ADAPTABILITY BY DESIGN

Incorporating Adaptability Constructs in the Design of Digital Business Ecosystems

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PREFACE

This research, conducted as part of my Master Thesis, marks the end of my Master and my time as a student. A number of years ago, I made the decision to move to Enschede and sign up for the BSc Business & IT, offered by the University of Twente. It proved to be a right decision as, after I had finished the bachelor, immediately decided to stay at the university and continue in the same field of study by enrolling for the MSc Business Information Technology. As a result, the last two years have been dedicated to this study and, in particular, to the area of Enterprise Architecture. During my time as a student, I have had the pleasure of acquiring many new skills, joining several committees, studying abroad and getting to meet many new people.

For the final part of my study, the writing of a Thesis, I joined the department of Enterprise Architecture within Deloitte Consulting. Taking up almost 7,5 months, the process proved to be highly engaging, enjoyable, and, from time to time, quite challenging. Nevertheless, with the help of many people, I was able to overcome these challenges and work towards the successful completion of my Thesis.

During the last months, I have received a lot of feedback and support from a number of people. Firstly, I would like to express my gratitude to Maria Iacob and Marten van Sinderen, my supervisors from the University of Twente, for providing me with ample insights and support to enhance the quality of my research. Furthermore, I would like to convey my sincere thanks to my supervisors from Deloitte, Jacco Roest and Jeroen Monteban, for their outstanding support throughout the entire research process. Their experience, opinions, guidance and, above all, sincere interests in my research have been of a great help. Furthermore, thanks go to all the participants of the conducted interviews and case studies. Without their support, the results presented in this research would never have been obtained.

Lastly, I would like to thank my colleagues at Deloitte for both their support to and involvement in my Thesis and all the chats that we had. Special thanks go to my fellow interns: Erik, Nunzia, Rik, Tessel and Yannick. It goes without saying that our daily chats, progress sharing, and foosball games were of key importance to both my motivation and research.

Finally, I would like to give a warm thanks to my family and friends. If it wasn't for the unwavering support of my parents, my life as a student would certainly not have been what it was. And, most important, the lasting encouragement and motivational talks by my girlfriend Marieke have proven to be indispensable.

I hope you will enjoy reading this research. Feel free to reach out to me in case you have any questions.

Paul Verhoeven
Amersfoort, September 25th, 2019

EXECUTIVE SUMMARY

Today's global market is becoming increasingly competitive, causing significant performance and survival challenges for organisations. To effectively deal with these challenges, organisations are looking for new ways to add value to their current business processes. Consequently, they are shifting towards a new type of organisational model, digital business ecosystems (DBE), to coordinate their processes with partners in the network and strategically align their business and IT environments to enhance their competitive advantage. For a long time, Enterprise Architecture (EA) has successfully supported these processes. Nevertheless, the increasing demand to participate in digital business ecosystems imposes new challenges on existing EA frameworks and methods.

One of the major challenges identified by academic research is adaptability. Existing research has shown that EA methods currently insufficiently support adaptability in reacting to internal and external change demands. Consequently, this research aims to resolve the issue of adaptability by identifying relevant DBE adaptability constructs and incorporating these in a development method for DBE architectures by proposing an extension to an existing EA architecture development method. This can also be observed in the main research question of this research, as shown below.

How can adaptability be incorporated in an existing Enterprise Architecture method for the design of Ecosystem-oriented Architectures?

For the identification of relevant DBE adaptability constructs, referred to as requirements and capabilities, several research methods have been employed. The adaptability requirements were identified through the employment of a systematic literature review. After that, the requirements were validated on their applicability, and their corresponding capabilities were selected through a number of semi-structured interviews. Having identified the constructs, an existing EA method, the TOGAF ADM, was selected and extended to facilitate the incorporation of DBE adaptability constructs. Subsequently, case studies have been conducted to validate the findings of the research and collect data regarding an existing DBE-case for the application of the extended method. The last step of this research comprised the development of DBE adaptability viewpoints, serving as a guide for future DBE-related projects. In addition, ArchiMate, a modelling language for the TOGAF ADM, was extended to accommodate the proposed changes.

The conducted research has resulted in the novel identification of DBE adaptability constructs, that can be incorporated in future DBE-related projects. In addition, the research has provided an extension of an existing EA method, proposing necessary steps and insights for the development of ecosystem-oriented architectures (EOA). The presented additions have furthermore been substantiated with several proposed extensions for the method's corresponding modelling language. The findings presented in this research contribute in several ways to the existing area of DBE research and to practice. To academic research, it proposes constructs for DBE adaptability, extends an EA method to facilitate their incorporation in the development of EOAs and illustrates how, by applying the extended method, adaptability patterns can be modelled using an EA modelling language on a DBE use case. To practice, the research provides valuable guidelines for developing EOAs and incorporating adaptability as a design principle in DBE-related projects.

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LIST OF ABBREVIATIONS

ADM	Architecture Development Method
BE	Business Ecosystem
CBP	Capability-Based Planning
CN	Collaborative Network
CNO	Collaborative Networked Organisations
CS	Computer Science
DBE	Digital Business Ecosystem
DE	Digital Ecosystem
DfC	Design for Changeability
DSM	Design Science Methodology
EA	Enterprise Architecture
EAM	Enterprise Architecture Management
EE	Enterprise Engineering
EvE	Evolutionary Environment
ExE	Execution Environment
EOA	Ecosystem (Oriented) Architecture
IP	Interview Protocol
IPR	Interview Protocol Refinement
IS	Information Systems
LRP	Literature Review Protocol
MSP	Mobility Service Provider
MVE	Minimum Viable Ecosystem
PSA	Project Start Architecture
SS	Scoping Search
SLA	Service Level Agreement
SLR	Systematic Literature Review
SME	Subject-Matter Expert
SSLR	Semi-Systematic Literature Review
TMT	Telecommunications, Media & Entertainment
TNC	Transportation Network Company

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1 INTRODUCTION

In this section, the conducted research is introduced. Furthermore, background information, containing several definitions, is provided. Lastly, the research design, containing several topics, including the stated problem, objectives of the research and the research questions, is addressed.

1.1 Introduction

Seven of the world's ten largest companies currently depend on ecosystems (Fuller, Jacobides, & Reeves, 2019). Moreover, ecosystem thinking has become more prominent than ever for companies across the S&P 500 (Fuller et al., 2019). Merely a few months ago, the World Economic Forum published a paper in which they stressed that: "In a few short years, the ranking of most valuable companies by market capitalization has totally shifted to being dominated by one business model – digital platforms and ecosystems" (Jacobides, Sundararajan, & Alstyne, 2019). All around the world, digital ecosystems are growing and flourishing rapidly, fundamentally changing the way organisations are adding value (Batterink, 2017).

The shift towards collaborating in these novel types of organisational networks can be traced back to the advancement of digital technologies that has led to increasingly strong globalisation and digitalisation dominating today's global markets (Senyo, Liu, & Effah, 2019; Tanriverdi & Lim, 2017). Consequently, the market's competitive atmosphere is continuously growing stronger, leading to increased performance and survival challenges for organisations (Hagel, Brown, Wooll, & Maar, 2015; Vargas, Cuenca, Boza, Sacala, & Moisescu, 2016). To successfully cope with these challenges, organisations must add value to their current business processes by strategically aligning their business and IT environments and by achieving integration and coordinating their processes with partners within their collaborative network (Vargas et al., 2016).

For decades, the processes of analysing and coordinating the intertwinement of business and IT architecture within organisations has been successfully supported by Enterprise Architecture approaches (Drews & Schirmer, 2014). Since the moment Zachman first designed a framework for modelling entities and relations across the layers of an Enterprise Architecture, considerable knowledge has been generated on how to manage enterprise architectures within organisations (Simon, Fischbach, & Schoder, 2013; J. A. Zachman, 1987). Nevertheless, the increasing demand for enhancing organisational interoperability by forming ecosystems imposes new challenges on existing Enterprise Architecture frameworks and methods (Cheah, 2007; Drews & Schirmer, 2014).

Consequently, adaptability has been identified as one of the major challenges for the Enterprise Architecture community (Valtonen, Nurmi, & Seppänen, 2018). Academic research shows that existing Enterprise Architecture methods and tools provide insufficient support for achieving adaptability in reacting to internal and external change demands and, therefore, are not adaptive enough in the face of today's complex environment (Korhonen, Lapalme, McDavid, & Gill, 2016). Moreover, Zimmermann, Schmidt, Jugel, & Möhring (2015) stress that EA approaches must become more holistic and adaptable for them to remain applicable to modern environments where ecosystems have grown in their existing. Although in the field of Digital Business Ecosystems (DBE) research efforts have been made to resolve adaptability shortcomings, a remarkable 50.5% of DBE research is conceptual and is categorised as non-empirical (Senyo et al., 2019). Furthermore, at least 72% of the published DBE research lacks the use of any theory, which could be explained by the relative novelty of the DBE concept (Senyo et al., 2019).

This research aims to contribute to the current state of DBE research by resolving the described adaptability shortcomings through the identification of relevant adaptability constructs and the design of an 'Adaptability by Design' method by extending an existing architectural development method.

1.2 Background

In this section, background information with regards to several topics discussed in this research is given. Firstly, the current terminology surrounding collaborative networks is addressed. After that, several definitions with regards to Enterprise Architecture and ecosystems are presented. Lastly, the taxonomy of adaptability is introduced.

