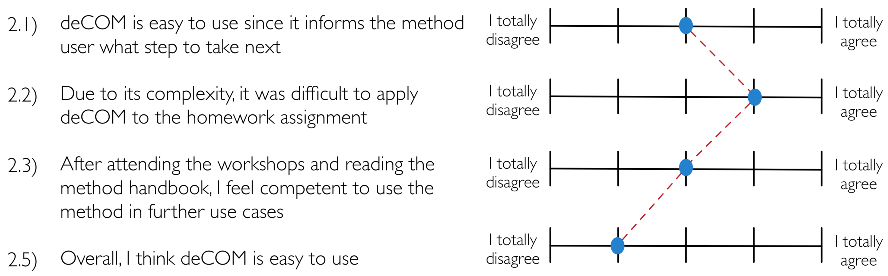


Figure 6.21.: Modal values for *Perceived Ease of Use*

Flexibility. This property was investigated by only one direct question (Q 2.4[16]). The participants agree that the method is flexible and can be adjusted in different settings. On the other side, since the participants never used deCOM v6 in other settings than in the lecture and the homework assignment, this result only can be rated as an expectation, which may vary under different circumstances. As such, the output is an early indicator and requires further research in larger

16 *I believe the method is flexible, i.e. it can be adopted according to the information set prior to the context modeling task.*

settings.

Maintainability. This property was measured by only one question (Q 3.3[17]). The resulting model value was 3, which implies that the participants were not quite sure whether the method is easy to maintain. As a matter of fact such a neutral value was expected since the participants interacted with the method in a short time frame, where no change demands were addressed to the method. By embedding the notion of "component orientation" into the question, we aimed to minimize this risk. Similar with the Flexibility property, we argue that although having the initial results, this aspect can only be investigated in a context where the participants use the method and maintain it in line with the requirements.

Perceived Usefulness. This evaluation property was investigated by three questions, Q 3.1, Q 3.4 and Q 3.5. The resulting modal value was 4. Consequently, the participants think that deCOM v6 is useful, i.e. they agree that it enables an easy communication of contextual influences of a digital service with related stakeholders and is helpful to model business context. However, the participants seem to be uncertain, whether deCOM v6 is an effective solution for analysing contextual influences in a digital service. This might be due to the lack of information concerning the practical problems that the method aims to solve in a real organizational setting. One result supporting this hypothesis is that the participants were uncertain whether they would intend to use deCOM v6 if they need to model business context in future (Q 3.2). We argue that a stronger demonstration of real world problems, as performed in Chapter 3, and informing the user how the method may help to solve those could increase the rates towards more positive values. The modal values concerning Perceived Usefulness are illustrated in Figure 6.22.

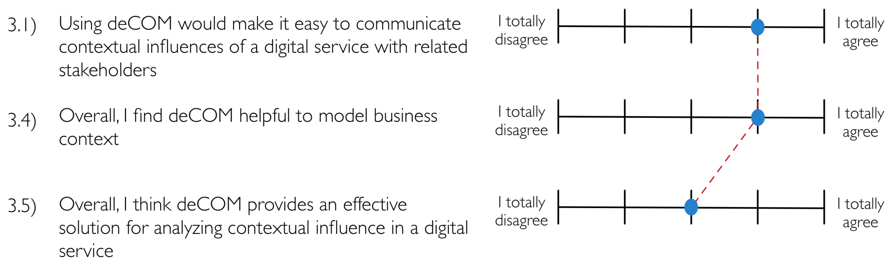


Figure 6.22.: Modal values for *Perceived Usefulness*

The survey results including mean and median values as well as the standard deviation are shown in Appendix D.2.

Interview Results

17 *Because of its component based structure, I believe deCOM is easy to maintain*

In the following, the responses of the participants to the follow-up questions are summarized and interpreted.

- Q1. Have you ever heard about context modelling or context modelling methods before?
  Nearly all of the respondents had heard about context modelling, but mostly in terms of ubiquitous computing. In other words, they were not acquainted with the modelling of the context of an enterprise. Only one respondent stated that he had not even heard the term prior to the lecture. Hence, we argue that all participants are inexperienced with the notion of context in general and with context modelling in particular. This was an important finding in terms of the method evaluation, since the Ease of Learning and Understandability aspects can be measured better by involving inexperienced users.

- Q2. How much time did you require to complete your home assignment?
  As shown in Figure 6.19, the lecturer indicated 3 hours of time for completing the task. Team 1 and Team 2 stated that they required one and a half to two hours, whereas Team 3 and Team 4 needed three to four hours of time. Note that Team 1 and Team 2 used Microsoft Visio stencils for graphical modelling, whereas the other teams preferred pen and paper, which also may have influenced the required time for the task completion. The students learned the basics of the method in two lectures in a total of three hours. As teams worked in a group, we assume that an individual who is slightly knowledgeable in the field of conceptual modelling requires roughly seven and a half[18] (best case) to nine hours[19] (worst case) of time for learning the method and producing context models[20].

- Q3. Did you do the home assignment alone or with a fellow student?
  All students who participated to the interview stated that they performed the modelling tasks in teams of two, as recommended by the lecturer. This enabled discussing about the method and providing the lecturer as well as the bachelor candidate with additional information during the interview.

- Q4. How did you interact with deCOM method handbook, lecture slides and the examples?
  All participants stated that they mainly interacted with the method handbook, which was quite helpful. We found out a

18 Calculated as $(((1,5 \times 2) + (3 \times 2))/2) + 3$
19 Calculated as $(((2 \times 2) + (4 \times 2))/2) + 3$
20 The correctness of the developed models allowed us to assume that, although this aspect will be interpreted in the **Observation** part

pattern with respect to this interaction; the students first read the section about one method component and tried to understand the procedure as well as what it means for their modelling task. After having an overview of the component and its involved activities, they applied this method component step by step to the use case at hand. If they had problems regarding the method application, the students checked the respective example in the method handbook, and then they returned to the assigned task. After the students understood how a step needs to be conducted, they documented their results by means of graphical representations. One team (Team 3) interacted slightly different than the others based on the two facts. First difference is that they used the lecture slides handed out by the lecturer as complementary to the method handbook. Second, before applying the method, they discussed at first how it should be implemented on the use case. Following this discussion, the modelling of the context was performed only by one team member. In line with those answers, we argue that regarding deCOM v6, the procedures of the method (steps, activities and their order) and their demonstration in an example case helped the method users at most.

- Q5. Did you encounter any problems during the application of deCOM in the assignment?
  The responses addressed a few problems the users had during the method application. Some participants stated that the time frame set to learn the method was not enough. Moreover, they also criticized that the method handbook does not point out to the fact how a spreadsheet should be used, e.g. where to exactly begin with the modelling. This deemed important as the models grew over time. Another problem voiced by the students was that they were often not sure whether they were applying the method correctly. This is interesting, since the method users had examples demonstrating the method application in the handbook, which could have guided them. Furthermore, each method component produces certain outputs, with which the students could have compared their own models. One final important remark addressed by the participants was the lack of tool support when drawing context models on their computers. The lecturer recommended to use Microsoft Visio and provided the students stencils supporting the deCOM notation. However, the students were not satisfied by the stencils in general. In particular, they were missing the *process* model element. There was a noticeable fact that Team 1 and Team 2 reported less problems during the application of deCOM than Team 3 and 4. Nevertheless, it extends the boundaries of this thesis to analyse the main factors behind this fact.

- Q6. Would you like to give us further recommendations on how to improve the understandability and ease of learning of deCOM?
  The participants pointed out that the process of gateway identification is very clearly described in the method handbook. However, the part about variant identification does not remain on the same quality and clarity level. Furthermore, as mentioned earlier, they recommended to include a hint at the beginning of the method handbook that the models and spreadsheets grow while performing all components of deCOM.

During the interview, one more question was generated spontaneously concerning the low rates of intention to use compared to the high rates of perceived usefulness. This question was asked only by one interviewer.

- Q7. (follow-up question). The result of the survey indicates that most of the participants think that deCOMis useful, but they also have not the intention to use it. Do you have any idea why this could be?
  The respondents argued that the effort to learn the method is rather high and this might have shadowed its benefits, which is only to some extent documented in the method handbook. Moreover, they stated that the lectures focused on the method itself more than on its benefits and the practical problems it may solve. These responses confirm our aforementioned assumption that a stronger demonstration of real world problems and informing the user how the method may help to solve those could increase the rates towards more positive values.

Observation
After finishing the second lecture and having introduced the basic concepts of deCOM v6, the lecturer provided the students with a homework assignment. One task in this assignment was applying the method in a fictional use case and sending the resulting models via email to the lecturer (cf. Figure 6.19). The use case description reports from an industrial case from a fictional enterprise called "AutoPhar". This enterprise offers pharmaceutical companies BPO services. AutoPhar aims to the scale its BSP by adapting the service provision and the underlying business processes to the industry landscape of the client. The use case description delivers a goal model, with four main goals and a high-level process model as well as its variations according to the influencing factors. The students are recommended to analyse the starting situation and, since the method allows different starting points, to find out which branch of the method should be selected. Based on this, they should identify the business context of AutoPhar, find out what causes changes in their service provisions,

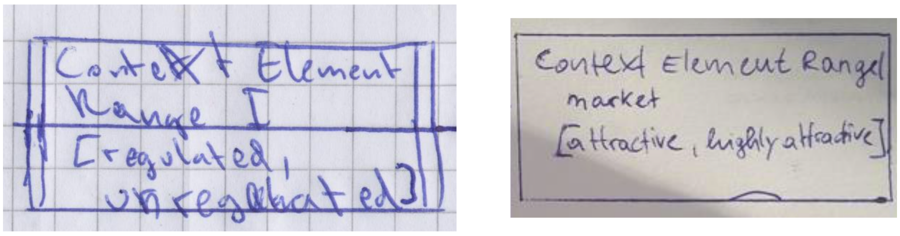
and if this changes have an influence on the goal fulfilment. As result of this task, the students were expected model the business context of AutoPhar by applying deCOM v6.

Five teams performed the task and delivered their resulting models. For the analysis purposes, these models are numbered from M1 to M5. The models were examined and compared based on the following three aspects:

- Was the deCOM notation used correctly?
- Were the associations between the objects of the model noted correctly?
- Which differences and similarities can be observed between the resulting context models?

Notation

Three teams used the deCOM notation correctly, whereas the models of two teams (M4 and M5) included some mistakes. The team developing the M4 documented one Context Element Range with a horizontal line in the middle of the object (cf. Figure 6.23a). Interestingly, the team developing the M5 also draw Context Element Range incorrectly, i.e. without vertical lines on both sides of the box (cf. Figure 6.23b). Note that teams developing the remaining models M1, M2 and M3 used Microsoft Visio stencils which enforce the method users to model the case with the correct notation.



a) b)

Figure 6.23.: Two examples of incorrect notation use

Associations

The associations were documented exactly as they are described in deCOM except for one model, where the label of the association from Capability to Goal and the Context Element was missing. This mistake might have happened accidentally, since all other associations in the same model were correct. Apart from that we did not observe any inconsistencies.

Differences and similarities

Although nearly all of the models look different, it was possible to identify two important similarities amongst them. First, in every model, Capability was perceived to be the central concepts which is linking the contextual factors to the enterprise objectives. Second, even with different degree of granularity, the Context Elements had similar meanings, despite being named differently (e.g. *Influence of regulatory trends* vs *Regulated environment*).

Observing the outputs in detail, there were two models (M1 and M2), which were very close to the lecturer's solution provided to the students afterwards. These two models were detailed and comprised of similarities concerning the identified Context Elements and Measurable Properties. One could mention a third model (M3), which was also detailed, but had another perspective on the business context of AutoPhar. In this third model, the students were not able to capture the Measurable Properties, although remaining parts of the model parts were correct. Compared to the other outputs, the M4 was less detailed and included fewer model primitives than the former models. On the other hand, the team producing M4 documented the steps, activities and the resulting outputs in greater detail. Altogether, it is fair to say that these four models offer the possibility to represent the contextual factors and can be interpreted by everyone who is knowledgeable of the deCOM's notation.

An exception to this finding is the M5, which includes one Context Element, two Context Element Ranges and two Measurable Properties. It seems like the students only analysed one variation point and documented their findings, without further performing and completing the modelling task. This team examined the gateways, measured their influence on goals and performed a dependency analysis as well. In other words, like the team designing the M4, they focused on producing the outputs of respective method components and paid less attention to the final context model. To conclude this part, we argue that the students understood the contextual factors that influence AutoPhar's business and documented these by applying deCOM with varying granularity and level of correctness.

6.2.6.4 *Summary of Evaluation Episode 6*

EE6 is the final evaluation cycle, which was performed in the course of a bachelor thesis. In this EE, we used interviews, questionnaires and observation techniques to evaluate deCOM v6. The properties subject to evaluation were Actual Effectiveness, Perceived Ease of Use, Understandability, Ease of Learning, Flexibility, Perceived Usefulness, Maintainability and Intention to Use.

For performing the evaluation activities an experiment was designed, comprising of four main phases. The first phase concerned the introduction and presentation of deCOM v6, which was performed in workshop fashion by the author of this thesis. The second phase was implemented by an homework assignment, in which the students applied the method in one use case and reflected their view on certain aspects of the method via an online questionnaire. The third phase consisted of interviews with the students that performed the modelling tasks in the second phase. The evaluation episode was closed by the fourth phase, where the resulting context models were examined in terms of their correctness, completeness and notation use.

The survey participants more likely agree that deCOM v6 incorporates a number of constructs that enhances the understandability during the interviews, such as meta-models, clearly defined procedures, guidelines and examples. This is also reflected in the produced context models, which have a fair level of completeness and correctness. An interesting finding is that the students did not report anything special regarding the method understandability, although the responses to the Q 1.4 imply that they somewhat had problems in this aspect. As far as the questions that measure the method understandability show, it seems like the concepts and their explanation caused understandability problems. A further reason could also be, as some of the students reported in the interviews, that one needs more time to learn the method, i.e. it is not a straightforward process to understand it.

The respondents were somewhere between uncertain and likely certain concerning the Ease of Learning. Integrating these results to the answers given during the interview, it seems like the participants are divided in two groups. The first group seems to be satisfied with the methodical guidance and the workshops, they state that it is easy to learn the method based on these artefacts. The second group argues only to some extent that the aforementioned artefacts suffice to learn the method and believes that one needs more time to learn the method. Based on such statements, we conclude that the method is not perceived to be hard to learn, but it requires some effort to acquire knowledge about it. The time frame to learn the method is estimated between 7,5 to 9 hours, including a three hour workshop.

Concerning the Perceived Ease of Use, there was rather a negative tendency and most of the participants stated that they are more likely to disagree deCOM is easy to use. During the interviews we found an interesting remark related to this aspect. It became clear that the students were uncertain whether they were applying the method to the case at hand correctly, which might have affected their perception for ease of use. This uncertainty could have been reduced by simply comparing the required outputs by the method with the outputs produced by the students. Due to the restricted time frame, as mentioned by some of the respondents, we believe that this option was resource consuming and thus was not preferred. Furthermore, the respondents were not certain whether they could potentially use the method in further cases, which might have a negative influence on Intention to Use. Such low rates of this property can be explained in two ways. First, the students perhaps do not believe that they could need the method in the future. Second, the lecturer did not communicate the benefits of the method use and the problems it may solve well enough, as pointed out by some of the interviewees.

The method was perceived to be useful by the survey participants. The results showed that the method enables to communicate the contextual influences with related stakeholders and helps them to model business context. This finding is confirmed after examining the produced context models, the students were able to identify main contextual influences, probably communicated those between each other, reached a consensus and sent the models to the lecturer.

We have also measured two further evaluation properties, namely "Maintainability" and "Flexibility". The participants agreed that that the method is flexible, i.e. it can be adopted according to the information set prior to the context modelling task. However, we argue that this perception might change when the respondents encounter situations, in which they need to adapt the method. Regarding the former aspect, the participants were not quite sure whether the method is easy to maintain. Likewise, this value may change and hard to derive any implications as the participants interacted with the method in a short time frame, where no change demands were addressed.

6.3 CONCLUSIONS AND SUMMARY

deCOM has been developed based on the DSR paradigm. In DSR, the aim is to construct a purposeful artefact with an intention to support the solution of a relevant problem. As mentioned in section 2.1.3, DSR proposes a number of guidelines. In particular, Guideline 3 suggests that *the utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods*. This section concludes the activities related to the evaluation of the method and summarizes the findings.

Framework for evaluation

deCOM was designed in an iterative fashion. Each design cycle produced an artefact, i.e. a new version of the method, which was subject to evaluation in different settings with different objectives. For evaluating the method, FEDS approach proposed by Venable and colleagues was applied [52], which was extensively discussed in section 2.4. The *build-evaluate* core philosophy of DSR allowed us to integrate evaluation results to the new design process, i.e. the evaluation activities executed after each method version contributed to the refinement of the procedures, concepts and notation of the following method versions.

Evaluation goals

Each evaluation activity is performed to satisfy a certain goal, e.g. ensuring the efficacy of the artefact or testing the intention to use the artefact in real situations. The objectives correlate with the requirements that the artefact should fulfil. Against the background that methods are designed to improve performance of a task, we prioritized to measure the actual efficiency, the actual effectiveness, perceived efficacy and the intention to use for deCOM. The perceived efficacy is subdivided further in the evaluation properties "perceived ease of use, perceived usefulness, ease of learning, understandability, maintainability, fit with the organisation" and "flexibility". The evaluation properties proposed in FEDS and evaluation constructs introduced in MEM were mapped conceptually, as shown in Figure 6.3.

Evaluation episodes (EE)

A total of six evaluation episodes have been performed, each focusing on a certain aspect of deCOM and adopting various research methods for measuring the aforementioned properties. Figure 6.24 illustrates the evaluation episodes, their functional purpose, the paradigm of study, applied method, evaluated properties and the requirements, which the evaluation results contribute to.