1.2.1 Collaborative Network

In the existing literature, many terms are used to refer to environments used by organisations to collaborate and co-create value. Moreover, these terms are often associated with a multitude of collaborative networks (CN) or different aspects within them. Several studies have attempted to consolidate the widespread usage of these terms depicting similar types of CNs (M. A. R. Bakhtiyari, 2017; Camarinha-Matos & Afsarmanesh, 2012; Vargas, Boza, Cuenca, & Ortiz, 2013). An essential factor differentiating two significant types of CNs is the intended duration of their collaboration (Camarinha-Matos & Afsarmanesh, 2012), as can be seen in Figure 1.

The two types of CNs that result from that separation are Collaborative Networked Organisations (CNO), characterised by their structure, governance principles and rules, and Ad-Hoc Collaborative Networks, which are more "spontaneous" in nature and have no clear structure. A further distinction can be made between long-term strategic networks and goal-oriented networks. According to Camarinha-Matos & Afsarmanesh, long-term strategic networks are founded to form alliances aimed at offering the conditions and environment to support rapid and fluid configuration of CNs, when opportunities arise. Goal-oriented networks, on the other hand, are initiated to work towards a common goal or set of compatible goals. Often, these networks are dissolved after the opportunity or project is accomplished.

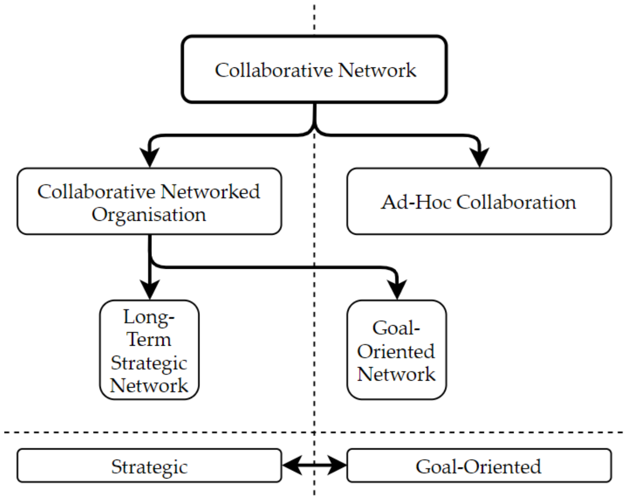

Figure 1: Collaborative Network Taxonomy
(Adapted from Camarinha-Matos & Afsarmanesh (2012))

1.2.2 Architecture

In this study, the notion of architecture is frequently referred to. Nevertheless, the meaning of the term is dependent on the context it is applied to. Therefore, in this section, the notion and its context are briefly introduced.

Architecture

The word "architecture" encompasses many different definitions depending on the context it is used for. Within the field of Information Technology, architecture can be defined as:

> "The set of design artefacts, or descriptive representations, that are relevant for describing an object such that it can be produced to requirements (quality) as well as maintained over the period of its useful life (change)" (John A. Zachman, 1996).

In line with this definition, IEEE came up with the following definition in its IEEE Standard 1471-2000 several years later:

> "The fundamental organisation of a system embodied in its components, their relationships to each other, and to the environment, and the principle guiding its design and evolution" (IEEE Computer Society, 2000).

In the above definitions, architecture is part of 'an object' and 'a system', as it is context-agnostic. In essence, both definitions point out that architecture could be categorised as "structure with a vision" (Jonkers et al., 2006). Nevertheless, the definition changes once 'an object' is replaced by 'enterprise' or 'ecosystem'. Throughout this research, the latter definition is primarily considered.

Enterprise

An enterprise can be referred to as: "Any collection of organisations that has a common set of goals and/or a single bottom line" (The Open Group, 2006). The separate domains within an enterprise, comprising its data, applications, processes, products and technologies are considered by Enterprise Architecture (EA), as described below:

Enterprise Architecture

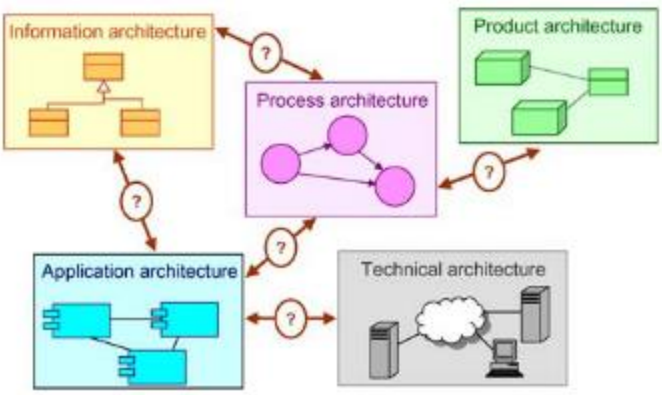

Figure 2: Enterprise Architecture Domains
(Jonkers et al., 2006)

Architecture at an organisational level is frequently referred to as 'Enterprise Architecture' (EA). A commonly accepted definition of EA, as is also visualised in Figure 2, was introduced by Lankhorst (2017), and states:

> "A coherent whole of principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business, processes, information systems, and infrastructure".

EA can support the guidance of the business while allowing for flexibility and adaptability. Moreover, it helps provide a holistic view of the enterprise (Jonkers et al., 2006). The guidance provided by EA comes in two forms: as a process as well as a product (Lankhorst, 2017). The product serves mostly as the guide contains the architectural documents and models across the four domains of EA: the business, data (information and data), application and technology domains as shown as 'Architecture Domains' in Figure 3. However, EA is also a process spanning further than the sheer development of architectural products. This role is rather cross-disciplinary and combines four separate capabilities as shown as 'Enterprise Architecture Capability' in Figure 3 ("Enterprise Architecture Capability," realIRM).

The roles and skills of individuals involved in the architectural process are part of the 'People' capability. The content capability holds the principles, standards, inventory, models and roadmaps available in the EA repository. Thirdly, modelling tools are part of the 'Tools' capability. To conclude, the 'Processes' capability combines the previous three capabilities for the delivery of EA products and services ("Enterprise Architecture Capability," realIRM).

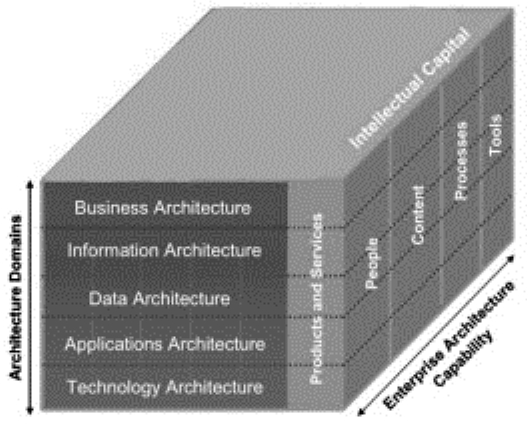

Figure 3: Enterprise Architecture Domains & Capabilities
(Adapted from "Enterprise Architecture Capability," realIRM)

Ecosystem

The definition of an enterprise showed that these are not merely limited to siloed organisations. Instead, an enterprise could also be a chain of distant organisations that are linked together by common ownership (The Open Group, 2006). It is the joint ownership that differentiates enterprises from ecosystems, as ecosystems enable both collaborative and competitive organisations to bundle forces in one community (Senyo et al., 2019). Moreover, ecosystems can be referred to as self-sustaining, self-organising, collaborative and evolving environments, as was pointed out by (Abdul, Khalil, Dominic, Fadzil, & Hassan, 2011).

Within this research, we subsequently follow the definition by Ramljak (2017), who states that an ecosystem is:

> "A complex web of interdependent enterprises and relationships aimed to create and allocate business value. Ecosystems are broad by nature, potentially spanning multiple geographies and industries, including public and private institutions and consumers".

Ecosystem-oriented Architecture

Architecture at the level of an ecosystem can be referred to as Ecosystem Architecture. Within this research, we use the term Ecosystem-oriented Architecture (EOA), to prevent accidental confusion with the term Enterprise Architecture (EA).

An EOA shares significant similarities with an EA. Nevertheless, it is positioned in an entirely new context with collaborative and competitive organisations where other vendors and clients are also involved in the ecosystem. However, to the best of our knowledge, as of yet there exists no standalone definition for EOAs. Therefore, the following slightly adapted definition from Lankhorst (2017) is used throughout this research:

> "A coherent whole of principles, methods, and models that are used in the design and realisation of an ecosystem's organisational structure, business processes, information systems, and infrastructure".

1.2.3 Adaptability

Throughout this research, the notion of 'adaptability' is frequently used. Adaptability can be regarded as an umbrella term that spans a range of correlated developments in a range of areas (Andresen, 2006). The author argues that within an enterprise, or ecosystem, the aim should be at balancing these areas to leverage the overall adaptability. The five areas that were identified by Andresen (2006) are listed vertically in Figure 4. Below, a brief description of these five areas by Andresen (2006) is listed.

1. Area 1: **Organisation**

Organisational adaptability indicates the ability to synthesise new, productive capabilities from necessary resources, such as the expertise of people within the organisation.

2. Area 2: **Production**

This area depicts the ability to produce goods and services in line with customer demands.

3. Area 3: **Technology**

This adaptability area consists of the hardware, software and services that combined are part of the enterprise or ecosystem architecture.

4. Area 4: **Core Business Processes**

The area of core business processes contains the methods used to integrate the supplier relations, processes and delivery, allowing for individualised combinations of products and services.

5. Area 5: **People**

The last area is characterised by a skilled and innovative workforce. The adaptability includes standards and skills of involved personnel.

The five areas listed above show that adaptability applies to multiple parts of an enterprise or ecosystem. As such, different degrees of adaptability are required in different parts. Adaptability is a desirable design goal but must compete with other design goals. Moreover, changes may be gradual or abrupt, short-term or long-term or frequent or occasional. Therefore, a systematic framework to help organisations model, analyse and design their adaptive characteristics can be highly useful (Yu, Deng, & Sasmal, 2012).