#	Functional Purpose	Paradigm of Study	Method	Evaluation Property	Contributes to
1	Formative	Artificial	Criteria-based Expert opinion	Actual Effectiveness	FREQ 1 FREQ 2 FREQ 3 FREQ 5 NFREQ 1
2	Formative	Naturalistic	Action Research	Perceived Usefulness Fit with the Organisation	FREQ 1 FREQ 3 FREQ 4 NFREQ 1
3	Summative	Naturalistic	Case Study	Perceived Usefulness Perceived Ease of Use Understandability	All requirements, except for FREQ6 and FREQ7
4	Formative	Naturalistic	Client Feedback	Perceived Usefulness Fit with the Organisation Flexibility	FREQ 2 FREQ 4 FREQ 5 FREQ 6 NFREQ 2
5	Formative	Naturalistic	Technical Action Research Client Feedback	Perceived Usefulness Perceived Ease of Use Fit with the organisation Maintainability Ease of Learning Actual Efficiency	All requirements
6	Summative	Naturalistic	Observation Questionnaire Interview	Actual Effectiveness Perceived Ease of Use Understandability Ease of Learning Flexibility Perceived Usefulness Maintainability Intention to Use	All requirements

Figure 6.24.: Summary of all evaluation episodes

Results of the EE1

The aim of the EE 1 was testing the actual effectiveness of deCOM v1 (cf. Figure 2.6) in a selected case that represents the explicated problem. This evaluation episode is the equivalent of demonstration step in DSR procedure, in other words, demonstration is a weak form of evaluation. The enterprise modelling experts discussed deCOM v1 after it has been demonstrated and checked whether it fulfils the requirements FREQ1, FREQ2, FREQ3, FREQ 5 and NFREQ1. The results and change requests can be summarised as follows:

- The design decisions that helped to create the basic structure of the method are justified.
- The method demonstrates a good start for eliciting the business context, yet it does not quite satisfy the aforementioned requirements.
- Important concepts need to be aligned with the CaaS meta-model (cf. Figure 4.26).
- The meta-model should be extended with the concept of "variation point".
- The method should include tool support. The tool should use a context modelling notation.
- The procedures should be more fine granular.

Results of the EE2

The EE2 used action research to measure two properties, Perceived Usefulness and Fit with the Organisation. deCOM v2 (cf. Figure 6.8) was presented to an audience including both practitioners and scholars. The results and change requests can be summarised as follows:

- The terminology used by the method fit with the organisation and the procedures are easy to follow.
- The method is perceived to be useful, yet there are a number of improvement needs, which are documented in the following.
- The method should clearly separate between modelling (early design, late design) and operational (runtime) phases.
- The operational phase should be documented in a new method component. It should also be possible to express rules to allow for runtime decisions.
- Activities addressing business process variability are missing (e.g. how to represent variation point)
- It should be possible to classify context elements, such as "atomic" or "composite".

Results of the EE3

deCOM v3 (cf. Figure 6.10) integrated the aforementioned results and was evaluated in the EE3 by using single case study approach. Company stakeholders from everis were involved in the evaluation and provided feedback in the Perceived Usefulness, Perceived Ease of Use and Understandability aspects. The results and change requests can be summarised as follows:

- The method provides an effective solution for analysing a digital service's contextual influence.
- The method and context models created by it enhance the communication of the contextual influences to the stakeholders of the digital service.
- The method is perceived easy to use, still, additional guidelines were required, which are documented in the following.
- The method should provide guidelines to identify:
  - what constitutes a context element and how it is possible to distinguish it from other information objects and
  - variability and variation points in business process models
- Activities related to context element identification should be the focus of the method.
- The method user should be provided with pictograms for modelling context.

Results of the EE4

The EE4 focused on the 4th version of deCOM. In this evaluation episode, client feedback is collected during a CaaS meeting, where deCOM v4 (cf. Figure 6.12) was introduced by the author and discussed with the audience. Moreover, as this version has been used in industrial application cases in the project, another stream of client feedback was gathered from users' experiences with the method. The results and change requests can be summarised as follows:

- The flexibility of the method is restricted as it does not support potential ways of working.
- The method is useful to design the context of the business service. The applied terminology and the procedures fit with the organisations. Yet, it does not provide sufficient support to cope with the operationalisation aspects.
- The method should include rules and preconditions for implementing a context model.
- Guidelines for identifying context elements and measurable properties could be further enhanced.
- The method should be able to make use of various kinds of enterprise models that exist in the organisations.

Results of the EE5

deCOM v5 (cf. Figure 6.14) incorporated the change requests and was subject to evaluation in EE5. In this episode, two evaluation cycles were performed. The first cycle applied TAR, where a collaborative working week with SIV within the premises of CROZ was organised, the details of which are provided in section 6.2.5.1. Following evaluation results and change requests have been obtained during the first evaluation cycle of the EE5.

- deCOM v5 fits into the enterprise landscape of SIV, yet it was not perceived as easy to use.
- The method is well integrated with the tool environment for context modelling and supports the runtime aspects.
- From a conceptual point of view, deCOM v5 contributes to the application case related goals of SIV. The context model created after method application have been successfully deployed to adapt the behaviour of the clearing service at runtime.
- Further refinement of the concept "Context Element Range" (CER) is required. Briefly, a CER should represent every possible range of a Context Element and are not specified values (cf. Table 30).
- Easy-to-follow instructions within the method are needed.

The second evaluation cycle in the EE5 focused on the value creation perspectives and is detailed in section 6.2.5.2. Originally, the investigation was performed to measure the benefits of the CDD method. We filtered the parts of feedback that could be attributed to deCOM v5, which are summarised in the following.

- The method provides a solution for analysing a business service's contextual influence.
- The solution allows for partly standardizing services (contractual template) and configuring processes.
- The context models increase the rate of automation and decrease the efforts required to adapt the service to new situations.
- The context models produced via the method enhances the communication of the contextual influences to the stakeholders of the business service.
- All in all, the aforementioned benefits lead to strategic benefits in a sense that SIV can use the method offer flexible and adaptable digital services in the utility industry.
- Although the aforementioned aspects point out to certain benefits, the method is not perceived to be easy to use.

Results of the EE6

The subject of the EE6 was the final version of deCOM, which is presented in Chapter 5. In the course of a bachelor thesis, interviews, questionnaires and observation techniques are used in the EE6 to evaluate the method. The results of this episode are summarised as follows:

- The method is understandable and incorporates a number of constructs that enhance its understandability. But understanding the method is not an effort-free process.

- Regarding Ease of Learning, the respondents can be clustered into two groups. The first group states that it is rather easy to learn the method based on the provided guidance. The second group argues only to some extent that the aforementioned artefacts suffice to understand the method and believes that one needs more time to learn the method. Taking the first finding into consideration, we argue that the method is not hard to learn, yet it requires time to understand it, which is assumed to be between 7,5 to 9 hours.

- The method handbook and the examples are the most helpful resources for understanding the method. Still, the method handbook should point out to the fact how a spreadsheet during modelling activities should be used.

- The method helps to identify and model the contextual influences of a digital service. In this respect, the process of gateway identification is very clearly described in the method handbook, whereas variant identification is not of the same clarity.

- The method deems to be flexible, although the results may vary when the respondents encounter situations, in which they need to adapt the method.

- There is a negative tendency in terms of method's perceived ease of use, which may be related to the fact that the participants were uncertain whether they were applying the method to the case at hand correctly.

To conclude, deCOM is a method which has been iteratively developed in line with the feedback collected from various audiences, e.g. industrial stakeholders, scholars and students. All in all and based on the results introduced in this section, we argue that deCOM is perceived to be a valuable instrument to elicit, identify and model the contextual factors that may affect the provision of a digital service. The method is well documented, perceived to be useful, comprehensible and satisfies the requirements. The method's trade-off seems to reside in the effort required to learn it, i.e. although it fits with the investigated organisation landscapes and its application leads to certain benefits, it is not entirely easy to use and to learn the method.

Part IV

DISCUSSIONS AND CONCLUSION

7

DISCUSSION AND CONCLUSION

The purposeful design artefact proposed in this thesis is deCOM, a capability-based context modelling method, which aims to increase the degree of digital service flexibility by means of conceptual modelling. This chapter first discusses the findings by revisiting the research questions in section 7.1 and analysing to what extent the research process is in line with DSR in section 7.2. Afterwards, threats to validity are discussed in section 7.3, followed by the the lessons learned in section 7.4. Section 7.5 documents the limitations, section 7.6 concludes the work and derives final conclusions.

7.1 DISCUSSING THE RESULTS

The central research question investigated in this thesis is the following.

*RQ 1 From the **methodological** perspective, how can the design of digital services adaptable to changing requirements of the environment be supported?*

Next, we will briefly provide answers to the research questions (RQ) derived from RQ 1 and discuss the findings.

RQ 1.1 What are the current problems of the organizations offering digital services in changing environments?

The digital services are offered for a specific customer group, yet they need to be **customized** and **adjusted** to fulfil specific requirements. The need for such adaptation is shown in the literature, e.g. in [11], who defines the adaptation ability as the most important quality attribute of digital services. We supported the theoretical relevance with the application cases from the industry and performed a root cause analysis to reach a detailed understanding about the problems hindering flexible digital service design and provision. The identified problems addressed the lack of support for taking the contextual aspects during service design into account as well as the missing alignment between stakeholders on various levels. The answers to the RQ 1.1 is provided in Chapter 3 in more detail.

RQ 1.2 How are the terms ***services*** *and* ***digital services*** *defined in the literature?*

Service notion has been analysed in Information Science, Business Science and Computer Science [24]. The *Business Science* perspective uses *natural language for a high-level description of services*, referring to value exchanges. One of the most cited definition of the term service is from [14], which states that service is the application of competence for the benefit of another. The *Computer Science* perspective points out to *coarsely grained processes and tasks, implemented by Web services, to realize the IT-part of the service offering described by the business*. The *Information Science* researchers aim to bridge the gap between both communities by transforming the service notion *to a well-defined concept with concrete tasks that together realize this value-oriented activity* [24, p. 6].

A digital service is defined as "an activity or benefit that one party can give to another (. . .) through a digital transaction (information, software modules, or consumer goods) over Internet Protocol (IP)" [11, pp. 506]. In the literature, we came across similar terms, such as e-services, online services, web services. Furthermore, following the duality between services and business processes in [47], we observed that BPM plays a central role on designing, providing and innovating digital services [24, 15, 47, 48, 278, 152, 213]. We transferred this duality to the digital services area and showed that digital services are designed **process based**.

Regarding the understanding of Service notion, wide application area of the term as well as the current problems and challenges in digital services domain, we derived important implications for this work, i.e. the need for Business-IT alignment when designing services and taking contextual constraints into account.

RQ 1.3 Which approaches exist that improve the flexibility in the design and configuration of digital services?

In the literature, we did not identify direct proposals that aim to enhance the flexibility of digital service design or provision. Instead, the contributions focused on the role of BPM in making organisations or services more flexible. In particular, context-aware design of business processes and developments in the process variant management seem to relate to the problem at hand. The proposals and their shortcomings are investigated in Chapter 4 in detail. Briefly, both proposals result in overloaded and complex business process models, which deteriorate the quintessence of modelling and makes it nearly impossible to understand and deduce the contextual factors from them.

RQ 1.4 How should the method support for increasing digital service flexibility look like?

Context modelling seemed to be a promising approach to increase digital service flexibility, as it allows for capturing the adaptable parts of a service and reasons for change in a separate form, which makes the contextual information more accessible. By adhering to the principle of *separation of concerns*, the process models can be used to capture the organisational activities and not further complicated with additional contextual information. Thus, we argue that by representing the flexible parts of a digital service delivery within a context model, the process models would be somewhat relaxed. Furthermore, we argue that approaches are needed to bridge the gap between the design of digital services and their actual implementation. Following [1], we interpret the term **capability** as an instrument to realize Business-IT alignment and close this gap, which is a contribution to the scientific body of knowledge. As such, capability delivery considers the application context of the digital service and argues that context is the key term to offer flexible digital services by adapting the business processes at runtime [27, 35].

To support the enterprises in the context modelling activities, deCOM, a capability-based context modelling method method, is proposed, which states how the context is explicated, captured and designed. To shape the artefact in detail, functional and non-functional requirements are derived by using different techniques (cf. section 2.1.3.2). As the main problem is the lack of support in the identification of contextual factors, the method should inform its user concerning the context elicitation procedure, document the inputs needed and outputs produced. A shared understanding among the different roles participating to the design of a digital service needs to be established, which is why the method should provide a graphical notation to ease the communication between different stakeholders. The digital services are designed process-based. The standard processes are altered when offering services to the customers and variants of these standard processes are modelled and implemented. Thus, the method should offer mechanisms to highlight change factors in the business situation variability. The method should also support the situations, where formal enterprise knowledge is missing (or is not represented via conceptual models) and such knowledge is documented only textually.

The method should fulfil two non-functional requirements. To support different ways of working in organisations, the method has to provide an adaptable development methodology and should be modular. The modularity should be supported by low coupling (method has optional and mandatory parts) and high composability (method provides different entry points to the user). Last but not least, the method should be easy to use, easy to learn and provide practical guidelines to enhance the understandability. The resulting method is documented in Chapter 5.

RQ 1.5 Is the method applicable in enterprises offering digital services? Does the method use lead to an improvement in the provision of flexible digital services?

Guideline 3 of DSR suggests that the utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods. To answer the **RQ 1.5** and ensure the rigour of the design artefact, versions of deCOM were evaluated by using FEDS approach [52]. The evaluation results are summarized in the following.

- deCOM is perceived to be useful for eliciting the business context. It provides an effective solution for analysing a digital service's contextual influence.
- The applied terminology in deCOM and the procedures fit with the organisations.
- From a conceptual point of view, deCOM contributes to the application case related goals of SIV and everis. The context models created after method application have been successfully deployed to adapt the behaviour of the digital services at runtime. Especially, SIV group reported strategic benefits in a sense that they can use the method offer flexible and adaptable digital services in the utility industry. It is fair to expect that the method performs well within the organisations that have similar architectures to the ones described in the application cases. However, the method has not been tested in different organisations, which limits to scale up and derive more general conclusions.
- The context models produced via the method enhances the communication of the contextual influences to the stakeholders of the business service.
- The method is understandable and incorporates a number of constructs that enhance its understandability. But understanding the method is not an effort-free process.
- There is a negative tendency in terms of method's perceived ease of use.

What is "context" in the application cases?

Context is a widely used notion in many areas, such as Formal Logic, Artificial Intelligence, Philosophy, Pragmatics, Computational Linguistics, Computer Science, Cognitive Psychology [169]. As discussed in section 4.3.1, even in Computer Science, various interpretations of the term exist. We define context as any information characterising (i.e. changing, influencing) the provision and design of a digital service that fulfils enterprise goals in a changing environment. So, in the cases of SIV group and everis, with which aspects of *context* is the thesis concerned?

Brézillion and colleges define context in real life as "a complex description of shared knowledge about physical, social, historical, or other circumstances within which an action or an event occurs" [279, p. 575]. Furthermore, Tarasewich's categorization of context consists of environment (e.g. physical properties, location of objects), participants (e.g. mental states and personal properties) and activities (e.g. tasks and goals of participants) [280]. Two aspects from the combination of these interpretations relate to the aforementioned application cases as follows.

- **Knowledge**. We have shown in the industrial application cases from the utility sector and e-Government that different stakeholder roles participate to the service design and delivery. The implicit knowledge of knowledge workers or public servants as well as the explicit knowledge contained within the secondary data is subject to change. Context can be used both to describe the relevant parts of participant's implicit knowledge and also to represent and maintain the explicit knowledge in a model. Using context as an instrument should foster the adaptation process of digital services as shared knowledge allows for a common understanding amongst the participating stakeholders.

- **Task**. Context can be shaped within an action or a series of activities. As stated in the case descriptions, "the knowledge of the domain experts is implicit and it might not be possible to automatize the whole solution process simply by performing a series of machine-executable tasks due to fact that the parameters cannot be always predicted". Nevertheless, in both application cases the activities and tasks of the participants may be to a great extent proceduralized and put in a context for a flexible service configuration and delivery.

All in all, we argue that deCOM is perceived to be a valuable instrument to elicit, identify and model the context of a digital service. The method is well documented, perceived to be useful, comprehensible, satisfies the requirements and provides strategic benefits concerning digital service provision. The method's trade-off seems to reside in the effort required to learn it, i.e. although it fits with the investigated organisation landscapes and its application leads to certain benefits, it is not entirely easy to use and to learn the method.

7.2 DESIGN SCIENCE RESEARCH COMPATIBILITY

This thesis is coordinated and structured following the DSR paradigm. Although various methods are proposed on how to conduct research within the design science framework, core of the activites are the two phases, *build and evaluate*. After screening possible procedures to perform DSR (cf. Table 3), the process model by Peffers et al. is selected [72]. The model was slightly adapted in two senses. First, the problem identification step (activity 1) is included in the iteration, as the problem(s) motivating the design artefact do not remain stable over the course of the project. This is explained by the fact that the stakeholders benefiting from the purposeful artefact have a more sharpened view of the problems as the project advances. Second, the activities are mapped to the seven DSR Guidelines, as shown in Figure 2.2. In the following, we revisit each guideline and provide a short explanation concerning how they are fulfilled throughout the thesis.

- Guideline 1: Design as an Artefact. In this thesis, the purposeful artefact is a method called deCOM. The method is described in Chapter 5.
- Guideline 2: Problem Relevance. The global relevance of the problem is demonstrated in Chapter 3, which collects the findings from the literature and the two organisations offering digital services.
- Guideline 3: Design Evaluation. Based on the FEDS framework [52], the utility, quality, and efficacy of deCOM is rigorously demonstrated in Chapter 6.
- Guideline 4: Research Contributions. Section 1.1.3 highlights the contributions of the thesis, which are twofold. First contribution is the development of a component-based context modelling method, which should help enterprises to understand the application context of the digital services and allow for an enhancement in terms of flexibility. Second contribution concerns the integration of capabilities and services, which is rare in the literature. The thesis closes this gap by refining the traditional concept of capability and interpreting it as *a digital service together with its application context*.
- Guideline 5: Research Rigor: The work performed in this thesis can be categorized into ISR, which is necessarily a multiparadigmatic area. As such, different research methods have been applied to design and evaluate the artefact rigorously, as documented in Chapter 2 and Chapter 6.
- Guideline 6: Design as a Search Process. During the design and evaluation of deCOM, procedures are used to structure the research process. Examples of this can be observed in Figure 4.15 and Figure 4.28 when performing SLRs or in Figure 6.1

when evaluating the artefact. The adopted research procedure is also shown in Figure 2.2.

- Guideline 7: Communication of Research. The results of this thesis have been presented to both technology-oriented and management-oriented audiences, mostly in form of scientific publications (cf. section 1.3).

The question may arise, why the thesis have chosen to structure the research process in line with the DSR paradigm and not waterfall model, RUP or another framework for systems development. [49, p.162] provides very useful insights concerning the distinguishing characteristics of DSR compared to the other possible research streams, which justify its application in this thesis.

- Unlike a waterfall model, DSR does not prescribe a sequential way of working. The activities are not ordered temporally, rather, there is an input-output relationship between them. In the context of this thesis, this fact allows for revisiting an already performed step without violating the selected DSR procedure, e.g. when the requirements change or the problem definition is updated as the stakeholders have a sharpened view of it or when the evaluation of an artefact feeds into the new iteration of method design.

- Systems development does not necessarily prescribe application of rigorous research strategies and methods, which is a requirement in DSR.

- In DSR, the knowledge contribution should be related to the existing body of knowledge, which calls for an originality of results. This is not the case in systems development.

- Compared to systems development, communication of the results with practitioners and researchers is a distinguishing aspect of DSR. In the context of this thesis, sharing the research results with the research community allowed for receiving helpful feedback, which necessarily improved the design artefact.

7.3 THREATS TO VALIDITY

`Artefact validity`

Different ways to classify validity aspects and threats to validity in the literature [281]. In the domain of IS, at least three kinds of validity are mentioned [59, 281, 282]. *Construct validity* reflects "to what extent the operational measures that are studied really represent what the researcher have in mind and what is investigated according to the research questions" [281, p. 153]. *Internal validity* means that changes in the dependent variables can be safely attributed to changes in the independent variables [282]. *External validity* concerns the extent, to which it is possible to generalize the findings, and to what extent the findings are of interest to other people outside the investigated case [281].

Validity in a DSR project should be established from the evaluation of the developed artefacts [283, 71], which in this thesis have been performed based on the FEDS framework proposed by Venable et al. [52]. In this respect, the internal validity is assessed via the analysis of the efficacy, i.e. the utility/benefits derived from the use of deCOM are due to deCOM, not due to other factors. The external validity is investigated by measuring the perceived usefulness of deCOM as well as the intention to adopt it in the practice. The ensure the validity, the analogic inference design is selected (cf. section 6.2.5.1). Construct validity was established by evaluating the actual effectiveness and perceived usefulness in general and by relating the gained feedback to the requirements in each evaluation episode in particular.

`Evaluation validity`

When performing a DSR project, one threat is perceived to be that the researcher who developed the artefact is able to use it in a way that no one else can [95] (threat to external validity). To mitigate this risk, the artefact should be taught to other people, e.g. in form of a workshop, as it was done in the 6th evaluation episode. The teaching was followed by an evaluation cycle, consisting of the author of the thesis, the bachelor candidate and the students participating to the workshop. To ensure the validity of the evaluation instruments in the 6th episode, the bachelor candidate and the author of the thesis grouped the survey questions into the evaluation properties. Concerning such grouping, the main threat was the lack of studies that ensured the logical links between the properties, which was hard to mitigate. Likewise, the conceptual taxonomy of evaluation properties are partly conceptual, which are shown in Figure 6.3. However, as the relationships between the evaluation properties were not taken into consideration during the interpretation of results, it is doubtful, to what extent a scientifically proven conceptual taxonomy would affect our findings.

In terms of the questionnaire (cf. section 6.2.6), there are some factors that may influence the reliability of the results. One such factor is wording of the questions [277]. During the design phase of the EE 6, the questions were checked by some students who would not participate to the survey. The bachelor candidate performing the activities in the evaluation episode asked these students how they would interpret the questions and incorporated the gained feedback. Furthermore, in his supervisor role, the author of this thesis also checked the questions, which is expected to decrease the ambiguity. Still, the threat to reliability by unclear formulations somewhat cannot be completely erased, as English was not the mother tongue of the participants. Another threat to validity is the mood of the respondent, which may falsify the conclusions of the researcher, e.g. when she is in hurry or disinterested. Interestingly, we observed one participant, who mostly disagreed to the statements, even to the negated ones. By using the modal value, we tried to minimize the amount of noise and hinder false conclusions.

When performing interviews to collect data, a major threat is that stakeholders may answer interview questions in a desirable way or that the researcher herself interprets answers in a desirable way [95]. This can be mitigated by having others than the researcher when data is collected and coded, as it has been the case in all evaluation episodes. Evaluation activities in EE 5 and EE 6 illustrate good examples of this, where various roles (e.g. a bachelor student, enterprise modelling experts and the client using the artefact) are involved in collecting and interpreting the data. However, the participation of the stakeholders should be defined and documented clearly to eliminate side effects (cf. Figure 6.16). How such side effects may raise and be mitigated is worth mentioning in the case of the EE 6, where the interviews were performed in two different languages by two different interviewers. We selected this model for the time efficiency, i.e. the students were not obliged to participate in the evaluation activities and tend by nature to give a minimum of their time for an evaluation. To minimize the risks, we prepared a semi-structured interview and recorded the conversations. Still, the question remains whether this had an influence on the fact that English-speaking groups reported way less problems than the German-speaking groups. There could be two argumentations against this assumption. First, the level of models' correctness provided by the former teams are higher than the other teams. Second, the reported time frame required by the former teams to complete the tasks is lower, compared to the latter teams. As such, it is comprehensible that those teams report fewer problems, though it is not possible to find the ultimate answer to this phenomenon.

Validity in SLR

Ayora et al. expresses three main threats to the validity when performing SLRs, *selection bias, inaccuracy in data extraction and analysis*, as well as *reliability* [83]. To mitigate the first risk during performing a mapping study in capability modelling methods, the literature sources were cross-checked, selected and populated based on the rankings from [245, 246, 247]. Furthermore, inclusion and exclusion criteria are defined to have a more stabilized list of relevant papers. Concerning the SLR in context modelling methods, applying snowballing technique allowed to ensure that all relevant literature previously known to us was found.

As the SLRs have been performed solely by the researcher, the data extraction and analysis part might include subjective decisions. An attempt to eliminate this was using a research classification scheme in the capability modelling mapping study, which was adapted from

[92, 249] and [248] (cf. Figure 4.29). Concerning the SLR in context modelling methods, Goldkuhl's method conceptualisation framework was used to classify and analyse the findings in a comparable way (cf. Table 15).

A SLR must provide transparency for researchers who might repeat the analysis by extending the sources or changing the inclusion criteria. For this purposes, it has to demonstrate a clear procedure of the research process, i.e. the research questions, the search terms, criteria for inclusion or exclusion must be expressed clearly. Still, the final threat to validity is the hardest to mitigate, as the data extraction process is to some extent related with subjective decisions. Consequently, there is no guarantee that other researchers performing the same procedure will obtain exactly the same results.

7.4 EXPERIENCES, LESSONS LEARNED

This section briefly mentions gained experiences and lessons learned over the course of the thesis.

- **Demonstration vs. Evaluation**. In the selected DSR procedure, two activities seem similar, namely *demonstration* of an artefact and its *evaluation*. This raises the question for design science researchers, what exactly the difference between the two activities is. In this thesis, I found it beneficial to use the demonstration step as a weak form of evaluation, i.e. the first version of the designed artefact is introduced to a small group including enterprise modelling experts and gained feedback was integrated to the next method version. To be able to demonstrate the design artefact allowed in that sense for false starts. That is not to say that in my case the starting point was too far away from the desired level, rather, it was possible to demonstrate the proposal although if it was not perfect. Furthermore, due to the integrated results of the demonstration, the second method version was more mature and the time passed between the demonstration (first evaluation, in other words) and second evaluation gave me the opportunity to get to know the client context even better.

- **Systematic Literature Reviews**. One of the most challenging issue for a doctoral student in the context of her thesis is the data collection and analysis of existing body of knowledge. Which literature resources should be selected? What is an A conference and A+ journal, as this also depends on the research area? How is it possible to create unambiguous inclusion and exclusion criteria to create a pool of relevant papers? Do not I need an ontological alignment between many terms and concepts in order to compare them during data analysis? The list of questions is obviously not exhaustive. The difficulty of performing literature reviews is also a recognised subject amongst scholars (cf. [88, 81]). With the perspective of having a transparent and repeatable search process, I applied in this thesis systematic literature reviews to explore the current state in the areas which relates directly to the proposals core. Although it is impossible to eliminate the fact that two different researchers with the same literature sources, inclusion & exclusion criteria and pool of articles would come to different conclusions, I argue that risks can be to a certain extent hindered when performing the literature review in a systematic way. Moreover, based on a number of instances in the literature (e.g. [91]) it was possible and feasible for me to extend or adapt the selected SLR procedure. By explicitly defining how the procedure is refined and justifying its needs, I aimed to shape the literature review activities in line with the available resources and purpose of the research. Using two different SLR techniques, i.e. *snowballing* [92] and *Kitchenham's procedure* [89], let me discover the strengths and weaknesses of both approaches. I came to the conclusion that snowballing helped me to reach somewhat more consistent results than Kitchenham's procedure. This is actually not surprising, since the papers in the snowballing procedure (in a way) cite each other, which makes it easier for one to create a shared knowledge base that is applicable to the relevant papers, i.e. the concepts, the perspectives and the aspects investigated in the paper. This necessarily allows for a more transparent comparison of results. On the other hand, the finding of Jalali and Wohlin that "time and effort required in Kitchenham's approach is higher than Webster's (snowballing procedure)" did not apply to my case [93]. To eliminate the risk that snowballing might miss the articles with no relevant terms in the title, I searched in the keywords of the publications, screened the abstracts and in some cases even the full-text, which suits to the aforementioned principle of procedure refinement.

- **International research project**. I worked as a research assistant in CaaS project during my thesis. Such a position had benefits (highlighted with + in the following) but also brought a number of challenges (highlighted with - in the following) that should be taken care of. Next, I would like to mention these aspects.
  - \+ **Method Engineering**. In this thesis, Goldkuhl's method engineering framework was used. Selection of this framework is mainly based on the fact that it was applied in CaaS project. It is possible to speak two positive outcomes of this selection. First, compared to the other frameworks (e.g. ISO/IEC 2007) the effort to cover the industrial requirements with Goldkuhl's framework was considered to

lower. Second, during the artefact evaluation episodes, the author benefited from know how of enterprise modelling experts in CaaS project, who have extensive knowledge and experience with the framework. Detailed experiences concerning method engineering in the development of deCOM can be found in [284].

+ **Concepts**. During the method design, I certainly benefited from the capability meta-model, which was developed before and refined during CaaS project. The advantage of a such meta-model was twofold. First, the concepts that the deCOM method components refer to were to a great extent represented there and as such they have been reused. Second, to define the relationships between the concepts in notation development, I used the associations in the meta-model. According to the application case needs, the concepts and the meta-model were updated. In this respect, the evaluation cycles adopting action research was helpful, i.e. the practitioners involved in the method application raised their concerns whenever clarifications were needed. This created the basis for the discussions, where I could intervene as a "researcher" and help the client with the understandability issues.

+ **Tools**. One artefact resulted from the CaaS project is the CDD environment, consisting of a number of tools for capability design and delivery. Amongst them, the CDT can be applied for context modelling, which is ready for use after its downloaded and unpacked. The CDT is not an artefact developed by me. What I did in this respect is allowing for context modelling in two standard applications in Windows- and Apple-based computers by developing stencils, namely *MS Visio* and *OmniGraffle*. Still, note that CDT enforces the deCOM notation, whereas other applications do not provide such functionality.

– **Artefact for the sake of CaaS**. The first challenge was ensuring that deCOM is not a "local method", which only solves the problems defined in CaaS project and operates within this context. To scale up its relevance and demonstrate the possibility that the method works beyond the projects boundaries, I designed an evaluation episode (cf. EE 6 in section 6.2.6), which consisted of subjects unrelated to the CaaS project. In my opinion, the method used in CaaS project is a subset of what I developed during my thesis. This outcome is even positive as it allows to argue for the flexibility of the artefact, i.e. it can be adapted to different ways of working. Nevertheless, I think it is important to address this issue as a challenge for other doctoral students who might encounter similar situations.

– **Reporting in project**. Usually, research projects require developing extensive reports and deliverables concerning the performed activities and their outcomes. Documenting those efforts is certainly a team work, i.e. scholars and practitioners participating to the project contribute to the deliverables. A challenge in this context was, considering the high number of project deliverables as well as joint publications, being able to separate what is my *own text* and which parts originate from other authors. Looking back and assessing the influence of this with a critical eye to this thesis, I dealt with this type of challenge in problem investigation part (cf. Chapter 3). A simple solution that I came up with was basically correctly citing the parts that have not been written by me.

– **Capability aspect**. The work performed in CaaS project relates heavily to capabilities and their context-aware design. The ethos of the project is *to bring about a shift from the service-oriented paradigm to a capability delivery paradigm* [73]. Apparently, using capabilities for flexibility enhancement is an idea that is propagated in the project, which was proposed before this thesis began. In this thesis, this position is still defended and thus the challenging question is worth raising, why I mentioned the capability aspect as a contribution in the introduction part. There are three answers to that question. First, the focus in this thesis is not on the service-oriented paradigm of enterprises and a shift from it is not envisioned necessarily. Instead, the focus is narrower, it is directly on digital services offered by enterprises and capabilities serve as an abstraction from technical concepts. Second, SOA is an interesting field, yet, the problem I aimed to solve is not necessarily caused by adopting service-oriented paradigms, it has in part different root causes (cf. section 3.5). Third and last, to the best of my knowledge, there has been no work yet, including the ones performed in CaaS, which proposes capabilities as the way they are understood in this thesis, i.e. as a communication vehicle between different disciplines that study Service Science, such as Information Science, Business Science and Computer Science.

7.5 LIMITATIONS & FUTURE WORK

deCOM is an instrument to elicit, identify and model the context of a digital service, which has been positively evaluated a number of times. However, the method has certain limitations, which is discussed in this section.

The context modelling method takes a stance on conceptual modelling, which allows for "many-dimensional representational forms" [20]. These different dimensions and the need for abstracting from the reality may cause different stakeholders using deCOM to produce different results. This is a limitation of the method, i.e. the method does not work like an algorithm, which produces the same output and terminates when provided with the same input. On the other side, the question remains whether methods in conceptual modelling should strive for arriving at such unique results. In this respect, two important goals of Enterprise Modelling are *acquiring knowledge about the business from different stakeholders* and *stimulating communication and collaboration between different stakeholders* [268]. In the literature, we identified context modelling methods, which refine statements and find contextual facts by using formalisation techniques (c.f [211, 221]). Interestingly, even those methods state that the recommended activities are slightly subjective and results may vary based on stakeholders perceptions.

Using a conceptual modelling approach results in neglecting runtime aspects to a certain extent, such as the degree of service adaptation at runtime[1]. This is valid in the context of deCOM, i.e. the method does not quite specify how to implement a context model and use it in practice for digital service adjustment, instead, it prepares the method user for operational use by means of generic activities. However, using the advantages of component-oriented method development, one can simply refer to the *Adjustments Modelling* method proposed in CDD [244] and use it as a complementary component.

Another limitation is that deCOM is not applicable in all types of situations. Besides the preconditions of method use, as detailed in section 5.3, further questions need to be answered, which may limit (or scope) the method applicability in practice [244]. In case the responses to the below-listed questions are rather negative, then we do not recommended the application deCOM.

- Do you plan to offer the same business for different target groups and markets?
- Are there variations in the execution of business ideas or certain situations for various application scenarios?
- Is your business idea is closely related to digitalization and deliver IT-based solutions?

1 Note that on page 34, it was declared that in this thesis the term "flexibility" is used instead "adaptability", since the latter one implies the runtime aspects of the business service provision, whereas the former one connotes rather design time aspects and is more suitable from the capability point of view.

- Do you have a roles, processes and technology stack, similar to the one shown in Figure 3.1?

Concerning the gained knowledge, the results documented in this work have been presented in conferences, workshops, journals and in edited book chapters. The practitioners have also been informed, particularly in form of method handbooks and posters, although much attention needs to be given to the management-oriented audiences. This limitation triggers the future work, which will concern developing a method handbook and informing the interested parties. The method handbook will incorporate the feedback gained in EE 6 and will improve deCOM as follows.

- A guideline about how to interact with the method handbook will be added. Especially, the method user will be advised to compare her outputs with the templates provided in the method and outputs demonstrated with the examples.
- There will be a short text which will inform the method user about using a spreadsheet, e.g. where to exactly begin with the modelling.
- The activities and guidelines concerning the variant identification will be refined.
- The time frame required to learn the method will be added.

Another future work in this respect could be designing and record virtual course and create a deCOM learning package, which includes more application examples and a short quiz. This package can be referred to in the method handbook.

Digital economy is growing worldwide and seen as an important driver of innovation and competitiveness. Business world undergoes a digital transformation to seize the opportunities provided by the current paradigms, such as Internet of Things (IoT), Sensing Enterprises and Industry 4.0 [13]. To maximize their innovation potential, capitalize on instantaneous opportunities and sustain their interoperability, future enterprises and start-ups should posses the capability of sensing and smartly adapting their business models to varying business situations. There are also other research directions, which interest and motivate me to answer the following research questions:

- Contextualization and collaboration are both information-intensive aspects of value creation, which is one way for business model innovation [285]. What is "context" on a business model level and how should this be captured?
- Digitalization refers to the realization of new business models, e.g. through the IoT [111]. Which "smart" and "context-aware" solutions can be developed so that the firms benefit from digitalization to find new ways to create, deliver and capture value?

- As high start-up birth rates go hand in hand with a great risk of failure, to what extent can scholars develop solutions supporting entrepreneurial activities?

The final research direction that requires extending my current research concern *sensing capabilities* of future enterprises. This direction is acknowledged in Future Internet Enterprise Systems (FInES) Research Roadmap 2025 predicting such sensing capabilities will allow enterprises to put together internal and external operations to get important advantage over its competitors. As the competition is rather between networks of organizations, capabilities should be exchangeable, comparable and interoperable depending on the current context. In this respect, the term Sensing Enterprise is coined, which will emerge with the evolution of the IoT. My mid-term goal is developing rigorous solutions that support Sensing Enterprises in possession of autonomous decision making capabilities. Understanding the business contexts and processing the real-time information from both physical and virtual surroundings is one of the prerequisites concerning the decision making process.

To summarize, I aim to continue my future research towards investigating the influence of context on the innovation and adaptation of business models as well as on the benefits gained by configuring and managing contextual factors with a particular focus on sensing enterprises, which necessarily requires continuation of my current work.

7.6 CONCLUSION

Enterprises need to constantly adapt their service and product offerings to cope with the challenges caused by today's dynamic markets. Due to the intrinsic relationship between an enterprise and its IT, the organisations are expected to be flexible, not only in terms of their organizational structures but also regarding the IT supporting their service/ product design and delivery. The need for adapting the information systems to changing environments causes more complex landscapes [112].

This thesis tackles the flexibility problem from the perspective of enterprises offering digital services. This limitation is justified with the importance of digital economy & transformation as well as the strong paradigm shift towards a service economy.

The proposed solution is a context modelling method to support flexible digital service provision from the conceptual modelling point of view. [127] state that conceptual modelling should be concerned with business context to extend its boundaries and answer to the requirements of stakeholder goals in changing business environments.

In more detail, the author of the thesis aims to **improve the flexibility of digital services that are provided in changing environments**

by developing a context modelling method, deCOM, based on enterprise capabilities. Core contributions of this thesis is twofold.

C1. In order to offer flexible digital services, enterprises need to understand their application context. The analysed context modelling approaches (methods, techniques, frameworks, procedures) assume that contextual information is already known [53] and fail to show how to elicit contextual information in a systematic way. Moreover, they lack important elements, such as notation, tools required to model the context, the prerequisites to use the method etc., which would enhance their practical applicability. This work closes the gap by providing a method to identify and model the contextual factors, which influence design and delivery of a digital service.