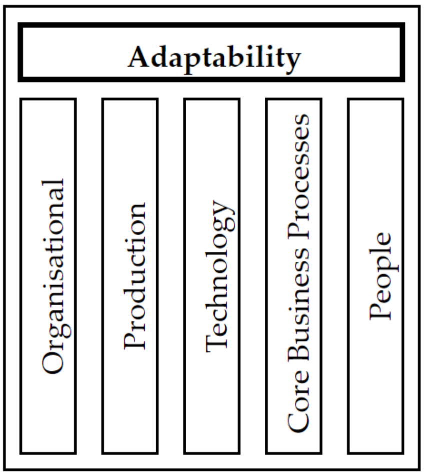

Figure 4: Adaptability Areas
(Adapted from Andresen (2006))

In short, throughout this research, the following basic definition of adaptability is adopted (Andresen & Gronau, 2006):

> "The ability of a system to adapt itself efficiently and fast to changing circumstances".

1.2.4 Requirement

Due to their broad applicability in several different domains, there currently exist many views on requirements and capabilities. Nevertheless, in the field of Computer Science and Information Systems, the notion 'requirement' has been defined somewhat similarly. In this research, the following definition proposed by Shrivathsan (2009) is adopted:

> "A requirement is a capability that a product must possess or something a product must do in order to ultimately satisfy a customer need".

Considering several existing sub-types of requirements, including functional requirements, technical requirements, business requirements and quality of service requirements, throughout this thesis the used notion shares significant similarities with the latter (Caminao, 2012). As such, throughout this research, the term is used to define operational constraints on functionalities (Caminao, 2012).

1.2.5 Capability

Combined with requirements, capabilities can describe the functionality that units, for example, ecosystem architectures, require and the functionality that these units can provide to other units. Furthermore, both notions are complementary to each other, meaning that each requirement has at least one matching capability (IBM Corporation, 2014). Throughout the fields of Enterprise Architecture and Information Systems, several highly similar definitions for 'capabilities' are used.

In this research, the definition proposed by Aldea, Iacob, Lankhorst, Quartel, & Wimsatt (2016) is used:

> "A capability is a particular ability or capacity that a business may possess or exchange to achieve a specific purpose or outcome".

Moreover, the authors mention that capabilities can be expressed in high-level terms and require some combination of assets, such as people, processes or technology. In this research, capabilities are introduced to substantiate the identified requirements. As such, the requirement can serve as main design principles for designing EOAs. Capabilities, on the other hand, provide more practical insights into how these design principles can be realised.

1.2.6 Definition Model

The definitions introduced in this Section are illustrated in Figure 5. Furthermore, their interrelations are added to show the structure of the presented definitions. The figure shows that architecture can be applied to both enterprises and ecosystems. For both cases, the architecture can be defined across similar layers. If applied to ecosystems, which are a sub-type of a collaborative network, several limitations exist. As such, research found that adaptability is the major limitation of EOAs. One of the goals of this study is to identify the requirements and capabilities that support the limitation of adaptability.

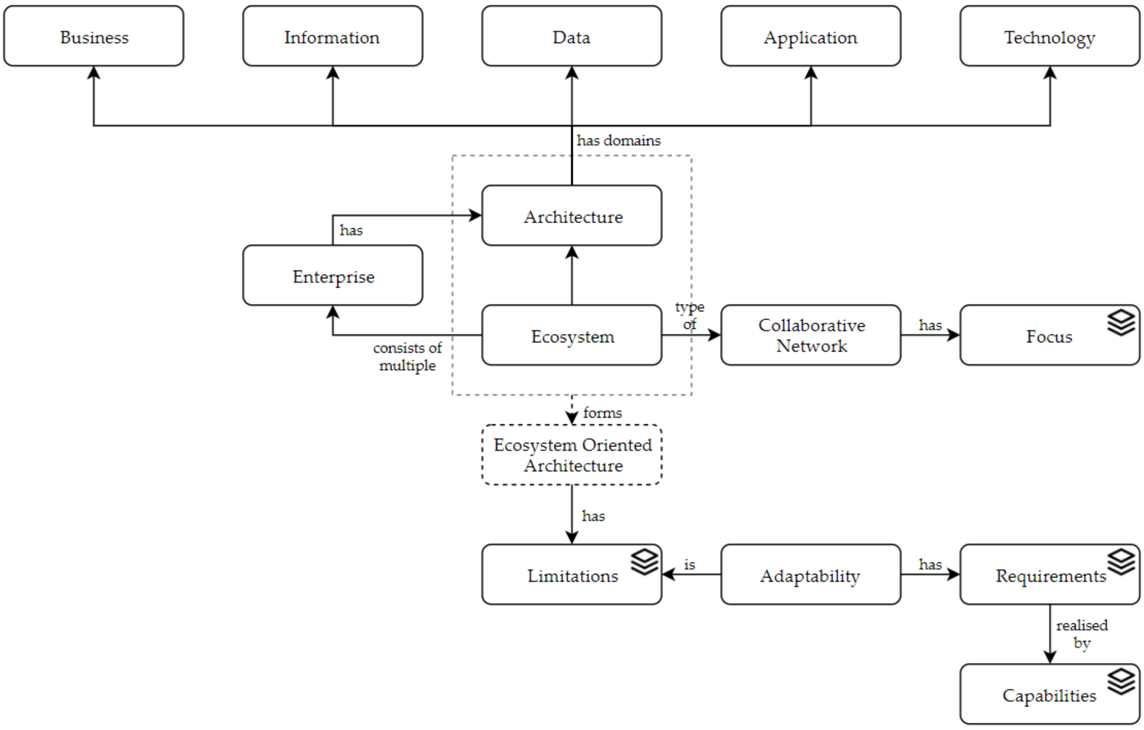

Figure 5: Definition Model & Relationships

1.3 Research Design

In this section, the design of this research is described. Firstly, the identified problem statement is addressed in Section 1.3.1. Afterwards, the objectives, scope, research questions and relevance of this study are discussed. Lastly, the final section provides a summarised overview of the research questions, their desired outcomes and the methods that have been applied to answer them.

1.3.1 Problem Statement

Globalisation and digitalisation dominate nowadays' markets (Tanriverdi & Lim, 2017; Vargas et al., 2016). Consequential, the global market's competitive atmosphere has grown stronger than ever before (Vargas et al., 2016). Increasing competitiveness has caused numerous organisations to face considerable performance and survival challenges (Hagel et al., 2015). To face these challenges, many organisations choose to participate in or create Digital Business Ecosystems (DBE) to add value to their business processes (Vargas et al., 2016).

The design of DBEs is challenging and complex. However, previous research[*] has shown that the EA capabilities, as shown in Figure 3, can play a pivotal role during this design phase. However, these capabilities have been developed for use within, more or less, siloed enterprises. If transitioned towards a new type of business, ecosystems, its contribution becomes debatable. As ecosystems are often located in turbulent and demanding environments, resulting in frequent changes occurring in its business, information, social and technological landscape, adaptability is of utmost importance to allow for fast and efficient responses to those changes (Yu et al., 2012). Nevertheless, existing EA methods and tools appear to lack sufficient support for integrating such adaptability in the design of EOAs (Korhonen & Halén, 2017; Masuda, Shirasaka, Yamamoto, & Hardjono, 2017; Yu et al., 2012).

1.3.2 Research Objective

From the problem statement described in the previous section, it becomes apparent that to resolve the obstacle of adaptability, it must be better incorporated in the design of DBEs. Consequently, the objectives of this research have been listed below.

Primary Objective

The primary objective of this research is the extension of an existing Enterprise Architecture (EA) method for architecture development, to guide the incorporation of novel adaptability constructs in the development of Ecosystem-oriented Architectures (EOA) for Digital Business Ecosystems (DBE).

Segregated into smaller objectives, the following sub-objectives can be identified:

Sub-Objective 1: Adaptability Constructs

Currently, it remains unclear what requirements and capabilities (jointly referred to as constructs) for ecosystemic adaptability are. In line with this, the first sub-objectives comprise the identification of novel adaptability constructs for DBEs.

Sub-Objective 2: Method Extension

To effectively apply the identified adaptability constructs to the design of DBEs, the second goal of this research is the extension of an existing EA development method, to facilitate the incorporation of the adaptability constructs in the development of EOAs. Consequently, these can be split up into the following parts:

- The extension of an existing EA method to (also) allow for EOA development
- The application of this extension to aid the incorporation of adaptability constructs in the design of DBEs

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[*] Research previously issued in Research Topics by the same author (Verhoeven, 2019).

Sub-Objective 3: EA Modelling Language Extension

To enable architects to adequately describe, analyse and visualise the relationships between business domains, several modelling languages have been proposed to be used alongside existing EA methods (The Open Group, 2017). Consequently, to aid the method extension described above, an existing EA Modelling Language is likewise extended by the proposition of novel modelling elements to facilitate the visualisation of EOAs and the subsequent adaptability constructs.