C2. The combination of capability and service research streams are rarely found in the literature [17]. However, when the notion of "Service" is analysed, we observed that several disciplines related to IS had diverse perceptions, all of which are relevant in the context of digital services. In this work, the term capability is proposed as a "glue", in other words, as a communication vehicle between those disciplines that study Service Science, such as Information Science, Business Science and Computer Science. This requires a refinement in the traditional interpretation of the capability notion, which is described as *context-aware digital services that are related to the enterprise goals and implemented by the business processes* and used as an instrument to bridge the gap between the design of digital services and their actual implementation.

The research paradigm adopted during the method development is DSR, which is a utility-focused problem-solving paradigm. Chapter 2 documents the research procedures proposed in DSR field as well as the applied research methods and frameworks in the thesis. Chapter 3 shows the relevance of the flexibility problem by analysing both the literature (knowledge base) and gathering evidence from two enterprises offering digital services. Against this background, the chapter examines the root causes of the problems and shapes the requirements that the artefact should fulfil. Chapter 4 investigates the proposals related to flexibility enhancement from two different perspectives, reports the current solution proposals in the literature and investigates their shortcomings by performing (systematic) literature reviews. Chapter 5 introduces the core proposal of the thesis, deCOM and describes each method component in detail. Furthermore, the chapter discusses the notion of "method" as well as the approaches in method engineering. *Artefact evaluation* is an essential part of any DSR project. Chapter 6 introduces FEDS, a framework to evaluate DSR artefacts [52]. FEDS is instantiated in a total of six evaluation episodes, each adopting different research methods and focusing on various method properties.

According to the evaluation results, deCOM perceived to be a useful, comprehensible and well-documented method to elicit, identify and model the context of a digital service. Nevertheless, it is not effort-free to learn the method, i.e. although its application leads to certain benefits, it is not entirely easy to use and to learn the method. Future work concerns mainly improving the learning-related aspects of deCOM and further investigating the notion of context with respect to business model innovation, entrepreneurship and Sensing Enterprises.

Appendices

A METHOD APPLICATION: USE CASE 1

This chapter introduces a fictional use case, where context plays a vital role on the provision of a digital service. For the use case, we assume that the enterprise objectives are already captured as goal models and the service provision is represented as business processes models.

Figure A.1.: A screen shot from the app

A worldwide airline called *ComfortFly* offers its customers a free digital application that supports the passengers regarding the time optimization. By using the app, the passenger should be at the airport, check in and go to her gate just in time. Based on the current situation, the app calculates the probability of a delay and cancellation. In case of a high probability, it recommends actions to the passenger, such as contacting the airline customer services or checking the flight status from the respective web page. The recommended action depends on the context of respective flight, which is affected by the airport situation, number of the delays or cancellations in the prior flight as well as on the traffic situation. These factors influence the travel time of the passenger. A simple screen shot is illustrated in Figure A.1, where the user is automatically informed about her respective flight.

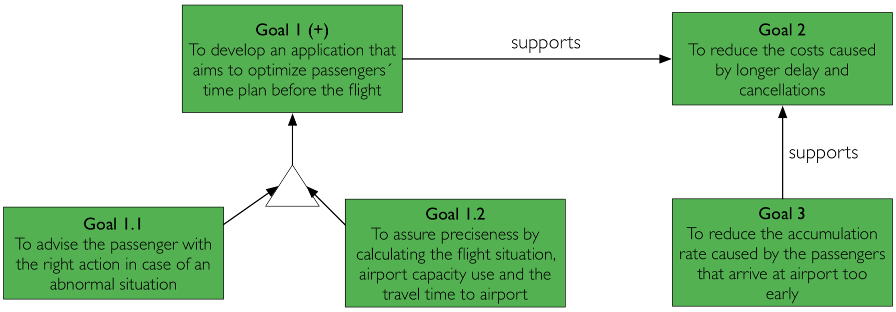


Figure A.2.: A simplified fragment of ComfortFly's goal model

A.1 PRACTICAL APPLICATION OF METHOD COMPONENT F

As a first step, the method user investigates whether the enterprise objectives of ComfortFly are expressed clearly and whether the stakeholders follow such goals. She finds out that the company conducted a participatory goal modelling session a few months ago, which was triggered by the problem of costs caused by longer delay and cancellations. The stakeholders reached a consensus and stated the goals as follows:

- We need to reduce the costs caused by longer delay and cancellations.
- We aim to reduce the accumulation rate caused by the passengers that arrive airport too early (because they are not aware of a huge delay probability).
- We aim to assure preciseness by calculating the flight situation, airport capacity use and the travel time to the airport. Moreover, we want to advise the user with the right action in case of an abnormal situation.
- We aim to develop an application, which monitors and processes passengers' situation to optimize her timing.

She finds out that the aforementioned goals of ComfortFly are modelled formally by using the 4EM method (cf. Figure 5.9). Moreover, the business processes that are motivated by the goals and required for the implementation of this service are thoroughly modelled. Based on this findings, she follows the fourth path, i.e. she should apply method components **A - B (apply only Step 2) - C - (G optional) - D - E (optional)**. A simplified fragment of ComfortFly's goal model is shown in Figure A.2.

A.2 PRACTICAL APPLICATION OF METHOD COMPONENT A

Step 1: Scope Setting (Activity 1, Establish the project)

After a successful meeting with stakeholders, the method user defines the problems as follows:

- ComfortFly had earlier developed an application, which aimed to optimize passengers' time by monitoring and processing the information related the passengers' situation. The configuration of this application proved to be inefficient, since each change would require going back to the process models, altering and updating them by adding or removing activities and gateways.
- The aforementioned problem can be alleviated by modelling the different contexts that the application workflow has to adapt. However, the solution engineers at ComfortFly do not exactly know, what context is and which information describes passengers' context. In the enterprise, there is a plethora of documentation explaining the dynamic aspects of passengers' journey from the earlier application development project. There are also business process models, which capture such dynamic aspects, but since they are complicated and many variations of them exist, it is hard to extract the right information.
- To provide the passenger with a precise information, the application needs to be prepared for various scenarios, i.e., their workflow has to cope with the changes occurring at run-time to support the passenger with the right action. This requires finding and implementing the right fragment from the business process models.

Enterprise Modelling (EM) is a method for developing, acquiring, and communicating enterprise knowledge and user requirements by a structured and iterative approach. A way of solving this problem is applying deCOM, a digital enterprise context modelling method that systematically covers the elicitation and specification of relevant context elements of any passenger. In doing so, the method should support ComfortFly's goals represented in Figure A.2. Moreover, it should graphically show what parts of the selected service should be flexible. By visualizing the contextual influence, ComfortFly gains all the usual benefits of modelling, not least using the business context model and capabilities as a vehicle for merging differing business viewpoints quickly, and for asking the right questions. The maintenance costs should decrease, because the context model should allow for adaptations of the workflow to various application scenarios. That such information is represented on a model level makes it easy to communicate the change factors with the stakeholders, which participate to the design and implementation of the digital service. The

Table 34.: Service selection matrix for ComfortFly Case

	Automation	Time	Flexibility	Cost
Customer Relations				x
On Board Services				x
Pre-flight Services	x	x	x	x
Booking Services	x	x		

process execution should also be improved in a sense that the application selects the right fragment of the business process depending on the runtime situation. The method engineer presents the benefits to the stakeholders, which contributes to an approval for method application.

Step 1: Scope Setting (Activity 2, Select the service)

The method user analyses the services and creates the service selection matrix (see Table 34). Based on the criteria, the method user confirms that developing the application in "Pre-flight services" area would increase the competitiveness. The stakeholders share this view.

A.3 PRACTICAL APPLICATION OF METHOD COMPONENT B

Step 1: Business Process Modelling

As already mentioned, the method user does not need to apply Step 1 (Business Process Modelling), since the business processes of Pre-flight services are modelled prior to deCOM application. After a company intern update of the business models, the method user continues with Step 2.

Step 2: Process Model Analysis

The input to this step is the process models of the selected service. The method user is provided with business process models and information about them. After a thorough analysis, she identifies in the following the locations where variability happens.

Figure A.3.: The high-level workflow of the application

Figure A.3 illustrates the high-level workflow. There are yet no gateways in the business process model. But she expected this (see

Guideline 5) and thus has to investigate the sub-processes for further variability.

The first sub-process is related to the flight situation assessment, as shown in Figure A.4. Here, the method user identifies two gateways.

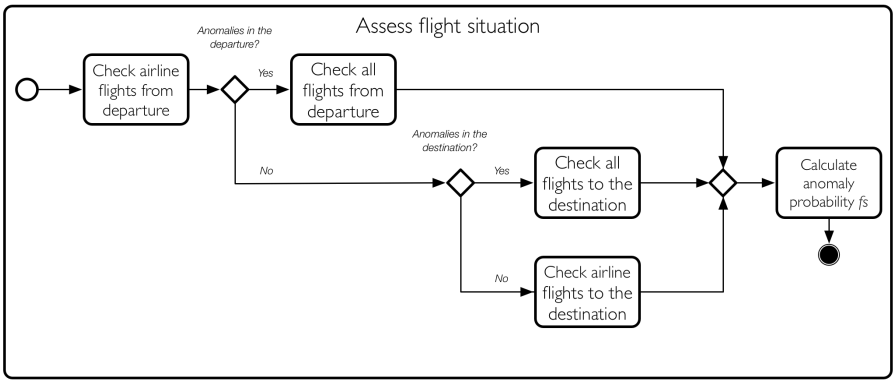


Figure A.4.: Flight situation assessment

The task "assess airport situation" consists of further sub-tasks, which are shown in Figure A.5. The method user identifies here only one gateway, "border control required?". The value of this gateway influences whether the task "analyse the passport control" is executed or not.

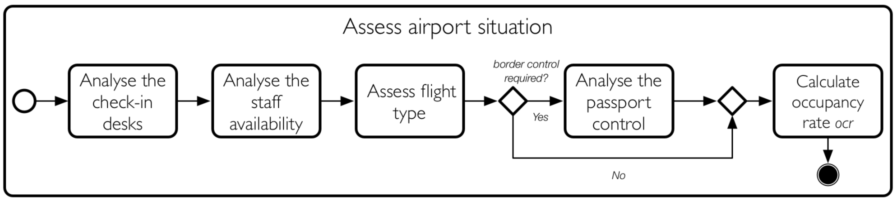


Figure A.5.: Airport situation assessment

The tasks "check traffic situation" and "calculate travel time *tt*to airport" are automated and executed exactly the same way each time. There are no gateways here (cf. Figure A.3).

In the last task, the application recommends user an action. As shown in A.7, finding the right action and supporting the user with the precise recommendation depends on how the prior gateways are resolved. The method user captures all of the gateways and documents them in Table 35. Please note that, in line with deCOM, the gateways with same conditions and same diverging paths are considered identical. For simplicity purposes, we eliminated the identical gateways from Table 35.

An important remark concerns the application of Activity 2, *Identify process variants*. The method user analyses all the business process models related to the service provision. She concludes that the variability can be analysed *only* by investigating the gateways. This is closely related to the design decision of the business process mod-

Table 35.: Capturing the gateways

Gateway	Condition
GW1	Anomalies in departure?
GW2	Anomalies in destination?
GW3	Border control required?
GW4	Anomaly probability?
GW5	Flight type?
GW6	Airport occupation?

eller at ComfortFly. To give an example, the task "assess airport situation" could be modelled as depicted in Figure A.6A and A.6B (with and without border control, respectively). The difference between the model shown in Figure A.5 and in Figure A.6 is that the former one represents variability with a gateway and the latter one with process variants. This is the reason, why deCOM supports the analysis of both gateways and process variants.

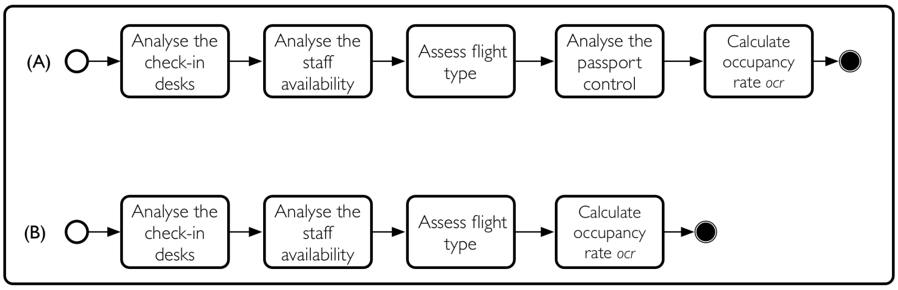


Figure A.6.: Two process variants of the task "assess airport situation"

A.4 PRACTICAL APPLICATION OF METHOD COMPONENT C & G

Step 1: Text-based Fact Elicitation (MC G) & Context Element Elicitation (MC C)

The method user applies MC C and MC G in parallel. She was not experienced in fact elicitation techniques, so she gathers information about the Pre-flight services app. In the following, we introduce the textual data that were extracted from the documents.

- Task *Flight situation assessment*: Number of delays and cancellations from the departure point as well as at the destination location will used as input data to calculate the anomaly probability *fs*. The *fs* can assume values **low, middle, high** and for each value, the actions to be taken may change for the passenger.
- Task *Airport situation assessment*: In order to recommend the precise action to the user, the application analyses the capacity use

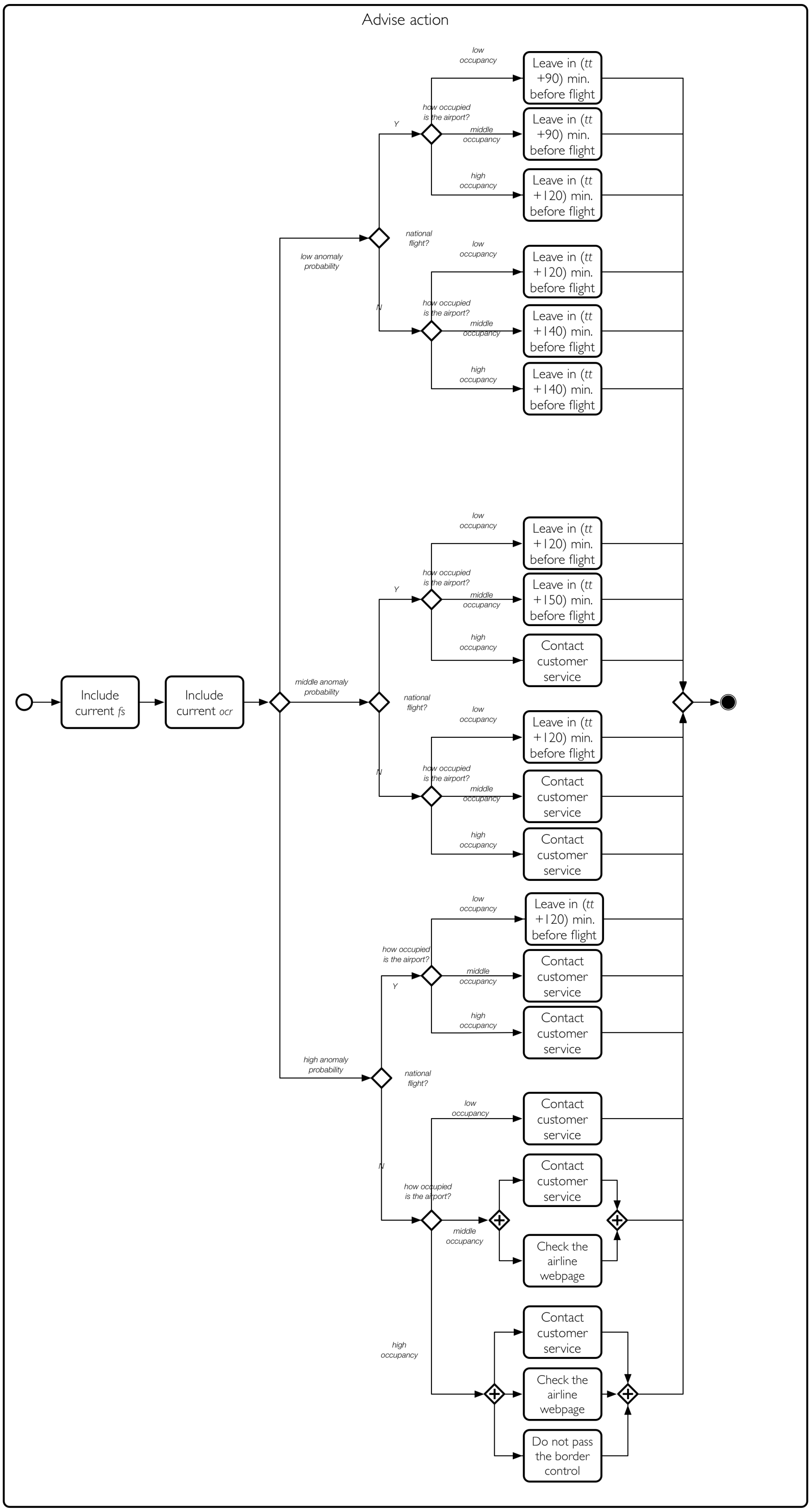


Figure A.7.: Actions recommended by the application based on user context, detailed view in the check-in desks and the availability of the staff. The flight assessment type is required to identify whether the flight is national or international and whether the flight requires a border control. In such cases, the analysis of the queue on the pass control is also added to the workflow (cf. Figure A.5). Based on the results, the occupancy rate *ocr* is calculated, which may assume the values "**low, mid, high**".

- The application uses the respective values produced at those gateways as input data to calculate the anomaly probability *fs*, which is a very important value for advising the passenger with correct timing.
- After assessing the flight and airport situations, the application checks the traffic situation to calculate the required time to arrive at the airport. For this, the application has to have access to the user location. Next, the travel time *tt* to the airport is calculated.

The application supports the passenger with a number of recommendations, depending on her context (see Figure A.7). The recommendations refer to 7 process variants. The selection to implement the right variant depends on the user context:

1. *Leave in (tt + 90) minutes before the flight*: This action is advisable, when the passenger attends to a national flight from a low or mid-occupied airport, where the anomaly probability is low.
2. *Leave in (tt + 120) minutes before the flight*: This action is advisable, when the passenger either attends to a national flight from a high occupied airport (anomaly not regarded), or to an international flight from a low occupied airport, where the anomaly probability is low or mid.
3. *Leave in (tt + 140) minutes before the flight*: This action is advisable, when the passenger attends to an international flight from a low or mid occupied airport, where the anomaly probability is low.
4. *Leave in (tt + 150) minutes before the flight*: This action is advisable, when the passenger attends to a national flight from a mid-occupied airport, where the anomaly probability is middle.
5. *Contact customer service*: If the context of the passenger is one of the following, then the passenger should contact the customer service to ask for the most current information about the flight.
    - The passenger attends to a national flight from a highly occupied airport with a middle anomaly probability,
    - The passenger attends to a national flight from a mid- or highly occupied airport with a high anomaly probability,

- The passenger attends to an international flight from a mid- or highly occupied airport with a middle anomaly probability,
- The passenger attends to an international flight from a low-occupied airport with a high anomaly probability.

6. *Contact customer service and check the airline web page*: This action is advisable, when the passenger attends to an international flight from a mid-occupied airport, where the anomaly probability is high. In the *check airline web page* activity, the application directs the passenger is automatically to the online flight status query page.

7. *Contact customer service, check the airline web page and do not pass the border control*: This action is advisable, when the passenger attends to an international flight from a highly occupied airport, where the anomaly probability is also high. If the passenger is already in the airport due to any reason, the application recommends not passing the border control. The reason is that after passing the passport screening, the passenger can only leave the secured area after a very complex procedure. Hence, in case of a longer delay, crossing the border control means practically killing time where everything is overpriced.

Now that the method user has a better overview on the workflow and description of the service, she first identifies the factors that cause variability. For this, she uses the list of gateways (see Table 35) and alters it by adding the columns "gateway analysis" and "factor". For each gateway, she denotes why they exist and why they are needed, as shown in Table 36.

After that, she investigates the extent, to which the factors influence goal fulfilment and adds a column 'goal influence' to the table. She finds out that resolving all gateways except for GW3 have a strong contribution to goal fulfilment.

Table 36.: Identifying and analysing factors causing variability

Gateway	Condition	Gateway Analysis	Factor	Goal Influence
GW1	Anomalies in departure?	If there are anomalies in the departure, then not only the flights of ComfortFly, but of all the airline companies are checked. Anomalies in the departure are required to calculate the anomaly probability (fs)	Anomaly probability calculation	Strong
GW2	Anomalies in destination?	If there are anomalies in the destination, then not only the flights of ComfortFly, but of all the airline companies are checked. Anomalies in the departure are required to calculate the anomaly probability (fs)	Anomaly probability calculation	Strong
GW3	Border control required?	If border control is required, then its capacity utilization is taken as an input to calculate the occupancy rate (ocr). On the other side, the results of the calculation are not expected to raise the preciseness of recommendation	Airport occupancy rate calculation	Weak
GW4	Anomaly probability?	The anomaly probability (fs) is a mandatory input required to advise the right action to the user	Anomaly probability calculation	Strong
GW5	National flight?	The passengers attending to an international flight have to be at the airport 30 min. earlier than the passengers of a national flight	Flight type	Strong
GW6	Airport occupation?	The occupancy rate of the airport (ocr) is a mandatory input required to advise the right action to the user	Airport occupancy rate calculation	Strong

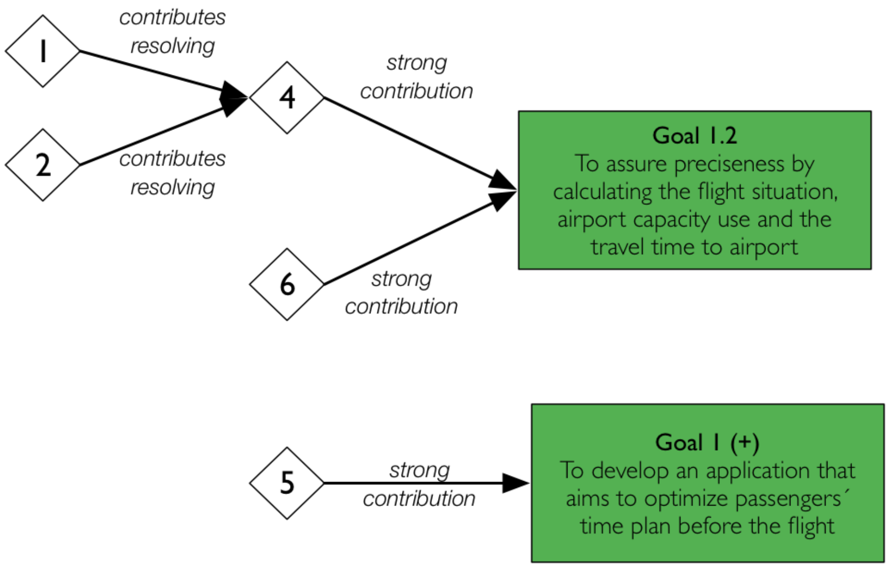


Figure A.8.: Dependency analysis between gateways

She filters out GW3 from the table and conducts a dependency analysis between gateways. The GW1 and GW2 contributes resolving GW4, since the *anomalies in departure* and *anomalies in destination* are calculated to find out the anomaly probability *(fs)*. It means that their actual contribution to goal fulfilment after they are resolved is due to GW4 and hence *indirect*. She documents this by creating a simple taxonomy between gateways (see Figure A.8). Then with the gateways that have a direct and strong goal contribution, she creates the variation points (see Table 37). The variation points will help us to establish the connection between the context elements and important gateways in the context model. After this, she consults the findings with the domain experts.

Table 37.: Renaming the gateways as variation points

Gateway	Condition
GW4	VP1
GW5	VP2
GW6	VP3

Step 2: Context Element Design

The factors causing variability in the business processes are analysed and discussed with domain experts thoroughly (see Table 36). As a result, the factors that have both strong and direct influence on goals are modelled as context elements[1]. The remaining factors are not

1 Context elements are context entities that affect the service design and provision by causing variability and they are related to enterprise objectives

"idle", i.e. they are typical candidates used to specify the properties of a context element, which help to measure its value. In deCOM, we call these attributes "Measurable Property". Following Guideline 8, the method user decides to use GW1 and GW2 as measurable properties.

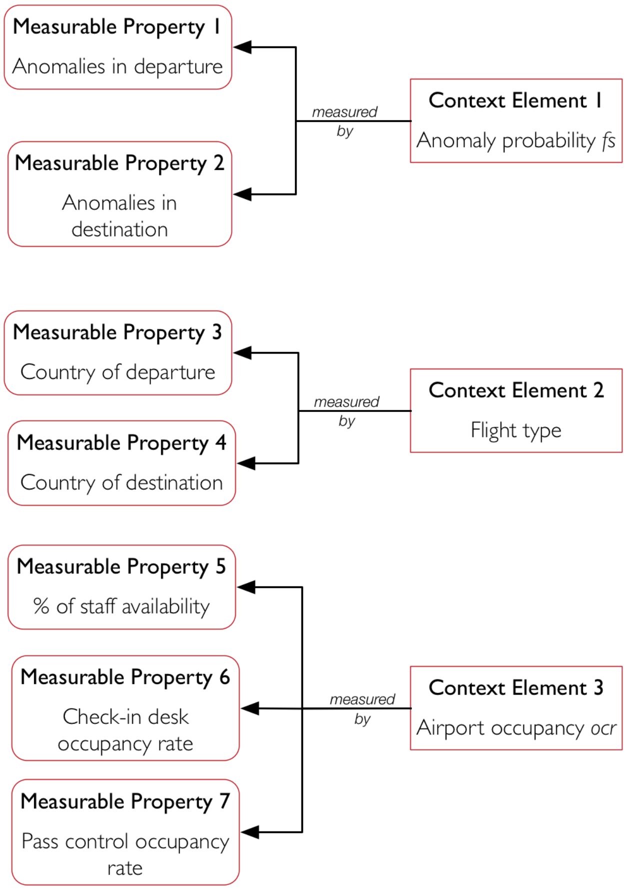


Figure A.9.: Initial context model

A *Context Element* (CE) is measured by one or more *Measurable Property* (MP). The context model including only two model elements (CE and MP) is illustrated in Figure A.9. As one can notice, not all the measurable properties are extracted from the idle gateways. For instance, to find out the value of CE "Flight type, one way is to determine the country of departure and destination of the flight.
Also the business process models can help to define the MPs. To calculate the *ocr* value (CE 3), the application needs to calculate the percentage of staff availability (MP5), check-in desk occupancy rate (MP6) and pass control occupancy rate (MP7). This can be extracted from the business process models depicted in Figure A.5.

A.5 PRACTICAL APPLICATION OF METHOD COMPONENT D

Step 1: Context Set Design

As of now, the method user has an overview of the enterprise goals, the pre-flight service that is to be designed context-aware, the business processes and the context, which is required to adapt the behaviour of the application (recommending the user what to do). To establish a connection between the aforementioned aspects, the method user defines the capability as "Dynamic Passenger Support" (see Figure A.10).

For this capability, all three context elements are relevant. The allowed values are extracted from the textual descriptions, which the method gathered and analysed in accordance with MC G (see section A.4).

There is a strong relation between the capability and the context element ranges. For example, when we further decompose the capability and express it as "Dynamic Passenger Support in High Anomaly Probability", then the Context Element Range 1 only assumes the value "high". Likewise, the capability can be defined as "Dynamic Passenger Support in International Flights", which requires assuming only "international" as the value of Context Element Range 2. It means that the context model provides ComfortFly with the required flexibility, in case they need configurations and adaptations in the application.

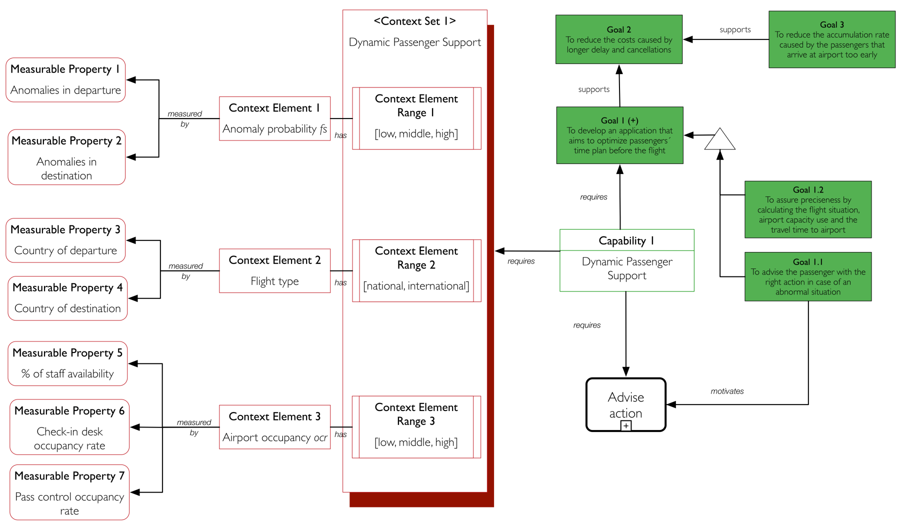


Figure A.10.: Context model including capability, as a connector of all three views

A.6 PRACTICAL APPLICATION OF METHOD COMPONENT E

Step 1: Design Binding

The method user first selects context providers. The context providers are the sources, which provide data to obtain the values of context elements by operating on the measurable properties. By monitoring the changes and calculating the values after each change, the system should be able to adapt its recommendations to the user.

In that example, the application needs to monitor the Airport Operations Management System for receiving the information on MP1, MP2 and MP7. The remaining measurable properties are taken from the ComfortFly's own ERP system.

Following that, the method user specifies mathematical operations to define the values of context elements ranges. This is illustrated in Table 38.

After that the decision logic is specified, i.e. which action should the application recommend to the user in what circumstances. In deCOM terminology, the decision logic is termed as adjustments, because the system behaviour (in that case, the recommendation) is adapted in accordance with the specified adjustments. The adjustments are shown in Table 39.

The final context model is illustrated in Figure 30. Please consider following limitations:

- We did not model all the process variants in Figure A.11 for the sake of simplicity.
- The decision logic represented in "adjustments" model element consists of the adjustments from Table 39.
- A double click on the classes "context calculation" and "adjustment" would open a Java-editor, where the exact codes of the operations can be programmed.

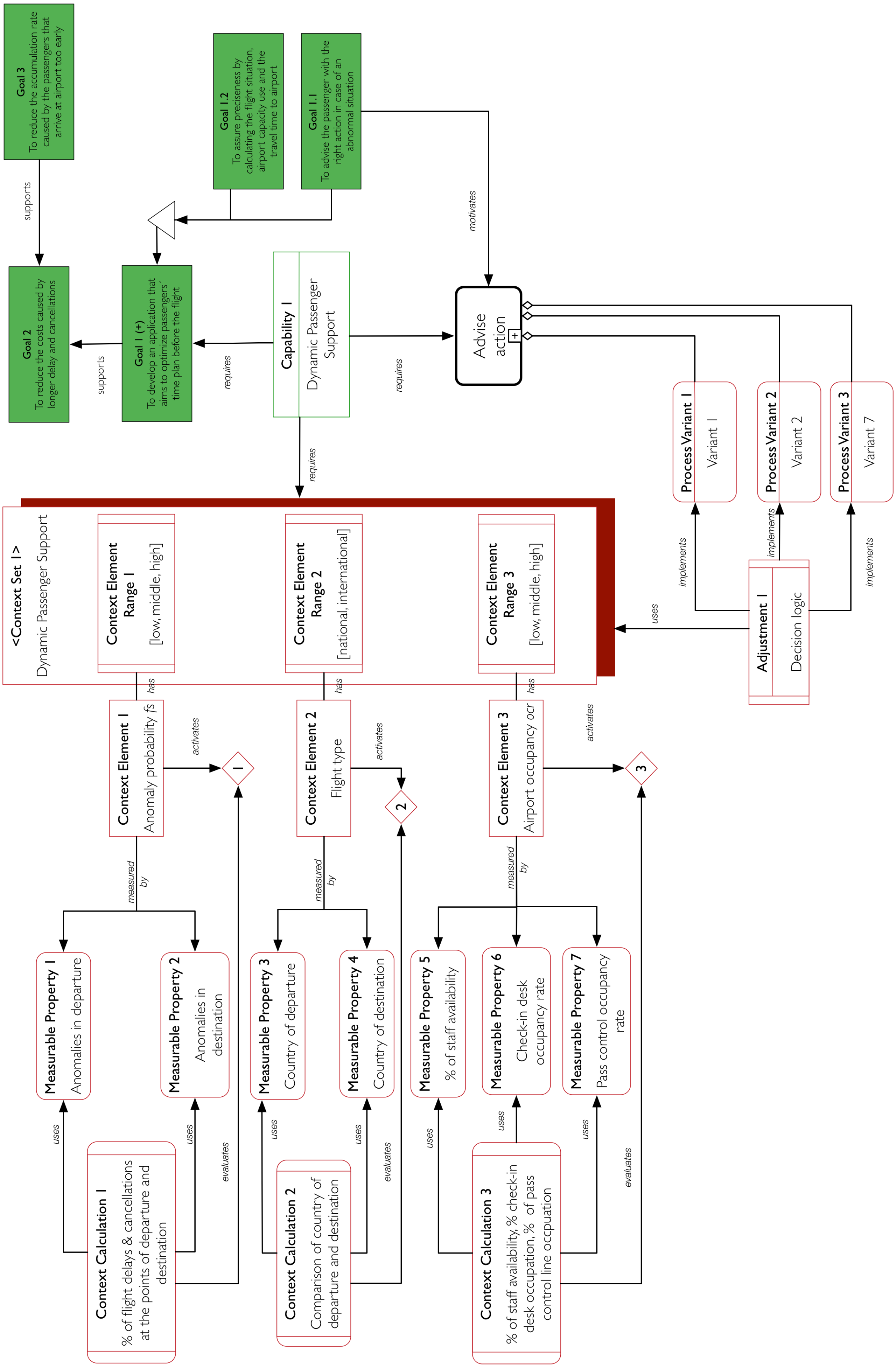


Figure A.11.: Final context model, incorporating the calculations and adjustments

Table 38.: Adding calculations to the context model

Context Element	Calculation	Obtained from	CER
CE1	1-4% of all flights are delayed or cancelled at the point of departure	MP1	Low fs
	1-4% of all flights are delayed or cancelled at the point of destination	MP2	
	5-9% of all flights are delayed or cancelled at the point of departure	MP1	Middle fs
	5-9% of all flights are delayed or cancelled at the point of destination	MP2	
	Over 10% of all flights are delayed or cancelled at the point of departure	MP1	High fs
	Over 10% of all flights are delayed or cancelled,at the point of destination	MP2	
CE2	Country of departure =/ country of destination	MP3, MP4	International
	Country of departure = country of destination	MP3, MP4	National
CE3	75-100% of staff is available	MP5	Low ocr
	50-100% of check in desks are unoccupied	MP6	
	50-100% of pass control lines are unoccupied	MP7	
	50-74% of staff is available	MP5	Low ocr
	50-100% of check in desks are unoccupied	MP6	
	50-100% of pass control lines are unoccupied	MP7	
	0-50% of staff is available (other values are disregarded in that case)	MP5	High ocr
	0-50% of check in desks are unoccupied (other values are disregarded in that case)	MP6	High ocr
	0-50% of pass control lines are unoccupied (other values are disregarded in that case)	MP7	High ocr

Table 39.: Adding adjustments to the context model

Adjustment	Process Variant
If *fs* = ″low″ AND ocr = ″low, middle″ AND flight type = ″national″	PV1
If *fs* = ″low″ AND ocr = ″high″ AND flight type = ″national″	PV2
If *fs* = ″low″ AND ocr = ″low″ AND flight type = ″international″	PV2
If *fs* = ″low″ AND ocr = ″middle, high″ AND flight type = ″international″	PV3
If *fs* = ″middle″ AND ocr = ″low″	PV2
If *fs* = ″middle″ AND ocr = ″middle″ AND flight type = ″national″	PV4
If *fs* = ″middle″ AND ocr = ″high″ AND flight type = ″national″	PV5
If *fs* = ″middle″ AND ocr = ″middle, high″ AND flight type = ″international″	PV5
If *fs* = ″high″ AND ocr = ″low″ AND flight type = ″national″	PV2
If *fs* = ″high″ AND ocr = ″middle, high″ AND flight type = ″national″	PV5
If *fs* = ″high″ AND ocr = ″middle″ AND flight type = ″international″	PV6
If *fs* = ″high″ AND ocr = ″high″ AND flight type = ″international″	PV7

B

METHOD APPLICATION: USE CASE 2

Healthcare processes require the cooperation of different organizational units and medical disciplines. In such an environment, optimal process support becomes crucial. This use case focuses on the organizational process of a radiology department with order entry & reporting and taken from [286, 287].
Healthcare procedures constitute a part of the fundamental processes of clinical practice. *Academy Healthcare* is currently updating their Workflow Management System (WFMS) to capture the organizational knowledge necessary to coordinate the healthcare process among different people and organizational units. Though these processes remain same over time, their implementation may vary depending on the patient context.

B.1 PRACTICAL APPLICATION OF METHOD COMPONENT F

As a first step, the method user investigates whether the enterprise objectives of *Academy Healthcare* are expressed clearly and whether the stakeholders follow such goals. She finds out that the company conducted a participatory goal modelling session a few months ago, which was triggered by mainly two problems:

- The communication problems between the organizational units caused that some patients were not transferred from the hospital to their home back.
- The hospital staff was not consistent whether to perform additional examinations to the patient, which does not necessarily relate to her indications (such as mammography).