Design Science Methodology: Design Problem

In addition to the listed objectives, the goals of this research have been applied to the design problem template proposed in the Design Science Methodology (DSM) proposed by (Wieringa, 2014). As prescribed in the DSM, for the successful execution of the methodology, the researcher must first identify the research problem context, the artefact used to improve the problem and several requirements and goals. For this process, the design problem template by Wieringa (2014) can be used, as seen below:

improve	<a problem context>
by	<(re)designing an artefact>
that satisfies	<some requirements>
in order to	<help stakeholders achieve some goal>

If applied to the context of this research, the problem template results in the following design problem:

improve	the adaptability of DBEs
by	extending an existing EA architecture development method for EOAs
that	incorporates adaptability constructs
in order to	design adaptable DBEs and improve competitive advantage

1.3.3 Research Scope

The scope of this research comprises adaptability as a design principle for Digital Business Ecosystems. Since numerous other types of collaborative networks and ecosystems exist, adaptability as a principle contains different implications for each type. Therefore, the results of this research are merely focussed on DBEs to ensure their validity and generalisability. Moreover, the identified adaptability constructs are limited to the design phase of DBEs and serve as guidelines for future ecosystem-related design projects where adaptability is incorporated as a design principle. Therefore, the operationalisation of the results is limited as metrics for adaptability (to quantify potential improvements) were excluded for scoping reasons.

1.3.4 Research Questions

To achieve the objective addressed in Section 1.3.2, in this research, the following main research question will be answered:

How can adaptability be incorporated in an existing Enterprise Architecture method for the design of Ecosystem-oriented Architectures?

This central question gives substance to the goal of this research to enhance the adaptability of Digital Ecosystems and propose an 'Adaptability by Design' method. For the answering of the main research question, several sub-questions must be answered. The following sub-questions are addressed in this study:

1. How are digital business ecosystems defined by relevant academic literature?

Throughout existing literature, there exists a variety of terms and definitions used for describing digital business ecosystems (DBE) and their components. Therefore, relevant academic literature must be reviewed to identify an appropriate definition for a DBE and its components and clarify the current state of research surrounding this field of study.

2. Which architectural requirements influence digital business ecosystem adaptability?

The goal of this research is to identify what adaptability in the context of DBE research comprises and how this can be incorporated in a method for designing adaptable DBEs. Therefore, this research question serves to identify, synthesise and define core requirements for DBE adaptability.

3. What are capabilities substantiating the adaptability requirements?

The previous sub-question addresses the identification of high-level design principles, in this research referred to as requirements, for adaptability. However, as these requirements clarify what to consider when aiming for improving adaptability, they do not support the actual advancement towards that goal. By engaging in a literature review and qualitative interviews, capabilities that can be incorporated in the 'Adaptability by Design' method and their relationship with the previously identified requirements are analysed for the answering of this sub-question.

4. To what extent are the identified adaptability requirements for DBEs compatible with existing EA frameworks?

Existing EA methods and tools lack sufficient support for incorporating adaptability in the design of DBEs (Korhonen & Halén, 2017; Masuda et al., 2017; Yu et al., 2012). Therefore, it is necessary to analyse to what extent these EA methods and tools are lacking in their support for designing DBEs and incorporating the identified adaptability constructs.

5. How can an EA method be extended to support the newly identified adaptability constructs?

This sub-question serves to identify solutions for the previously identified shortcomings. The answer to this sub-question will provide a synthetisation of the adaptability constructs by extending parts of existing EA frameworks and incorporating the found adaptability constructs. The results of this question show the applicability of existing EA frameworks when applied for the development of a new type of architecture.

The main research question, sub-questions and their relations addresses in this section are illustrated in Figure 6.

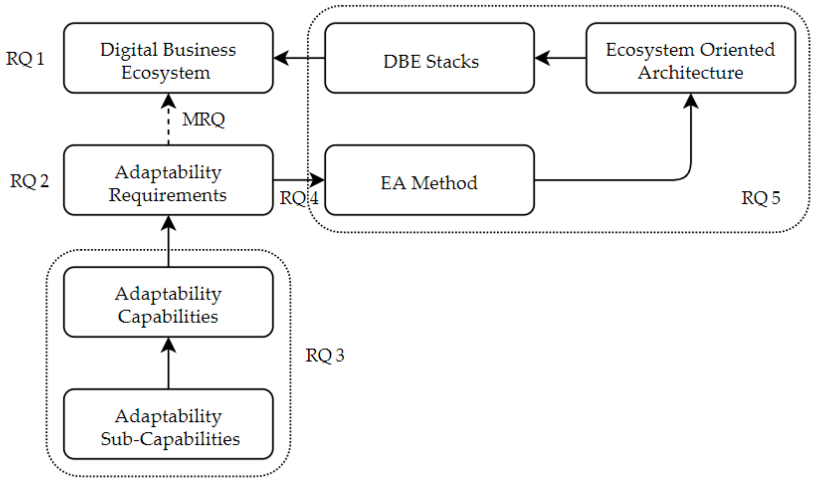

Figure 6: Relations of Research Questions

1.3.5 Research Relevance

Ecosystems are becoming increasingly important for organisations to remain competitive and survive in today's complex and fast-changing markets. The growing importance of participating in digital business ecosystems has triggered the need for supporting frameworks and methods. Consequently, the role of Enterprise Architecture has started to shift, considering their proven frameworks and methods.

This research contributes to the existing DBE field of research by analysing the applicability of existing EA frameworks and methods. Moreover, it attempts to solve one of the major identified limitations of applying EA frameworks and methods to DBEs, adaptability. By identifying essential requirements and capabilities for DBE adaptability, common pitfalls in the design of these ecosystems can be captured in advance. Furthermore, the adaptability constructs are applied to an existing EA method, subsequently analysing its applicability on ecosystems. The final contribution of this research comes from the proposed adaptability viewpoints substantiating the design phases of the select EA method. These viewpoints provide novel insights into how adaptability can be incorporated in the design of DBEs and moreover identifies shortcomings arising from the application of an existing EA method on ecosystems.

1.3.6 Research Process

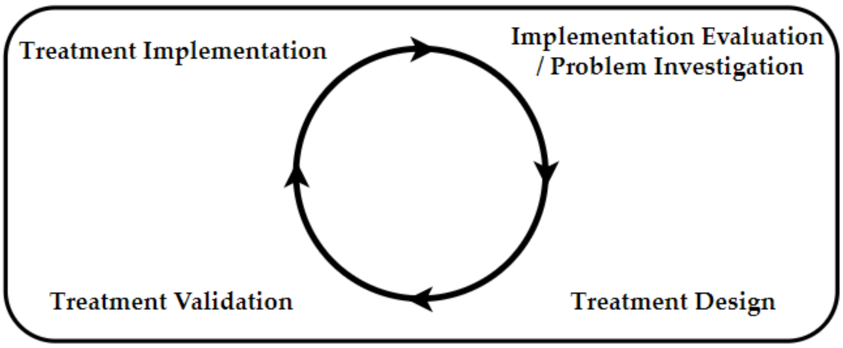

Figure 7: Engineering Cycle
(Adapted from Wieringa (2014))

The answering of the research questions listed in Section 1.3.4 leads to the extension of an existing EA method for application to the design phase of DBEs. For this research, a commonly accepted methodology in the field of Information Systems (IS) to design IS artefacts is adopted. This methodology, Design Science Methodology (DSM) proposes guidelines to allow for a structured process leading from the investigation of a problem to the design and validation of an artefact (Wieringa, 2014). Figure 8 illustrates the entire Engineering Cycle, as proposed by Wieringa. However, the steps of 'Treatment Implementation' and 'Implementation Evaluation' go out of scope for this research and are therefore excluded. Once these two steps are excluded from the Engineering Cycle, the cycle could be referred to as the Design Cycle (Wieringa, 2014).

The Design Cycle comprises three main steps for the development of IS artefacts. The goal of the first step, 'Problem Investigation', is to "investigate an improvement problem before an artefact is designed and when no requirements for an artefact have been identified yet" (Wieringa, 2014). The first tasks in this step include the identification, description, explanation and evaluation of the to be treated problem. The following phase, 'Treatment Design' comprises the process of designing the actual research artefact. Finally, the third phase of the Design Cycle serves to validate whether the artefact can help to achieve the previously set goals. The Design Cycle could be referred to as a 'higher-level' research process, where essential steps for design science research are proposed. Nevertheless, the researcher is free to adopt any method to achieve the prescribed steps. Figure 8 illustrates the research process that was adopted for this study. The applied research methods are briefly discussed below. Subsequently, Chapter 3 discussed the research methods in more detail.

To investigate the research problem, a systematic literature review (SLR) was executed as part of the 'Problem Investigation' phase. To structure the literature review process, concepts were drawn from the review guide proposed by Okoli (2015a). Nevertheless, before initiating the SLR, a Scoping Search (SS) was executed to become familiarised with the field of Digital Business Ecosystems (DBE) first and obtain a more detailed research direction (Booth, Sutton, & Papaioannou, 2016). The following SLR served to analyse existing literature to clarify the current terminology used to define DBEs (RQ 1) and furthermore to identify architectural requirements that influence DBE adaptability (RQ 2). From the SLR, it became apparent that in the field of DBE research, a majority of the published papers were conceptual and lacked any theoretical basis (Senyo et al., 2019). This finding was confirmed by the lack of capabilities that were proposed to substantiate the described high-level requirements. These findings led to the execution of a third iteration, in the form of a Semi-Systematic Literature Review (SSLR), which supported the semi-structured identification of adaptability capabilities.

Considering that only limited academic literature discussed approaches, in this research referred to as capabilities, for enhancing adaptability, empirical research in the form of semi-structured interviews with Subject-Matter Experts (SME's) from the field of DBEs were employed. These interviews, which were held at a broad range of different cases, served the identification of relevant adaptability capabilities. Besides, the Semi-Structured Interviews were executed to validate the requirements identified throughout the SLR and to analyse how existing EA frameworks could support the incorporation of adaptability in the design of DBEs.