After goal modelling sessions, stakeholders reached a consensus and stated the respective goals as follows (see also Figure B.1):

- To enhance the service quality by increasing patient satisfaction and consistency in the performed examinations
- To increase the support of core organizational processes between the hospital units

- To conduct additional examinations consistently
- To reduce the rate of breast and prostate cancer by early detection
- To accompany the patient before, during and after the examination stage
- To comply with current regulations, by-laws and rules

The method user finds out that the aforementioned goals of *Academy Healthcare* are modelled formally by using a notation called 4EM. Moreover, the business processes that are motivated by the goals and required for the implementation of this service are thoroughly modelled. Based on this findings, she follows the fourth path, i.e. she should apply method components **A - B (apply only Step 2) - C - (G optional) - D - E (optional)**. A fragment of Academy Healthcare's goal model is shown in Figure B.1.

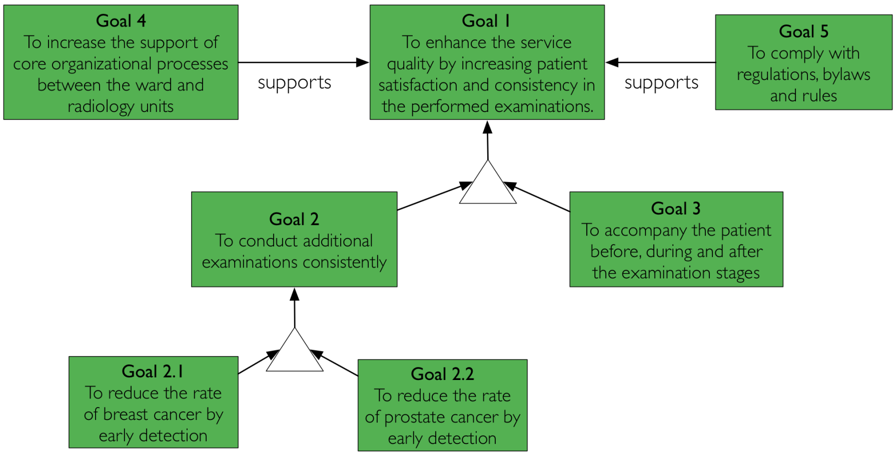


Figure B.1.: Goal model of Academy Healthcare

B.2 PRACTICAL APPLICATION OF METHOD COMPONENT A

Step 1: Scope Setting (Activity 1, Establish the project)

After a successful meeting with stakeholders, the method user defines the problems as follows:

- The processes at the hospital have to be standardized in all different branches. The existing WFMS fulfils this requirement. However, the healthcare organizational processes have to be adapted to the context of patients with specific needs. Every adaptation of the healthcare organizational process must result in a unique process variant. This may cause an exponential growth in the number of variants, considering the indications of the patient and her background. Moreover, the solution engineers have to manage and maintain the business rules expressed in the business rule engine of WFMS, it is hard to track changes for domain experts and business analysts after each configuration.

- Different roles and stakeholders participate to the design and implementation of business processes. They want to see where the changes in the generic processes happen, document it properly and have a shared understanding on different levels.
- The aforementioned problem can be alleviated by modelling the different contexts that the workflows have to adapt. However, the solution engineers at Academy Healthcare do not exactly know, what context is and which information describes patients' context.

EM is a method for developing, acquiring, and communicating enterprise knowledge and user requirements by a structured and iterative approach. A way of solving this problem is applying deCOM, a context modelling method that systematically covers the elicitation and specification of relevant context elements of any patient. By doing this graphically, they gain all the usual benefits of modelling, not least using the business context model and capabilities as a vehicle for merging differing business viewpoints quickly, and for asking the right questions. The method supports Academy Healthcare's goals represented in Figure B.1 by:

- assuring consistent and tailored performance of examinations,
- synchronization of tasks between different organizational units,
- relating variability in the workflows to configurable factors.

Moreover, it would be possible to store the resulting context model separately. The changes can be made directly in the model, without expressing additional rules in the WFMS. That such information is represented on a model level makes it easy to communicate with the stakeholders. The method engineer presents the benefits to the stakeholders. The stakeholders would like to apply the method and implement first a **prototype** of the context model in certain units of the hospital. Next step defines, which service area is selected by the method user based on the instruments provided by deCOM.

Step 1: Scope Setting (Activity 2, Select the service)

The method user analyses the services and creates the service selection matrix (see Table 40). Based on the criteria, the method user recommends developing the prototype in two areas, namely "Patient

Table 40.: Service selection matrix for Academy Healthcare Case

	Automation	Time	Flexibility	Cost
Information Services	x	x		
Patient Relations				x
Patient & Clinical Support Services	x	x	x	x
Diagnostic Services	x	x	x	x

& Clinical Support Services" and "Diagnostic Services". The stakeholders asked method user to particularly focus on the two units *"ward"* and *"radiology"*, since there has been lately a number of communication problems between the two units, which caused patient dissatisfaction.

B.3 PRACTICAL APPLICATION OF METHOD COMPONENT B

Step 1: Business Process Modelling

The method user does not need to apply Step 1 in MC B, since the interactions between the ward and radiology units are modelled prior to deCOM's application. In the following subsection (Step 2), we will introduce the business process models and their variants.

Step 2: Process Model Analysis

In its usual flow, an order is placed by a nurse or a physician at the ward. Then, the indication is checked in the radiology department and depending on the result, the order placer is informed whether the request has been rejected or scheduled. The actual radiological examination and the corresponding documentation is done in the examination room. The radiology report is generated afterwards. If necessary, some iterations for corrections are passed until the experienced radiologist can validate the report by his signature. The final report is sent back to the order placer, which is archived. We show this generic procedure in Figure B.2.
Depending on a number of drivers, this generic procedure may change. One is related to the patient's gender. There are commonly diagnosed diseases in female and male patients. According to the statistics, about 12% of U.S. women will develop invasive breast cancer over the course of her lifetime, which is the second most diag-

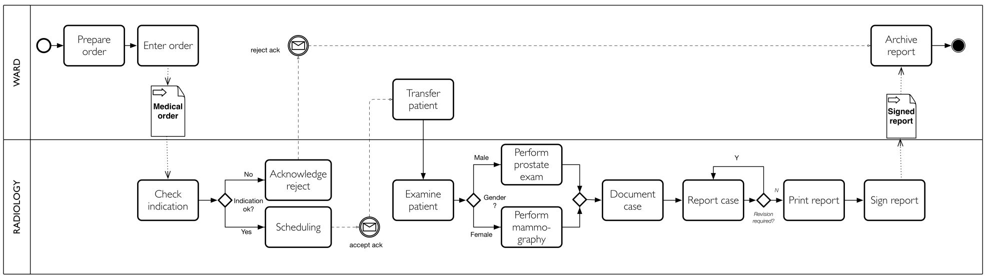


Figure B.2.: Generic procedure of patient treatment

nosed cancer among American woman[1]. Mammography is a specific type of breast imaging that uses low-dose x-rays to detect cancer early before women experience symptoms when it is most treatable[2]. A mammography exam, called a mammogram, aids in the early detection and diagnosis of breast diseases in women. Academy Healthcare is aware of this fact and the WFMS generates the task "Perform mammography exam", in case the patient is female (see Figure B.3).
Prostate cancer is the most common cancer among men, except for skin cancer[3]. Approximately 14.0 percent of men will be diagnosed with prostate cancer at some point during their lifetime, based on 2010-2012 data[4]. Likewise, the WFMS generates the task "Perform prostate examination", if the accepted patient is male. Both cases are depicted in Figure B.3. Note that regardless of the indications, these tests have to be performed.

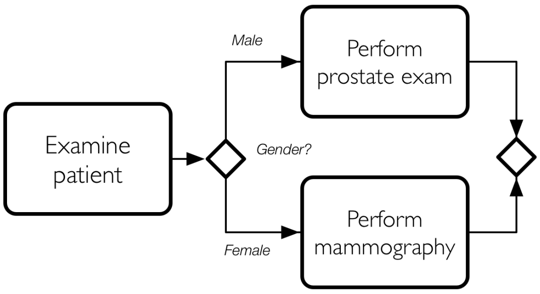


Figure B.3.: A fragment for execution of the gender-based processes

The next change driver is patient's disability. Handling patients with disabilities requires the adaptation of the generic process model. Here, the selection of the right variant depends on the following information:

- The healthcare organization handles the case of a blind patient, which requires escorting the patient in and out of the radiology

1 http://www.breastcancer.org/symptoms/understand_bc/statistics, Last Retrieved 12.12.2016
2 http://www.radiologyinfo.org/en/info.cfm?pg=mammo, Last Retrieved 12.12.2016
3 http://www.cancer.net/cancer-types/prostate-cancer/statistics, Last Retrieved 12.12.2016
4 http://seer.cancer.gov/statfacts/html/prost.html, Last Retrieved 12.12.2016

department. Moreover, in case of a patient treatment with disability, *Academy Healthcare* has to check the patient's age after order entry. If the patient is under 18, the treatment is rejected and the patient is sent to another facility. This is due to a lately promulgated regulation, to which *Academy Healthcare* does not entirely comply. The process of blind patient treatment is illustrated in Figure B.4.

- The healthcare organization handles the case of a paralysed patient, which requires the scheduling and getting the patient with an ambulance at the ward department, and assisting the patient throughout the medical examination at the radiology department. The age restriction applies to such cases as well. The treatment of a paralysed patient is represented in Figure B.5.

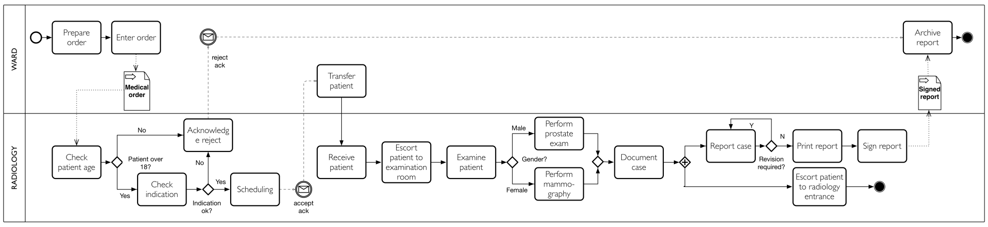


Figure B.4.: Treatment of a blind patient

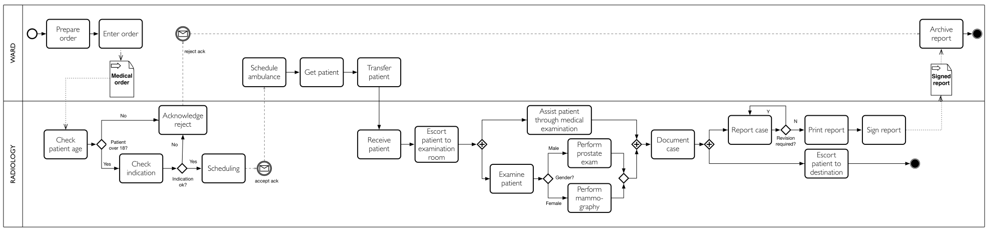


Figure B.5.: Treatment of a paralysed patient

In line with Guideline 5 and Guideline 6 the method user investigates the consolidated business process model (cf. Figure B.6, Figure B.7, Figure B.8)[5] and identifies the following gateways (also numbered in Figures):

1. Checking, whether the patient is disabled
2. Checking the patient's age
3. Checking the indication
4. Checking, whether the patient is paralysed

5 The consolidated process model is divided into three parts for a better readability.

5. Checking the type of disability
6. Checking the gender
7. Checking, whether a revision is required

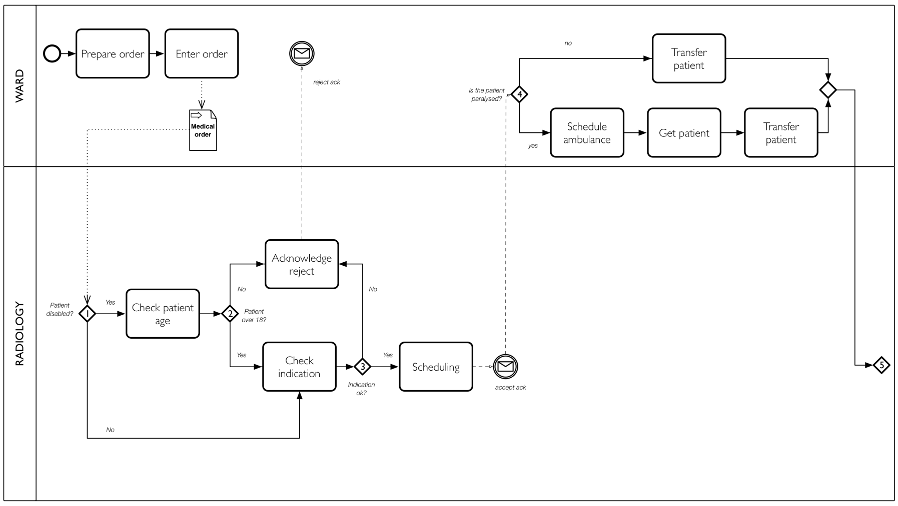


Figure B.6.: Consolidated view of Academy Healthcare processes, Part I (continued in the next figure)

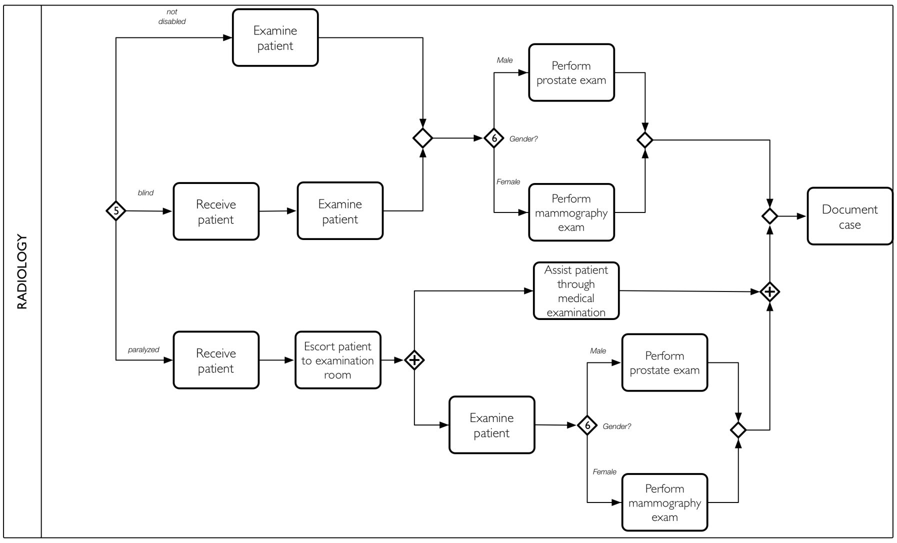


Figure B.7.: Consolidated view of Academy Healthcare processes, Part II (continued in the next figure)

Table 41 documents the identified gateways with the respective condition expressions (which are also numbered in Figure B.6, Figure B.7, Figure B.8).
As deCOM states, the only way to identify variability is not the analysis of gateways, but also of the business process models as a whole and understand their rationale. The method user observes that there

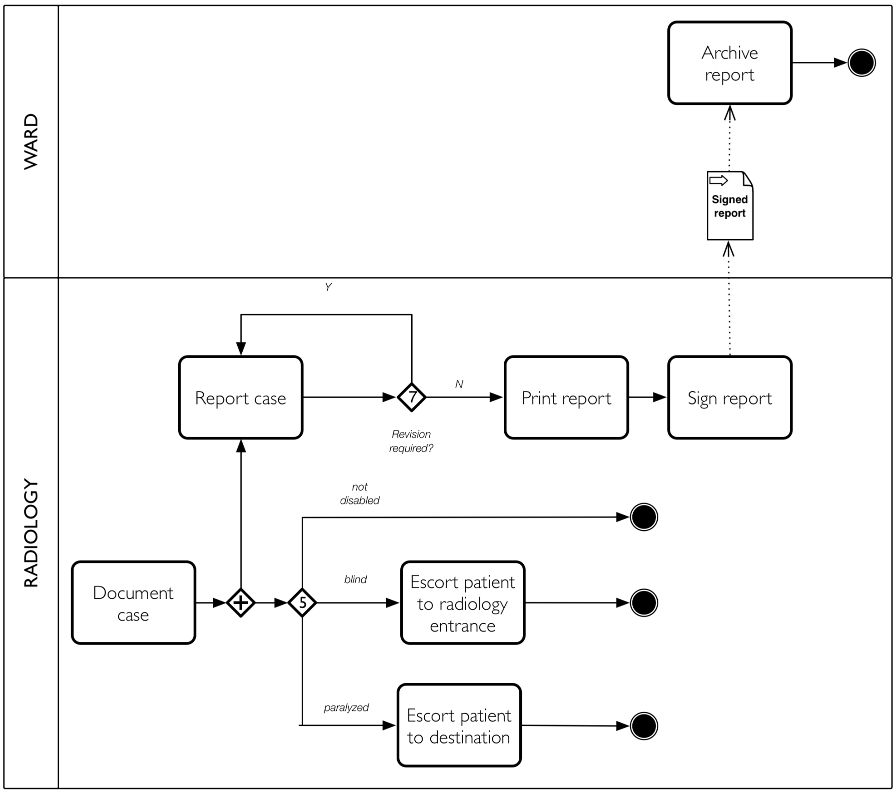


Figure B.8.: Consolidated view of Academy Healthcare processes, Part III

are deviations from the generic procedure (so called *process variants*). For instance, if the patient is blind, apart from checking her age, the radiology unit has to receive the patient and escort her to the examination room. After the examination, the patient will again be escorted to radiology entrance. The method user collects the process variants (PV) as depicted in Figure B.9 and proceeds to the next step.

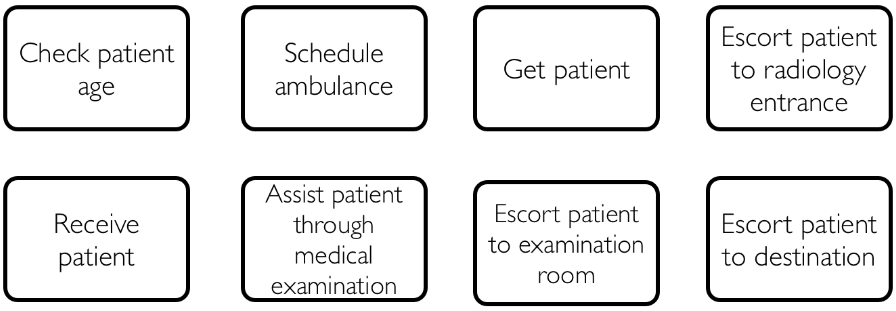


Figure B.9.: Tasks that may be added to the generic process

Table 41.: Capturing the gateways in Academy Healthcare case

Gateway	Condition
GW1	Patient disabled?
GW2	Patient over 18?
GW3	Indication ok?
GW4	Patient paralysed?
GW5	Type of disability?
GW6	Patient male or female?
GW7	Is revision necessary?
GW8	Identical to GW5, hence denoted same in Figure B.8

B.4 PRACTICAL APPLICATION OF METHOD COMPONENT C

Step 1: Context Element Elicitation (MC C)

The method engineer uses the list of gateways (see Table 41) as input. First, she analyses the gateways, i.e. for each gateway, she documents why they exist and why they are needed. To document this, she extends the table with the column "gateway analysis". Second, she extracts the main factors from the analysis and adds the column "factor". Last, she investigates the influence of the factors to goal fulfilment and adds a column "goal influence" to the table (see Table 42).

Next, she analyses the dependency between the gateways, which are evaluated with "Strong" in the goal fulfilment column. The result is depicted in Figure B.10.

There are the factors, which do not contribute to goal fulfilment, or only indirect. These are not idle. In line with Guideline 8, they can be used when defining he measurable properties or context element ranges. Figure B.10 shows the dependency analysis between variation points.

The gateways, which affect the goals after they are resolved are renamed as variation points[6]. Variation points will help us to establish the connection between the context elements and important gateways in the context model (Table 43). Please note that different gateways maybe represented by the same variation point, when the gateways are identical. An example is shown with GW5 and GW8, which are represented by VP3 as their evaluation causes the execution of same paths.

6 Note that the GW8 was deliberately not removed from the variation points table. The aim here is to show, how the method forces the elimination of identical gateways during their renaming to variation points.

Table 42.: Identifying and analysing factors causing variability in Academy Healthcare case

Gateway	Condition	Gateway Analysis	Factor	Goal Influence
GW1	Patient disabled?	*Academy Healthcare* has to check the patients age after order entry, if the patient is disabled. This is due to a regulatory requirement, which the enterprise currently cannot entirely fulfil	Patient age for regulatory compliance	Strong
GW2	Patient over 18?	The gateway is evaluated only then, when the patient is disabled	GW1	Strong
GW3	Indication ok?	The patient is rejected, if the indication is not ok. Any health-care institution is supposed to ”*check the indications*” of a patient, which is a standard procedure	Standard process	Weak
GW4	Patient paralysed?	If the patient is paralysed, then two additional tasks (schedule ambulance, get patient) are added to the workflow, before transferring her	Paralysed patient’s treatment	Strong
GW5	Type of disability?	To implement the exact patient treatment workflow, the system has to know the patient disability. The WFMS distinguishes between the blind and paralysed patients as well as the patients that are not disabled. The system obtains the this information from the ”Condition” field in the medical order mask during ”enter order” activity	Varying treatment based on patients condition	Strong
GW6	Patient male or female?	The gender of the patient influences the additional examinations during the radiology process, i.e. regardless of the accepted indications; either a mammography exam or a prostate exam will be conducted	Patient’s gender	Strong
GW7	Is revision necessary?	In any hospital, for each reported case, *a revision* has to be performed before printing the report	Standard process	Weak
GW8	Identical to GW5	Identical to GW5	Identical to GW5	Identical to GW5

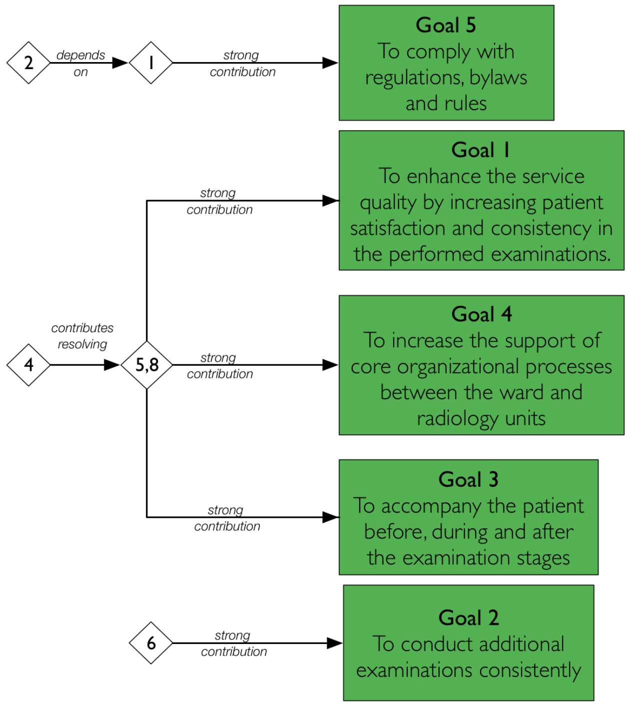


Figure B.10.: Dependency analysis between gateways

Table 43.: Renaming the gateways as variation points

Gateway	Condition
GW1	VP1
GW5	VP3
GW6	VP2
GW8	VP3

Step 2: Context Element Design

The factors causing variability in business processes are analysed and discussed with domain experts thoroughly (see Table 41). As a result, the factors that has a strong and direct influence on goals are modelled as context elements. The remaining factors are not "idle", i.e. they are typical candidates for defining the permitted values of a context element *(Context Element Ranges)* or specify the properties of a context element which helps to measure its value *(Measurable Property)*. The initial context model with two model elements *CE* and *MP* is depicted in Figure B.11.

B.5 PRACTICAL APPLICATION OF METHOD COMPONENT D

Step 1: Context Set Design

By reaching this step, the method user has an overview of the enterprise goals, the communication between ward and radiology units,

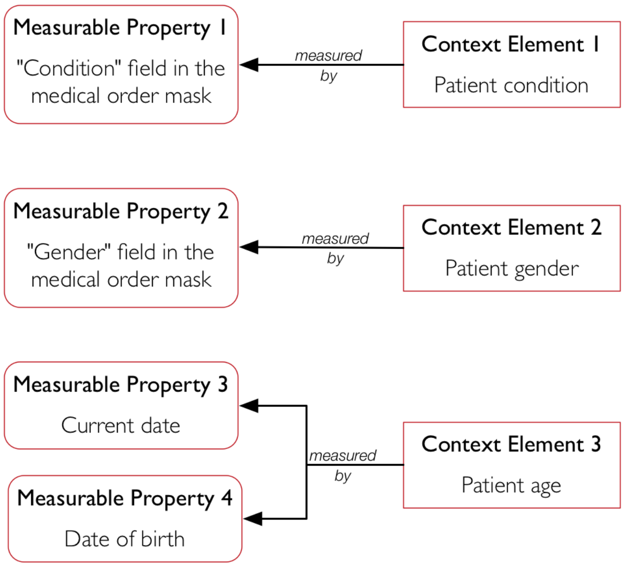


Figure B.11.: Initial context model, including CEs and MPs

the business process that have to be executed as well as its various contexts, which is required to adapt the behaviour of WFMS. To establish a connection between the aforementioned aspects, the method user defines the capability as "Configurable Patient Treatment in Radiology".

For this capability, all three context elements are relevant. Their values are extracted from the process descriptions and business process models. The resulting model is depicted in Figure B.12.

The description of the capability determines which context elements and which context element ranges are relevant. For instance, when one designs a capability "Disabled Patient Treatment in Radiology", then Context Element Range 1 in Figure B.12 would assume the values [blind, paralysed]". Likewise, one can define a capability "Male Patient Treatment", which requires removing Context Element 2 and its ranges.

B.6 PRACTICAL APPLICATION OF METHOD COMPONENT E

Step 1: Design Binding

The method user first selects the context providers. The context providers are the sources, which provide data to obtain the values of context elements by calculating the measurable properties. In that example, the application needs to monitor the WFMS for receiving information about the measurable properties. Following that, the method user specifies mathematical operations to define the values of context elements ranges. This is illustrated in Table 44.

After the decision logic is specified, i.e. which tasks (process variants) should the WFMS implement in what circumstances. In deCOM ter-

Table 44.: Adding calculations to the context model in Academy Healthcare case

Context Element	Calculation	Obtained from	CER
CE1	Condition = blind	MP1	blind
	Condition = paralysed	MP1	paralysed
	Condition = ""	MP1	none
CE2	Patient gender = male	MP2	male
	Patient gender = female	MP2	female
CE3	Current date - Date of birth	MP3, MP4	In range, if calculation result >18

minology, the decision logic is termed as *adjustments*, because the system behaviour (in that case, the implementation of right process variant) is adapted in accordance with the specified adjustments. The adjustments are shown in Table 45[7].

Table 45.: Adding adjustments to the Academy Healthcare's context model

Adjustment	Process Variant
If *patient condition* = "none" AND *patient gender*= "male"	PV1
If *patient condition* = "none" AND *patient gender*= "female"	PV2
If *patient condition* = "blind" AND *patient gender*= "male" AND *patient age* >18	PV3
If *patient condition* = "blind" AND *patient gender*= "female" AND *patient age* >18	PV4
If *patient condition* = "paralysed" AND *patient gender*= "male" AND *patient age* >18	PV5
If *patient condition* = "paralysed" AND *patient gender*= "female" AND *patient age* >18	PV6
If *patient condition* = "paralysed, blind" AND *patient age* <18	PV7

The final context model is illustrated in Figure B.13. Please consider following limitations:

- We did not model in Figure B.13 all the process variants for the sake of simplicity.
- The decision logic represented in *adjustments* model element consists of the adjustments from Table 45.

7 For a better illustration, we recommend the user to download the respective variants of the business process models from this link https://drive.google.com/open?id=0B_qy9WuXXyDiWEZ6TVlsNHdIQzA

- A double click on the classes "calculation" and "adjustment" would open a Java-editor, where the exact codes of the operations can be programmed.

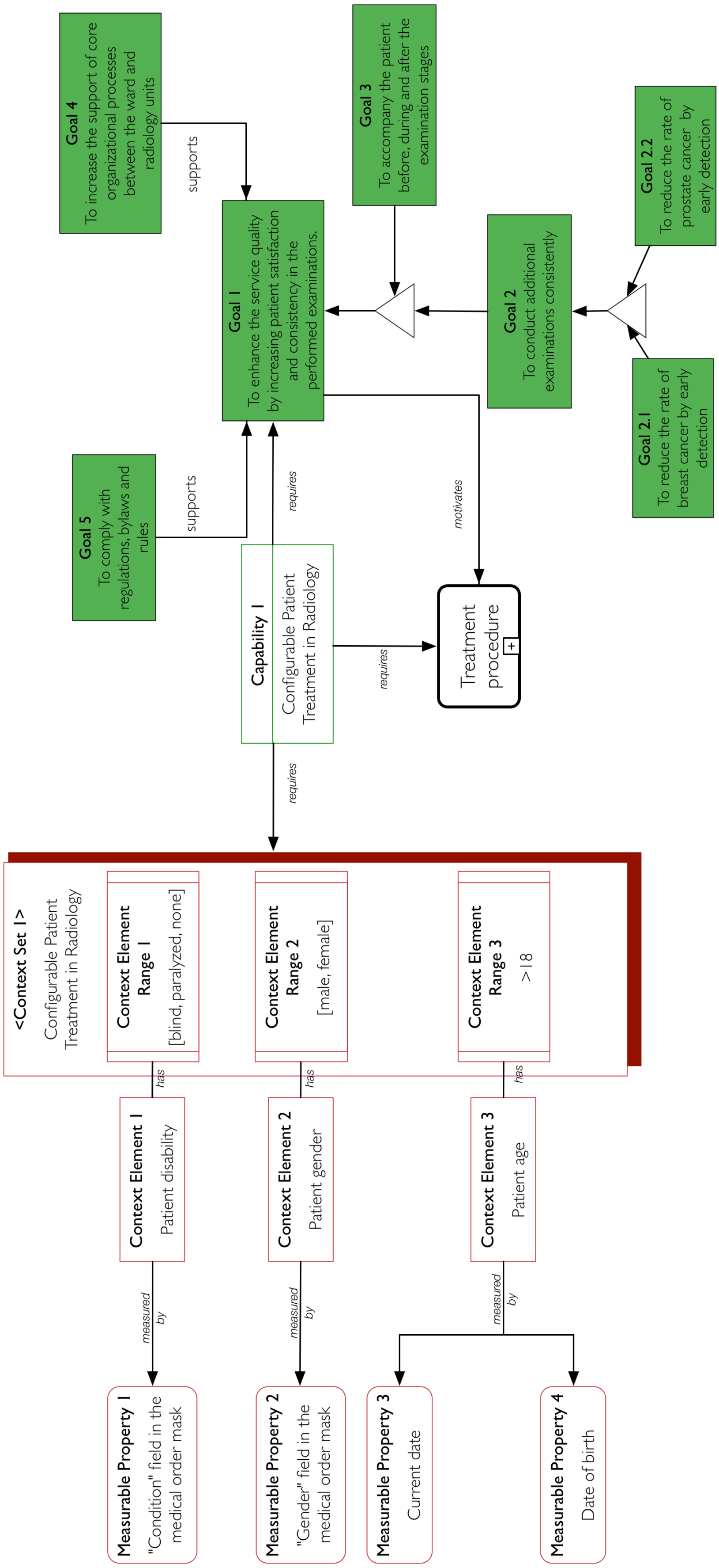


Figure B.12.: Context model including capability, as a connector of all three views

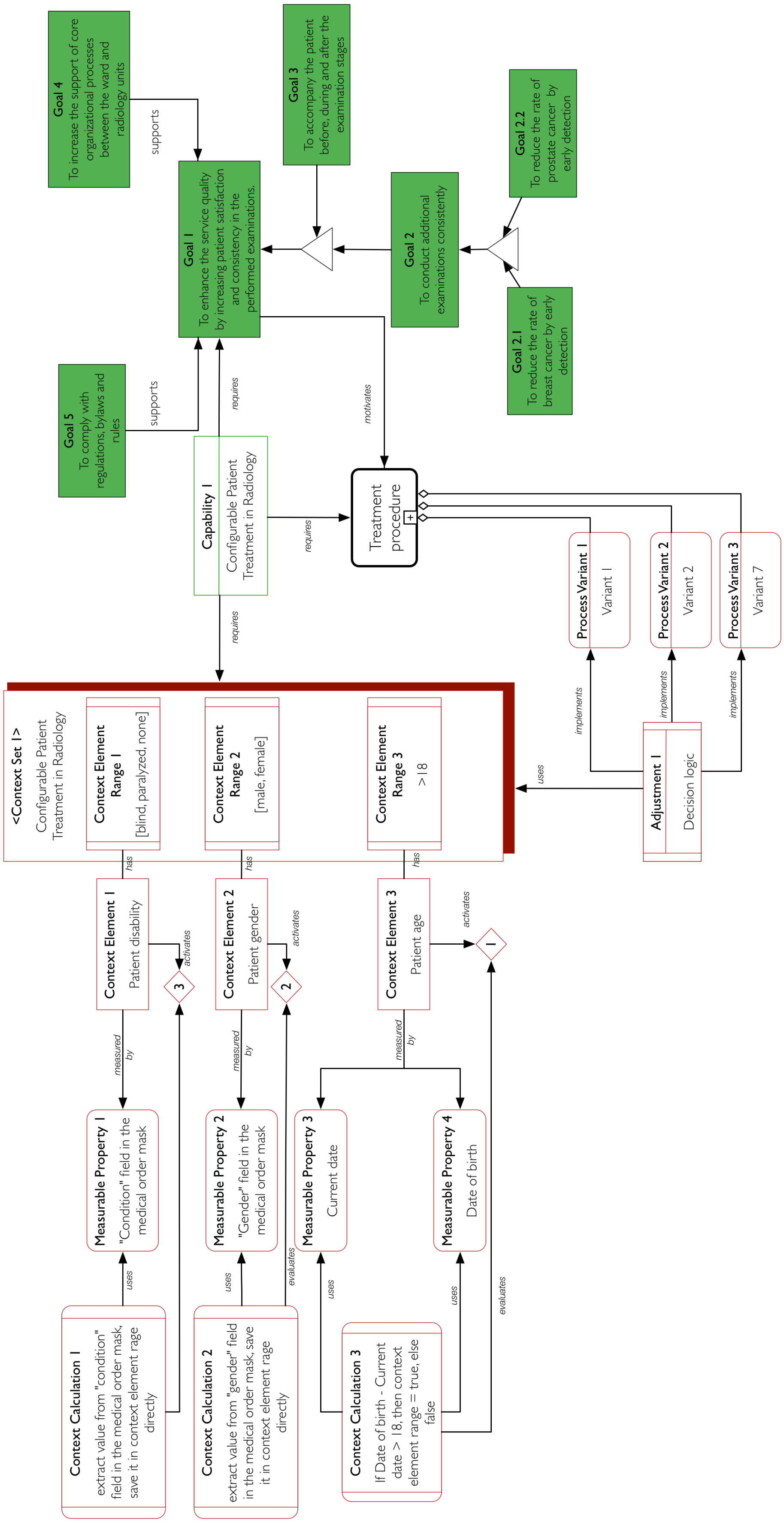


Figure B.13.: The final context model of Academy Healthcare case

C

SELECTED LIST OF PUBLICATIONS: SLR IN CONTEXT MODELLING METHODS

Table 46.: Analysed publications during the SLR for context modelling methods

Code	Title	Authors	Type	Name	Year
P1	Context-based modelling of information demand: approaches from information logistics and decision support	Levashova, T Lundqvist, M Sandkuhl, K Smirnov, A	Conference	European Conference on Information Systems	2006
P2	Conceptualizing Context For Adaptive Pervasive Commerce	Bauer, C Spiekermann, S	Conference	European Conference on Information Systems	2011
P3	Challenges in the context-aware management of business processes: A multiple case study	Ploesser, K Recker, J Rosemann, M	Conference	European Conference on Information Systems	2011
P4	Building a Methodology for Context-Aware Business Processes: Insights from an Exploratory Case Study	Ploesser, K. Recker, J, Rosemann, M.	Conference	European Conference on Information Systems	2010
P5	Automated Planning of context-aware Process Models	Heinrich, B Schn, D	Conference	European Conference on Information Systems	2015
P6	Business processes contextualisation via context analysis	De La Vara, J.L Ali, R Dalpiaz, F Snchez, J Giorgini, P	Conference	International Conference on Conceptual Modeling	2010
P7	Modeling Domain Variability in Requirements Engineering with Contexts	Lapouchnian, A Mylopoulos, J	Conference	International Conference on Conceptual Modeling	2009
IT1B1	Context change archetypes: Understanding the impact of context change on business processes	Ploesser, K Janiesch, C Recker, J Rosemann, M	Conference	Australasian Conference on Information Systems	2009
IT1B2	Supporting context-aware process design: Learnings from a design science study	Ploesser, K Recker, J Rosemann, M	Conference	BPM Workshops	2010
IT1B3	Contextualisation of business processes	Rosemann, M Recker, J Flender, C	Journal	International Journal of Business Process Integration and Management	2008
IT1B4	Context-based configuration of process variants	Hallerbach, A Bauer, T Reichert, M	Conference	International Workshop Technol. Context-Aware Bus. Process Manage. - TCoB, ICEIS 2008	2008
IT1B5	Capturing variability in business process models	Hallerbach, A Bauer, T Reichert, M	Journal	Journal of Software Maintenance and Evolution: Research and Practice	2010
IT1B6	A Goal-based Framework for Contextual Requirements Modeling and Analysis	Ali, R Dalpiaz, F Giorgini, P	Journal	Requirements Engieneering	2010
IT1F1	How to Identify the Relevant Elements of Context in Context-Aware Information Systems?	Sandkuhl, K Borchardt, U	Conference	International Conference on Perspectives in Business Informatics Research	2014
IT1F2	Towards a generic context model for BPM	Saidani, O Rolland, C Nurcan, S	Conference	Hawaii International Conference on System Sciences	2015
IT1F3	Conceptualisation of Contextual Factors for Business Process Performance	Kronsbein, D Meiser, D Leyer, M	Conference	International MultiConference of Engineers and Computer Scientists.	2013
IT1F4	COMPRO: A methodological approach for business process contextualisation.	de La Vara, J.L Ali, R Dalpiaz, F Sanchez, J Giorgini, P	Conference	On the Move to Meaningful Internet Systems	2010
IT1F5	Eliciting contextual requirements at design time: A case study	Knauss, A Damian, D Schneider, K	Conference	International Workshop on Empirical Requirements Engineering	2014
IT2F1	The quest for organizational flexibility: driving changes in business processes through the identification of relevant context.	Anastassiu, M Santoro, F.M Recker, J Rosemann, M	Journal	Business Process Management Journal	2016
IT2F2	Dynamic process adaptation: A context-aware approach	Tavares, N.V Werner, C.M.L Santoro, F.M.	Conference	Computer Supported Cooperative Work in Design	2011
IT2F3	Process Improvement Based on External Knowledge Context."	Eduardo, R Santoro, F.M. Baiao, F	Conference	Australasian Conference on Information Systems	2010
IT2F4	Towards a context-aware analysis of business process performance.	Leyer, M	Conference	Pacific Asia Conference of Information Systems	2011
IT3B1	A Methodology for Designing and Managing Context-Aware Workflows.	Modafferi, S Benatallah, B Casati, F Pernici, B	Conference	Mobile Information Systems II	2005
IT3B2	Towards a Methodology for Context Sensitive Systems Development	Ben Mena, T Saoud, N.B Ahmed, M.B Pavard, B	Conference	CONTEXT	2007
IT4B1	Making Workflows Context-aware: A Way to Support Knowledge-intensive Tasks	Heravizadeh, M Edmond, D	Conference	Asia-Pacific Conference on Conceptual Modelling	2008

D

6TH EVALUATION CYCLE: QUESTIONNAIRE AND SURVEY RESULTS

D.1 QUESTIONNAIRE

EvaSys	Digital Enterprise Context Modelling Method	Electric Paper

Bitte so markieren:	☐ ☒ ☐ ☐ ☐	Bitte verwenden Sie einen Kugelschreiber oder nicht zu starken Filzstift. Dieser Fragebogen wird maschinell erfasst.
Korrektur:	☐ ■ ☐ ☒ ☐	Bitte beachten Sie im Interesse einer optimalen Datenerfassung die links gegebenen Hinweise beim Ausfüllen.