The results obtained throughout the Literature Review and Interviews part of the Problem Investigation phase of the DSM could be used to extend an existing EA method to the context of DBEs and incorporate adaptability constructs in the phases responsible for developing the Ecosystem-oriented Architectures (EOAs). Finally, the adaptability constructs and their incorporation into an existing EA method have been validated. The validation was done through a case study with four experts from three different organisations involved in the design process of a new DBE. The constructs and method were presented during the case and validated on their applicability and usefulness, through extensive expert opinion sessions.

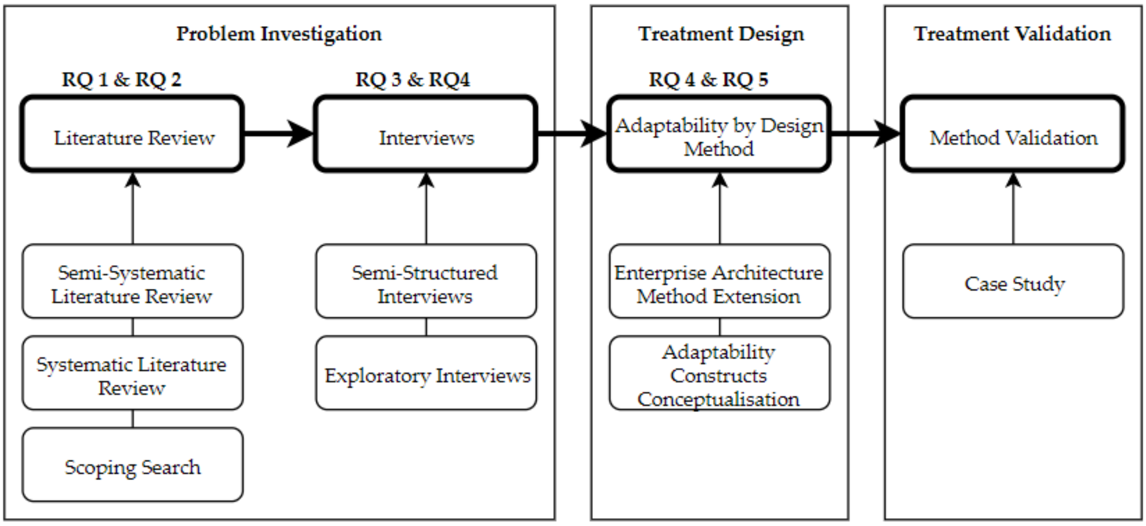

Figure 8: Design Science Methodology - Research Process

1.3.7 Research Overview

Table 1 provides a full overview of the introduced research questions and details. The table covers each of the requirements presented in Section 1.3.4, and furthermore includes one of the main questions of a previously conducted research as part of Research Topics. The results of that separate research were used to identify the research problem included in this study.

Table 1: Research Overview

Research Question	Section	Method	Outcome
Digital Business Ecosystems			
1. How are digital business ecosystems defined by relevant academic literature?	Section 2: Literature Review	Literature Review	Definition of DBEs & current state of research overview
• What are the challenges associated with transitioning from an Enterprise Architecture towards an Ecosystem-oriented Architecture?	Research Topics†	Literature Review	Challenges originating from the application of EA to DBEs
Adaptability			
2. Which architectural requirements influence digital business ecosystem adaptability?	Section 2: Literature Review	Literature Review	Identification of high-level requirements for adaptability

† Research previously issued in Research Topics by the same author (Verhoeven, 2019).

3.	What are capabilities substantiating the adaptability requirements?	Section 4: Interview Results	Interviews	Identification of capabilities substantiating requirements
Enterprise Architecture & Digital Business Ecosystems				
4.	To what extent are the identified adaptability requirements for DBEs compatible with existing EA frameworks?	Section 6: Validation & Section 5: Method Extension	Analysis of Validation & Case Study	Overview of TOGAF and method for the design of the method
Method Design				
5.	How can an EA method be extended to support the newly identified adaptability requirements?	Section 5: Method Extension	Analysis of Previously Obtained Results	Method extension for incorporating adaptability in design of DBEs

1.3.8 Document Structure

The conducted research, as described in this document, is addressed throughout several chapters. In Chapter 2, the methodology and obtained findings of the Literature Review are described. Chapter 3, subsequently, contains descriptions on each of the methods applied in this research. In Chapter 4, the findings obtained from the performed interviews are presented. The chapter thereafter, Chapter 5, describes the undertaken steps towards the extension of an existing EA method for the incorporation of DBE adaptability constructs. In Chapter 6, the findings collected from the validation of this research, using case studies, is addressed. The results, limitations and future research of this research are discussed and interpreted in Chapter 7, and the document is concluded by Chapter 8, which contains the answering of each research question and an overview of the contributions of this research.

2 LITERATURE REVIEW

In this section, the conducted literature review is addressed. Firstly, the methodology of the review is described, including a categorisation into three separate searches. Thereafter, the applied research process is addressed, showing, in summary, the results of the searches. Lastly, the corresponding research questions are answered and discussed in detail in the third section of this chapter.

2.1 Review Methodology

In this section, the methodology of the conducted literature reviews is discussed. Considering that the area of research on digital business ecosystems (DBE) is still in its infancy, the availability of academic papers remains limited (Abdul et al., 2011; Aldea, Kusumaningrum, Iacob, & Daneva, 2018). Therefore, it is highly essential to obtain a comprehensive overview of the available literature from the DBE area of research. To ensure this degree of comprehensiveness, a scientifically rigorous and structured approach is essential. Accordingly, the review documented in this research pursues existing guidelines of a Systematic Literature Review (SLR) (Okoli, 2015a). Moreover, the SLR is complemented by an initial scoping search to obtain familiarity with the field and a second iteration of the SLR, specifically on capabilities for adaptability.

2.1.1 Scoping Search

For the attainment of a 'general' research direction and to enhance familiarity with the area of research before commencing with the SLR, an exploratory and unstructured Scoping Search (SS) has been completed. The SS served four principal functions, as is briefly discussed in Table 2. Additionally, several requirements for the SLR were identified throughout this search. The objectives and insights of the SS are discussed in more detail in Appendix A.3. Literature Review Protocol.

Table 2: Principle Scoping Search Functions
(Adapted from Booth, Sutton, & Papaioannou (2016))

Principal Function	Brief Description
Methodological	Determination of appropriate review methods
Logistical	Estimation of required time and effort for review
Conceptual	Identification of topics that should be included or excluded
Practical	Identification of terms and synonyms to be used in search phase

2.1.2 Systematic Literature Review

To ensure a scientifically rigorous and structured approach, this research adopts the systematic literature review methodology for the collection of relevant data and the answering of its corresponding research questions. The full SLR structure can be found in Appendix A.1. Literature Review Structure and documents the strategy and process in more detail. The protocol draws its primary concepts from guides provided by Okoli (2015) and Kitchenham & Charters (2007). Moreover, several supporting concepts from Webster & Watson (2002), Bandara, Furtmueller, Gorbacheva, Miskon, & Beekhuyzen (2015) and Wolfswinkel, Furtmueller, & Wilderom (2013) were included.

Several research questions were addressed by the SLR. Firstly, it served to analyse the current state of research on the terminology for DBEs. Secondly, it answered research questions two by identifying requirements for DBE adaptability. Lastly, the fourth research question is served by addressing to what extent existing EA frameworks and methods support incorporating adaptability in EOAs. It should be noted that the SLR covered several other topics as well, but these were included in a previously issued report (Research Topics) by the same author (Verhoeven, 2019).

Figure 9 illustrates the conducted steps for the SLR, referred to as 'Search 1'. To select relevant literature, the search terms listed below have been used in several bibliographic sources. Additional details with regards to the SLR can be found in Appendix A.3. Literature Review Protocol.

- "*Ecosystem Architecture"
- "*Ecosystem Architecture" AND (Challenge* OR Risk*)
- Ecosystem AND Architecture
- "Enterprise Architecture"
- (Ecosystem OR "Ecosystem-oriented") AND Architecture
- "Enterprise Architecture" AND "Ecosystem Architecture"
- Ecosystem AND "Collaborative Network"

2.1.3 Semi-Systematic Adaptability Review

The SS and SLR have addressed several key research questions of this research. From the gained insights, it became apparent that, in light of the novelty of this area of research, knowledge with regards to capabilities or approaches supporting the proposed requirements for adaptability was limited. Furthermore, a large part of the discussed capabilities was highly subjective or based on personal experience, lacking extensive validation (Senyo et al., 2019). Therefore, an SLR was deemed too structured and extensive for the third research question.

Instead, a Semi-Systematic Literature Review (SSLR) was conducted to gain better insights and explore the suggested approaches. With this review method, the intention shifted from answering research question three to providing a basis for follow-up qualitative research. The search terms used to obtain relevant academic literature are listed below.

- Ecosystem AND Architecture AND Adapt*
- Ecosystem AND Adaptability
- "Enterprise Architecture" AND Adapt*
- "Adapt* Capabilit*" AND Architecture
- Changeability AND Ecosystem

2.2 Research Process

The literature review process, as was defined in Appendix A.3. Literature Review Protocol, has been summarised and visualised in Figure 9. The first search iteration adopted the search terms listed in Section 2.1.2 and led to the refined identification of 223 unique papers from academic bibliographic sources. Employing four refinement phases, this number of studies was reduced to a total of eleven papers. Subsequently, after the first iteration and the refinement of the findings, a forward and backward reference search was conducted. This process led to the inclusion of eight new papers, bringing the total of the first iteration to nineteen papers. The finalisation of the first iteration led to the second iteration, where several new search terms were included, as prescribed in Section 2.1.3. In total, the search terms and selection criteria resulted in the identification of 116 unique papers, not overlapping the set of studies identified in the first iteration. Using the same refinement process, this number was brought down to seven unique papers, which resulted in a total of ten papers after the reference search.

Combined, both literature review iterations resulted in the identification of 29 core papers for this research. Nevertheless, considering that several identified studies lacked a sufficient focus on adaptability, an extra refinement on this criterium resulted in a second core papers list of fifteen papers. Utilising both core literature lists, the defined research questions were deemed sufficiently answerable.

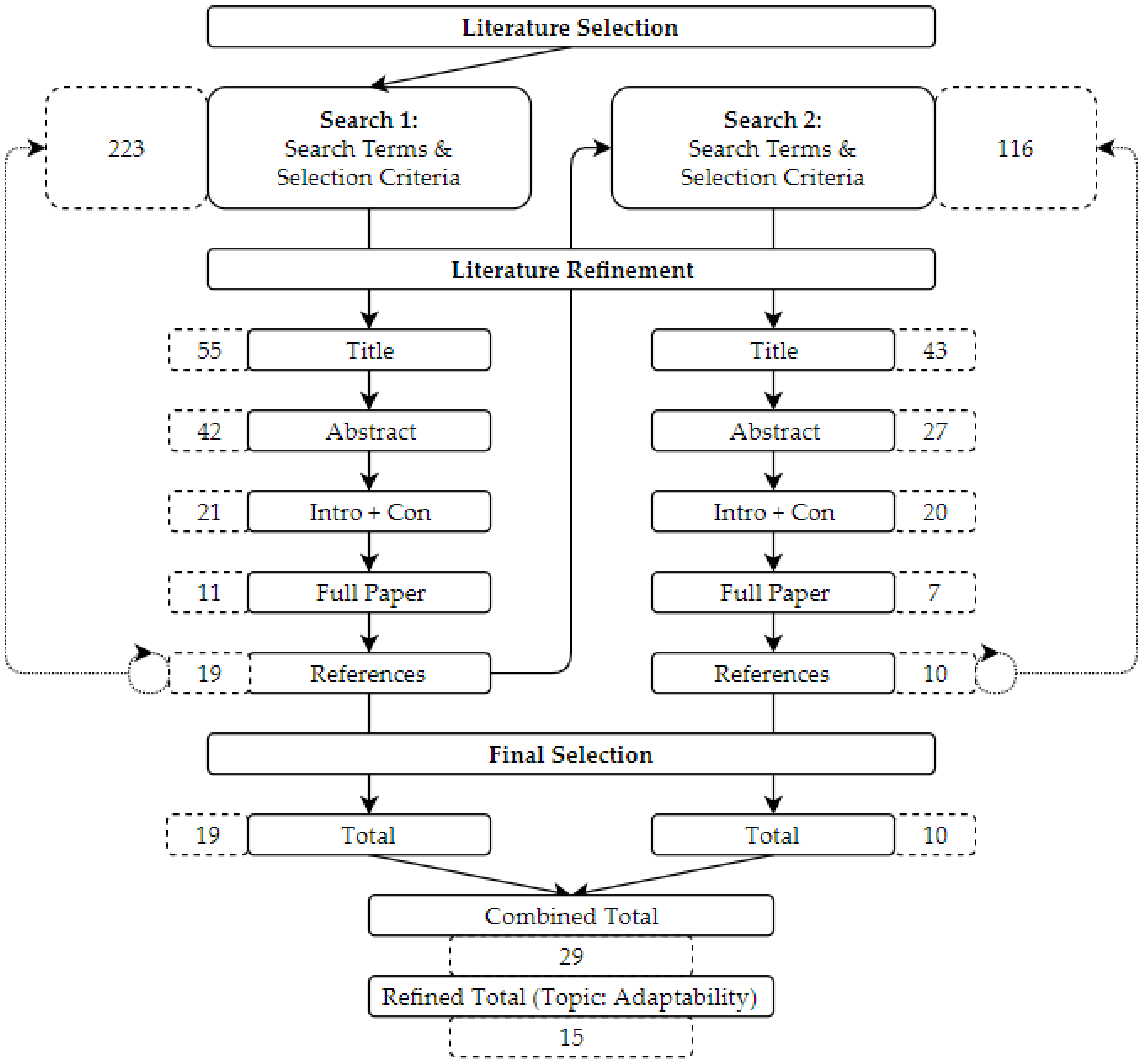

Figure 9: Literature Review Results Overview

2.3 Digital Business Ecosystems

In this section, the following research question is answered:

What terminology exists for defining digital business ecosystems?

2.3.1 Ecosystem Terminology

In the area of research surrounding DBEs, or similar types of ecosystems, a broad terminology is being used. Throughout the SLR, the applied search terms mostly focussed on Business- and Digital Ecosystems, a combination of both or Ecosystem-oriented Architectures. Nevertheless, throughout the literature, up to fifteen different types of ecosystems were discussed. Figure 10 highlights the top-3 most mentioned types of ecosystems. The full matrix on this topic can be found in Table 19.

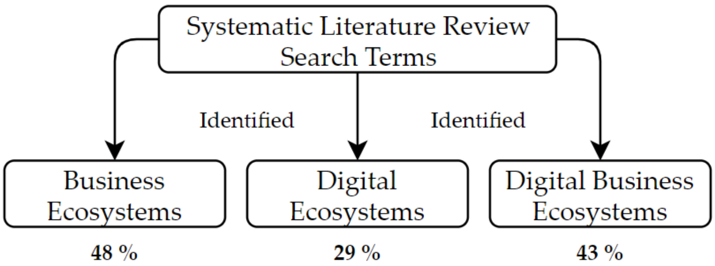

Figure 10: Identified Ecosystem Types Top-3

In 1993, Moore was the first researcher to take up the word 'business ecosystem' to refer to systems of actors that maintain relationships of coopetition. The term was derived from the field of biology, and in line with the numerous interdependent species within a natural ecosystem, business ecosystems also consisted of interdependent networks of organisations (Mäkinen & Dedehayir, 2012). Below, the definition for business ecosystems, proposed by Moore (1993) is shown:

> "An economic community supported by a foundation of interacting organisations and individuals – the 'organisms of the business world'. This economic community produces goods and services of value to customers, who themselves are a member of the ecosystem".

In addition to this definition, the author points out that for an ecosystem to be healthy, there must be a proper balance between cooperation and competition by the ecosystem participants (Moore, 1996).

In contrast to the notion of business ecosystems, digital ecosystems served as a digital counterpart of biological ecosystems (Averian, 2017). It was pointed out by Briscoe, Sadedin, & De Wilde (2011) that the term 'digital ecosystem' has been used to describe a variety of concepts, including the existing networking infrastructure of the Internet, Artificial Life research for complex systems and the future development of Information and Communications Technology (ICT) adoption for e-businesses, to support business ecosystems. Consequently, the following definition of digital ecosystems was proposed by Li, Badr, & Biennier (2012)/

> "A self-organising, scalable and sustainable system composed of heterogeneous digital entities and their interrelations focusing on interactions among entities to increase system utility, gain benefits and promote information sharing, inner and inter cooperation and system innovation" (Li et al., 2012).

The synthesis of the concept of DBE originated from 2002, where Nachira added 'digital' to Moore's (1996) concept of business ecosystems. Unlike Moore (2003), who one year later also used the word to focus exclusively on developing countries, Nachira proposed this term to refer to a new interpretation of what 'socio-economic development catalysed by ICTs' (Nachira, 2002). With the concept of DBE, a new emphasis was placed on the coevolution between the business ecosystem and its digital counterpart, the digital ecosystem. As pointed out in their research, "It was through the experience of mutual discovery between the technical and the socio-economic spheres of research that the concept of digital ecosystem was born and coupled with the concept of business ecosystem to create the digital business ecosystem" (Nachira, Nicolai, Dini, Louarn, & Leon, 2007). Consequently, in his study, the researcher defined DBEs as:

> "A "digital environment" populated by "digital species" which could be software components, applications, services, knowledge, business models, training modules, contractual frameworks, laws, …" (Nachira, 2002).

However, more recently, Senyo et al. described DBEs as an extension of the BEs concept (that generally portray generic organisational interdependence) by placing more importance on the centrality of digital technology (Senyo et al., 2019). This statement is furthermore supported by Camarinha-Matos & Afsarmanesh (2012), who argue that DBEs are simply BEs with a focus on ICT support. They furthermore mention that a DBE is comprised of two tiers, namely the BE and the DE. Thus, their definition is as follows:

> "A socio-technical environment of individuals, organisations and digital technologies with collaborative and competitive relationships to co-create value through shared digital platforms" (Senyo et al., 2019).