1. Understandability

Methods are systematic ways of problem solving and they inform the users about the actions to be performed as well as their order.

In this section, we kindly ask you to answer the questions regarding the understandability of deCOM, i.e. whether the method components, procedures and concepts are comprehensible.

The questions are scaled from **1 (I totally disagree)** to **5 (I totally agree)**.

			1	2	3	4	5	
1.1	deCOM explains the actions to be performed as well as their order in a comprehensible way.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.2	The relationship between the method components in deCOM are clearly shown.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.3	The component-oriented structure of deCOM helped me to understand the method better.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.4	I had problems regarding the understandability of the method.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.5	deCOM explains the important concepts unambiguously.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.6	The meta-model provided by deCOM helped me to understand the method better.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.7	The guidelines provided by deCOM helped me to understand the method.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.8	I think it is hard to learn deCOM.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
1.9	The examples in the method handbook helped me to understand deCOM.	I totally disagree	☐	☐	☐	☐	☐	I totally agree

2. Ease of Use

In this section, we kindly ask you to answer the questions regarding deCOM´s ease of use, i.e. whether it is flexible and applied with rather less effort.

The questions are scaled from 1 **(I totally disagree)** to **5 (I totally agree)**.

			1	2	3	4	5	
2.1	deCOM is easy to use since it informs the method user what step to take next.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
2.2	Due to its complexity, it was difficult to apply deCOM to the homework assignment.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
2.3	After attending the workshops and reading the method handbook, I feel competent to use the method in further use cases.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
2.4	I believe the method is flexible, i.e. it can be adopted according to the information set prior to the context modeling task.	I totally disagree	☐	☐	☐	☐	☐	I totally agree

MUSTER

2. Ease of Use [Fortsetzung]

			1	2	3	4	5	
2.5	Overall, I think deCOM is easy to use.	I totally disagree	☐	☐	☐	☐	☐	I totally agree

3. Usefulness

In this section, we kindly ask you to evaluate how useful deCOM is, i.e. whether it makes sense to perform it in industrial settings to identify contextual factors of a digital service provision.

The questions are scaled from **1 (I totally disagree)** to **5 (I totally agree)**.

			1	2	3	4	5	
3.1	Using deCOM would make it easy to communicate contextual influences of a digital service with related stakeholders.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
3.2	If I need to model business context in the future, I intend to use deCOM.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
3.3	Because of its component based structure, I believe deCOM is easy to maintain.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
3.4	Overall, I find deCOM helpful to model business context.	I totally disagree	☐	☐	☐	☐	☐	I totally agree
3.5	Overall, I think deCOM provides an effective solution for analyzing contextual influence in a digital service.	I totally disagree	☐	☐	☐	☐	☐	I totally agree

D.2 Survey results

Benjamin Siegler

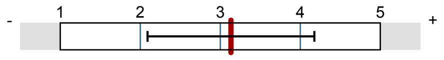
deCOM ()
Erfasste Fragebögen = 12

Globalwerte

1. Understandability

mw=3,4
s=1,1

2. Ease of Use

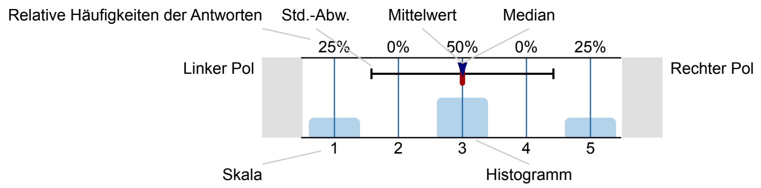


mw=3,1
s=1

Auswertungsteil der geschlossenen Fragen

Legende

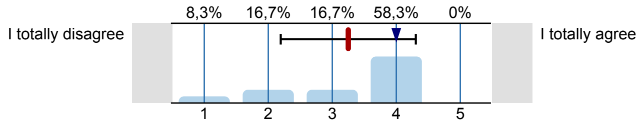
Fragetext



n=Anzahl
mw=Mittelwert
md=Median
s=Std.-Abw.
E.=Enthaltung

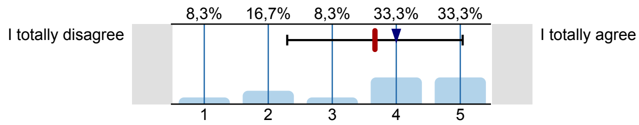
1. Understandability

1.1) deCOM explains the actions to be performed as well as their order in a comprehensible way.



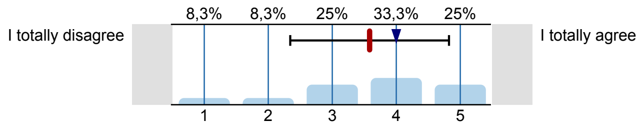
n=12
mw=3,3
md=4
s=1,1

1.2) The relationship between the method components in deCOM are clearly shown.



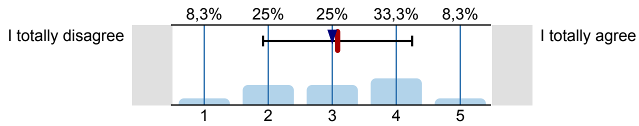
n=12
mw=3,7
md=4
s=1,4

1.3) The component-oriented structure of deCOM helped me to understand the method better.



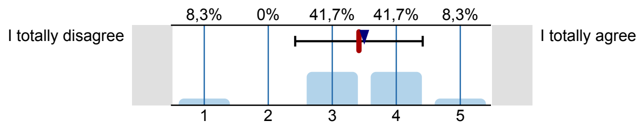
n=12
mw=3,6
md=4
s=1,2

1.4) I had problems regarding the understandability of the method.



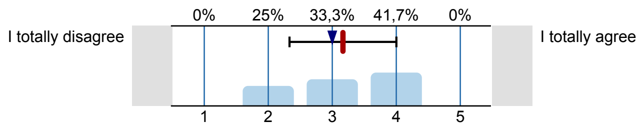
n=12
mw=3,1
md=3
s=1,2

1.5) deCOM explains the important concepts unambiguously.



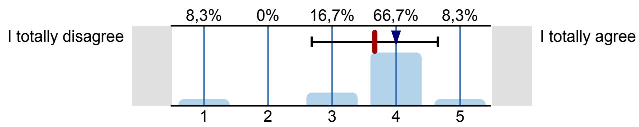
n=12
mw=3,4
md=3,5
s=1

1.6) The meta-model provided by deCOM helped me to understand the method better.



n=12
mw=3,2
md=3
s=0,8

1.7) The guidelines provided by deCOM helped me to understand the method.



n=12
mw=3,7
md=4
s=1

1.8) I think it is hard to learn deCOM.

	1	2	3	4	5	
I totally disagree	0%	33,3%	33,3%	16,7%	16,7%	I totally agree

n=12
mw=3,2
md=3
s=1,1

1.9) The examples in the method handbook helped me to understand deCOM.

	1	2	3	4	5	
I totally disagree	0%	0%	25%	50%	25%	I totally agree

n=12
mw=4
md=4
s=0,7

2. Ease of Use

2.1) deCOM is easy to use since it informs the method user what step to take next.

	1	2	3	4	5	
I totally disagree	0%	25%	41,7%	16,7%	16,7%	I totally agree

n=12
mw=3,3
md=3
s=1,1

2.2) Due to its complexity, it was difficult to apply deCOM to the homework assignment.

	1	2	3	4	5	
I totally disagree	0%	25%	16,7%	33,3%	25%	I totally agree

n=12
mw=3,6
md=4
s=1,2

2.3) After attending the workshops and reading the method handbook, I feel competent to use the method in further use cases.

	1	2	3	4	5	
I totally disagree	8,3%	16,7%	41,7%	33,3%	0%	I totally agree

n=12
mw=3
md=3
s=1

2.4) I believe the method is flexible, i.e. it can be adopted according to the information set prior to the context modeling task.

	1	2	3	4	5	
I totally disagree	8,3%	16,7%	25%	41,7%	8,3%	I totally agree

n=12
mw=3,3
md=3,5
s=1,1

2.5) Overall, I think deCOM is easy to use.

	1	2	3	4	5	
I totally disagree	8,3%	41,7%	33,3%	16,7%	0%	I totally agree

n=12
mw=2,6
md=2,5
s=0,9

3. Usefulness

3.1) Using deCOM would make it easy to communicate contextual influences of a digital service with related stakeholders.

	1	2	3	4	5	
I totally disagree	9,1%	0%	27,3%	54,5%	9,1%	I totally agree

n=11
mw=3,5
md=4
s=1

3.2) If I need to model business context in the future, I intend to use deCOM.

	1	2	3	4	5	
I totally disagree	25%	25%	41,7%	0%	8,3%	I totally agree

n=12
mw=2,4
md=2,5
s=1,2

3.3) Because of its component based structure, I believe deCOM is easy to maintain.

	1	2	3	4	5	
I totally disagree	0%	8,3%	41,7%	33,3%	16,7%	I totally agree

n=12
mw=3,6
md=3,5
s=0,9

3.4) Overall, I find deCOM helpful to model business context.

	1	2	3	4	5	
I totally disagree	16,7%	0%	25%	50%	8,3%	I totally agree

n=12
mw=3,3
md=4
s=1,2

3.5) Overall, I think deCOM provides an effective solution for analyzing contextual influence in a digital service.

	1	2	3	4	5	
I totally disagree	8,3%	8,3%	58,3%	16,7%	8,3%	I totally agree

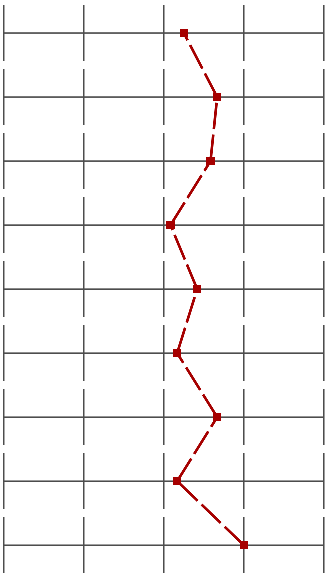
n=12
mw=3,1
md=3
s=1

Profillinie

Teilbereich: Fachschaften
Name der/des Lehrenden: Benjamin Siegler
Titel der Lehrveranstaltung: (Name der Umfrage) deCOM

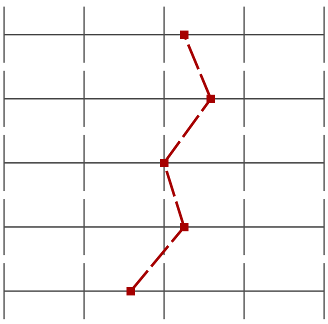
Verwendete Werte in der Profillinie: Mittelwert

1. Understandability



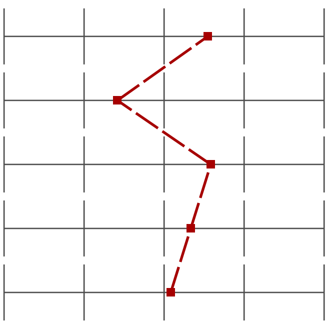
1.1)	deCOM explains the actions to be performed as well as their order in a comprehensible way.	I totally disagree	I totally agree	n=12 mw=3,3 md=4,0 s=1,1
1.2)	The relationship between the method components in deCOM are clearly shown.	I totally disagree	I totally agree	n=12 mw=3,7 md=4,0 s=1,4
1.3)	The component-oriented structure of deCOM helped me to understand the method better.	I totally disagree	I totally agree	n=12 mw=3,6 md=4,0 s=1,2
1.4)	I had problems regarding the understandability of the method.	I totally disagree	I totally agree	n=12 mw=3,1 md=3,0 s=1,2
1.5)	deCOM explains the important concepts unambiguously.	I totally disagree	I totally agree	n=12 mw=3,4 md=3,5 s=1,0
1.6)	The meta-model provided by deCOM helped me to understand the method better.	I totally disagree	I totally agree	n=12 mw=3,2 md=3,0 s=0,8
1.7)	The guidelines provided by deCOM helped me to understand the method.	I totally disagree	I totally agree	n=12 mw=3,7 md=4,0 s=1,0
1.8)	I think it is hard to learn deCOM.	I totally disagree	I totally agree	n=12 mw=3,2 md=3,0 s=1,1
1.9)	The examples in the method handbook helped me to understand deCOM.	I totally disagree	I totally agree	n=12 mw=4,0 md=4,0 s=0,7

2. Ease of Use



2.1)	deCOM is easy to use since it informs the method user what step to take next.	I totally disagree	I totally agree	n=12 mw=3,3 md=3,0 s=1,1
2.2)	Due to its complexity, it was difficult to apply deCOM to the homework assignment.	I totally disagree	I totally agree	n=12 mw=3,6 md=4,0 s=1,2
2.3)	After attending the workshops and reading the method handbook, I feel competent to use the method in further use cases.	I totally disagree	I totally agree	n=12 mw=3,0 md=3,0 s=1,0
2.4)	I believe the method is flexible, i.e. it can be adopted according to the information set prior to the context modeling task.	I totally disagree	I totally agree	n=12 mw=3,3 md=3,5 s=1,1
2.5)	Overall, I think deCOM is easy to use.	I totally disagree	I totally agree	n=12 mw=2,6 md=2,5 s=0,9

3. Usefulness



3.1)	Using deCOM would make it easy to communicate contextual influences of a digital service with related stakeholders.	I totally disagree	I totally agree	n=11 mw=3,5 md=4,0 s=1,0
3.2)	If I need to model business context in the future, I intend to use deCOM.	I totally disagree	I totally agree	n=12 mw=2,4 md=2,5 s=1,2
3.3)	Because of its component based structure, I believe deCOM is easy to maintain.	I totally disagree	I totally agree	n=12 mw=3,6 md=3,5 s=0,9
3.4)	Overall, I find deCOM helpful to model business context.	I totally disagree	I totally agree	n=12 mw=3,3 md=4,0 s=1,2
3.5)	Overall, I think deCOM provides an effective solution for analyzing contextual influence in a digital service.	I totally disagree	I totally agree	n=12 mw=3,1 md=3,0 s=1,0

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RESULTS

1. We are living in an economy which is characterised by rapid change and digitalization. The technological advances and the increasing globalisation of the economy require in many areas high adaptability of enterprises.

2. In order to improve their chances of success, enterprises need to cope with the challenges caused by today's dynamic markets. This requires a constant adaptation of service/ product offerings to gain competitiveness.

3. Enterprises adopt IS to improve their effectiveness in achieving goals, and are computerised with the purpose of increasing the efficiency of the work practice. Due to the intrinsic relationship between an enterprise, its ecosystems, and its IT, the aforementioned adaptation concerns not only organizational structures but also the IT supporting their service/ product design and delivery.

4. Since it is not possible to tackle the flexibility problem for the whole IS Design, the investigation in this work has been limited to the enterprises and organisations offering digital services. This limitation is justified with the importance of digital economy & transformation as well as the SDL-based paradigm shift towards service economy.

5. Challenge 1. Digital services are usually configured before being delivered to the customer in line with the application context. Enterprises need to understand this context to offer flexible services. The thesis shows the paucity of approaches concerning the elicitation and identification of contextual information in a systematic way.

6. Challenge 2. Different roles with varying backgrounds participate to design and implementation of digital services, which adds the need for alignment between those as a further challenge for flexibility.

7. Against this background, the thesis proposes deCOM, a capability-based context modelling method that aims to improve digital service flexibility by means of conceptual modelling.

8. deCOM has been evaluated in a total of six evaluation episodes, each focusing on a certain aspect of deCOM and adopting various research methods for measuring the properties *actual effi-*

ciency, *actual effectiveness*, *perceived efficacy* and the *intention to use*. It has been iteratively developed in line with the feedback collected from various audiences.

9. The results show that deCOM is a comprehensible, useful and well-documented method to elicit, identify and model the context of a digital service. The method's trade-off is the effort required to learn it, i.e. although it fits with the investigated organisation landscapes and its application leads to certain benefits, it is not entirely easy to use and to learn the method.

DECLARATION

I, Hasan Koç, declare that this thesis titled, ”A Capability-based Context Modelling Method to Enhance Digital Service Flexibility” and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

Signed: ______________________________

Date: ______________________________