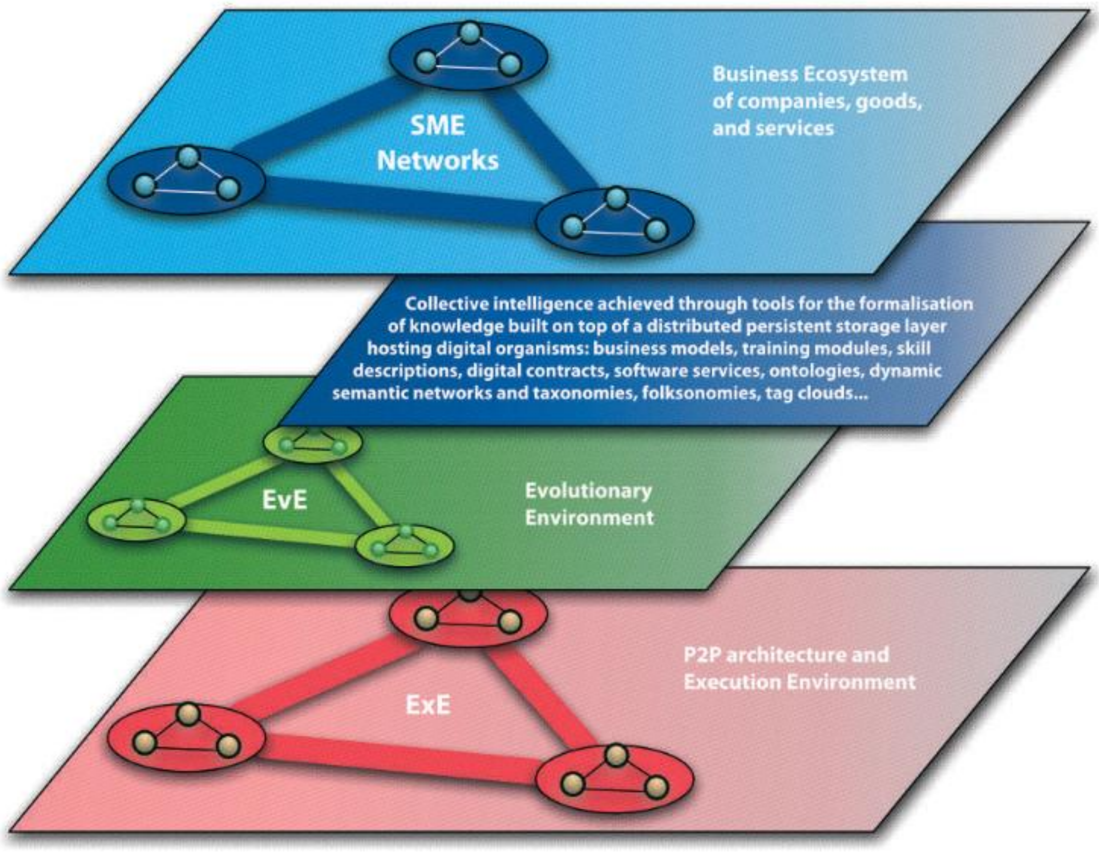

Figure 11: Stacked View of the Digital Business Ecosystem (Nachira et al., 2007)

The definition described above has consequently also been adopted in this research, considering its completeness. In Figure 11, the DBE is broken down into a stacked view. It becomes clear that within the DBE, the BE serves as the SME Network, containing the participating organisations and individuals of the ecosystem as a whole. The authors have included the Evolutionary Environment (EvE) as an extra layer to the DBE. Similar to a BE, where all the actors are interdependent and "coevolve their capabilities and roles" (Moore, 1996), in a DBE there exists a similar relationship between the biological- and software behaviour (Nachira et al., 2007). The third and last stack of the DBE is formed by the DE. The DE provides the technical infrastructure and is based on a Peer-to-Peer (P2P) distributed software technology (Nachira et al., 2007).

2.4 Function of Enterprise Architecture

From academic literature, it becomes apparent that in today's business environments, organisations are increasingly intertwined with complex ecosystems (Drews & Schirmer, 2014; Korhonen et al., 2016). These ecosystems extend beyond the boundaries of the organisations and can include several 'external' entities such as customers, suppliers, partners and even governments (Korhonen et al., 2016). The usage of Enterprise Architecture (EA) practices to support the strategic and business-IT alignment in digital (business) ecosystems has been proposed by both Drews & Schirmer (2014) and Vargas et al. (2013). Employing EA, organisations, ecosystems, and their architectures can be reconfigured more quickly and adapt better to the changing circumstances in their environments (Korhonen & Halén, 2017). Moreover, an enhanced degree of alignment is necessary, considering that organisations themselves are also becoming increasingly complex and more demanding towards flexible business processes supported by efficient IT infrastructures (Vargas et al., 2013).

Architectures developed through existing EA frameworks and method can serve as blueprints for both organisations and digital business ecosystems by providing a shared understanding of their organisational structures (Ramljak, 2017). Furthermore, the blueprints can be used to align strategic objectives and 'tactical demands', as was pointed out by Ramljak (2017). This is of utmost importance, as it helps to regard a business network as an ecosystem, allowing for enhanced understanding of the implications of a decision on an ecosystem participant on its environment (Wang & Wilde, 2008).

Moreover, the use of Enterprise Architecture (Management) was proposed by Zimmermann et al., (2018) to better organise and utilise distributed capabilities for the digital transformation by complex relationships between architectural elements. This way, the impact on both business and technology strategies by the transformation can be better managed (Zimmermann et al., 2018). Additionally, as mentioned by Korhonen et al. (2016), it is imperative to continuously adapt to changes originating from the business, information, social and technological landscape. Vargas et al. (2013) furthermore point out that the application of Enterprise Engineering (EE), using an EA approach, enables organisations to effectively manage the increasing technological complexity accrued while generating added value to their business processes and, at the same time, attempting to achieve integration and coordinate their processes with other ecosystem participants. This process supports the pursuit of efficiency and competitiveness to ensure survival in today's global market.

Currently, existing EA frameworks can provide the most thorough combination of modelling methods, techniques and languages, allowing for the planning, design and implementation of systems (M. A. R. Bakhtiyari, 2017). Considering that numerous companies are attempting to better support the tasks of strategic-, business-IT alignment and project portfolio management, EA can be leveraged for this purpose (Drews & Schirmer, 2014). Moreover, Drews & Schirmer (2014) stress that the goals and benefits of Enterprise Architecture Management (EAM) comprise transparency, improved business-IT alignment and the strategic controlling of the IT environment.

2.5 Adaptability Requirements

In this section, the following research question is addressed:

Which architectural requirements influence digital business ecosystem adaptability?

2.5.1 Selected Literature

The selected papers of the first iteration of the SLR lacked a specific focus on adaptability, considering that knowledge on that specific topic lacked during the first iteration. Subsequently, a second iteration of the SLR focussed specifically on adaptability in D(B)Es. The resulting list of papers, that were used for the answering of research question 2, therefore combined a selection of papers from both iterations. Table 18 in Appendix B.2. Selected Core Papers provides a list of the selected papers.

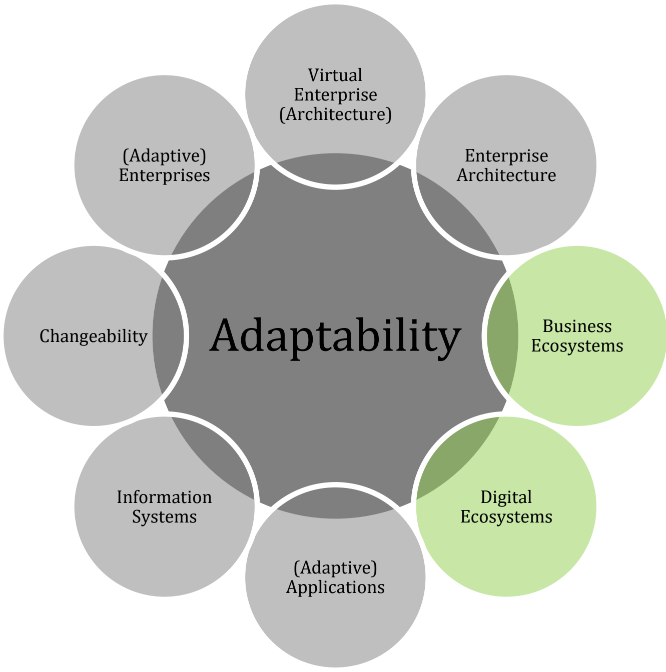

Figure 12: Identified Adaptability Research Topics

As pointed out previously, research on DBEs remains novel. Moreover, DBE research specifically on the topic of adaptability is even more scarce and conceptual (Senyo et al., 2019). Therefore, the search for literature related to adaptability was extended towards several other areas of research, as visible in Figure 12. The decision to include several related fields of study was made to enhance the amount of data on adaptability. Nevertheless, the results shown in Section 2.5.2 must be critically checked on their validity when transferred towards the DBE area of research. More specifically, the generalisability of the identified requirements can be unclear. Therefore, methodological triangulation is applied to verify (and enhance) the generalisability of the requirements (Guion, Diehl, & Mcdonald, 2002; Leung, 2015). Subsequently, the identified requirements are validated throughout the qualitative interviews and furthermore checked on validity during the case study. Both iterations of validation take place with experts from the field of ecosystems and therefore, the generalisability of the requirements can be enhanced.

2.5.2 Identified Adaptability Requirements

The SLR has led to the identification of fifteen papers providing highly relevant information on the topic of adaptability in several related areas of research. The literature was carefully analysed and synthesised in line with the protocol addressed in Appendix A.3. Literature Review Protocol The review has subsequently led to the classification of fifteen adaptability requirements, as are vertically outlined in Figure 14 and in more detail in Table 20 in the Appendix. From the overview, it becomes apparent that the requirements differ significantly in terms of prevalence. This phenomenon can be explained by the fact that these requirements were extracted from the literature on eight different research topics (Figure 12) and therefore, are perceived differently.

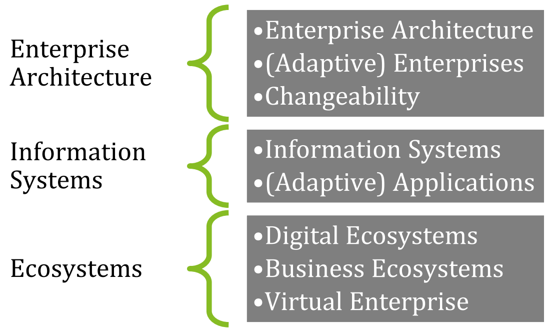

Figure 13: Adaptability Requirements Research Topics

The research topics of the selected papers could be traced back into three separate categories, namely: Enterprise Architecture (EA), Information Systems (IS) and Ecosystems as can be seen in Figure 13. These research topics contained several sub-categories, which were grouped based on their descriptions provided by the respective authors. The research topics of the literature served to ensure that the requirements covered at least the majority of the analysis's topics. Therefore, a prevalence threshold of 25% was introduced alongside the prerequisite that an adaptability requirement was addressed by at least two out of three research topics. The introduced prerequisites led to the selection of five general requirements for adaptability: awareness, continuity, flexibility, scalability and self-organisation. Below, these requirements are addressed based on the outcomes of the literature review.

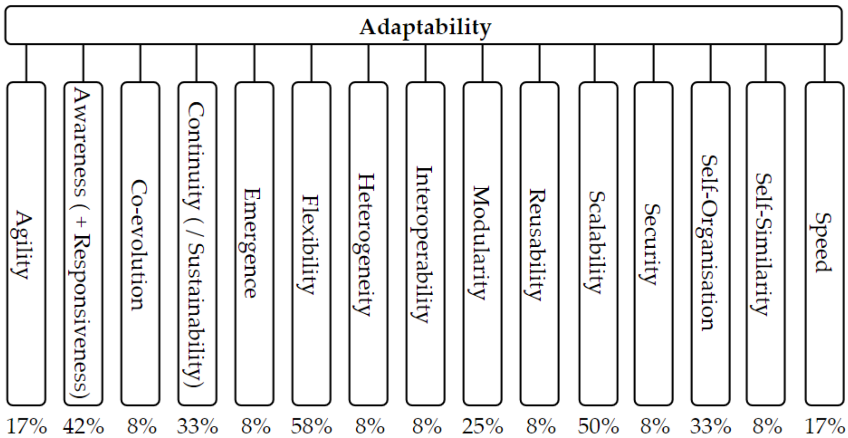

Figure 14: Adaptability Requirements Literature Overview

2.5.3 Awareness

Several authors highlight the importance of awareness in achieving adaptability. Introducing awareness as a design principle for the digital ecosystem implicates that the ecosystem must continuously assess its state and running context and subsequently take decisions to adjust its state towards newly established goals (Averian, 2018a). Averian (2018) referred to this type of awareness as 'context-awareness' and addressed it as the usage of contextual information for improved responding to user's requests. Korhonen, Lapalme, McDavid, & Gill (2016) have proposed a similar approach which states that, in their context of EA, to enhance adaptability EA should go beyond a single organisation and furthermore appreciate the 'enterprise-in-environment' ecosystemic perspective. In the context of DBEs, this would imply that adaptability is achieved by extending the perspective beyond the ecosystem and fully appreciating an ecosystem-in-environment perspective.

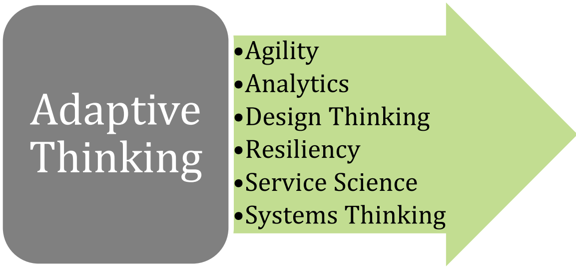

Figure 15: The Gill Framework® V3.0
(Adapted from Gill (2015))

In support of this statement, Korhonen et al. (2016) acknowledge the Gill Framework V3.0 designed by Gill (2015). Throughout the framework, the principle of analytics is addressed to illustrate the ability to "monitor, collect, analyse, and interpret data and information for actionable insights or changes or decision making" (Gill, 2015). These analytics could be of several types, including descriptive, diagnostic and predictive and are aimed at addressing the needs of stakeholders. Moreover, Korhonen et al. (2016) address context-awareness with the principle of 'systems thinking', stressing the need for a holistic approach. This approach could also support the requirement of awareness by identifying barriers and resistances that might stand in the way of change as a result to decisions made for newly established goals (Yu et al., 2012).

The requirement of awareness has also been referred to as 'responsiveness' (Masuda et al., 2017). The authors point out that it entails the ability to appropriately respond to dealing with changes while sensing situations. From this standpoint, technology scans could be executed to facilitate changes while sensing for new situations and updating the technology standard based on TOGAF (Masuda et al., 2017).

2.5.4 Continuity

A second frequently mentioned requirement in the systematic literature review was 'continuity'. Several authors underline the importance of continuous adaptation towards changes in the business, information, social and technological landscape (Korhonen et al., 2016; Li et al., 2012; van de Wetering & Bos, 2017). The authors furthermore discuss the focus of traditional EA, which was mostly on process standardisation and integration. Nevertheless, continuous adaptation is of utmost importance and should be an ongoing process supporting coherence and co-evolution with the environment (Korhonen et al., 2016).

Zimmermann et al. (2018) acknowledges the importance of continuity within adaptability and proposed a reference model to allow for open integration through a continuously bottom-up approach. Furthermore, they claim that adaptability can be characterised with continuous development and integration processes working mostly in smaller environments. Nevertheless, the authors recognise the challenges that come with continuous integration and intend to reduce these.

Both Li et al. (2012) and van de Wetering & Bos (2017) mention that the continuously changing requirements (originating from the ecosystemic environment) are the driving force for continuous adaptation by increased absorptive capabilities. To achieve this goal, co-evolution and dynamic interactions can be fostered so that there can be a focus on both technological, business and organisational requirement changes. The architecture should furthermore be flexible and allow for both expected and unexpected changes so that strategic objectives, goals and demands can continuously change within organisations.

2.5.5 Flexibility

Up to 67% of the selected studies from the SLR stressed the importance of incorporating flexibility in the design of adaptable Enterprise Architectures, information systems or ecosystem-oriented architectures. Part of its importance moreover originates from its contribution towards an increasing competitive advantage (van de Wetering & Bos, 2017). Flexibility can refer to the ability to enable flexible and rapid responses (change) in light of both expected and unexpected changes that lead to new requirements (Korhonen et al., 2016; Lapalme et al., 2016). However, several authors also recognise a predefined range of possible states or built-in provisions for anticipating to these changes if and when they materialise (Andresen & Gronau, 2006; Yu et al., 2012). Yu et al. (2012) furthermore address several propositions for flexibility, including the creation of flexible technology infrastructures, the adoption of configurable architectures and systems, the adoption of suitable organisational structures or the training of involved personnel.

In their paper, Fricke & Schulz (2005) highlight the differences between flexibility and agility, which are frequently mixed up. They point out that flexibility, the ability to be changed easily, differs from agility, addressing the ability to be changed rapidly. Flexibility is nevertheless identified and included in the Adaptive EA Framework proposed by Gill (2015), as visualised in Figure 15, as part of the agility principle. However, in their Adaptive Integrated EA Framework, Masuda et al. (2017) address the requirement separately.

2.5.6 Scalability

From the SLR results, another frequently mentioned requirement could be identified: scalability. Although the requirement is defined slightly different, depending on the field of research it was studied in, general outcomes can be identified. In their research, (Li et al., 2012) have performed an extensive literature review and deduced the following definition of scalability in the context of digital ecosystems (DE): “To a certain degree, a digital ecosystem is scalable if its performance stays effective and efficient while a large amount of input data or large quantities of heterogeneous participating entities are added”. In short, their proposed definition describes “the ability of a system, network or process to handle growing amounts of work in a graceful manner or its ability to be enlarged to accommodate that growth” (Li et al., 2012).

Several other researchers have proposed definitions similar to the one proposed by Li et al. (2012). As such, although proposed in the context of changeable systems, Dantas & Borba (2003) describe that extensibility, covering the same concepts as scalability, can make it more simple to achieve and subsequently minimise the potential impacts causes by the incorporation of new context elements. In line with that definition, adaptability in digital ecosystems would implicate that a system can admit a more significant number of connected entities, meaning that the system must be open to admitting the addition of new participants in a flexible way (Averian, 2018b). Fricke & Schulz (2005) lastly acknowledge that scalability implicates that units are independent of scale, both in the form of scaling upwards or downwards. In addition, the authors point out two approaches to tackling scalability. Either, several elements can be linked together to provide scaled performance, or a single element may be scaled through its characteristics' parameters.

2.5.7 Self-Organisation

The final adaptability requirement that was frequently mentioned throughout the selected core papers is 'self-organisation' (Andresen & Gronau, 2006; Korhonen et al., 2016; Li et al., 2012; Peltoniemi & Vuori, 2004). Self-organisation was first defined to demonstrate the spontaneous emergence of structures through local interactions (Li et al., 2012). As pointed out by Peltoniemi & Vuori (2004), the concept has been defined ambiguously in the existing literature. Nevertheless, the authors have attempted to draw the definition from features and functions of self-organisation described in related fields of study and for related terms. One of the suggestions provided by the authors describes the requirement as "the ability of complex systems to create new order and coherence" (Peltoniemi & Vuori, 2004). Moreover, they state that self-organisation comprises a process where there exists no internal or external leader who sets goals or is in control of the system. Instead, the events tend to occur spontaneously and are caused by local interactions (Peltoniemi & Vuori, 2004).

Peltoniemi & Vuori (2004) moreover refer to several author studies that have attempted to consolidate the terminology of self-organisation. Similarly, the notion is defined as "a process in which novel structures or features arise in a system without the intervention of an outside or inside controller". Self-organisation is an ongoing process since it will never have completed its outcome. (Peltoniemi & Vuori, 2004)". The researchers Li et al. (2012) have also attempted to propose a definition of self-organisation and stated "for an evolving agent population, the system for which its organisation is context-dependent, the perspective to which it is relative, and the self by which it is caused, a definition for its self-organisation can be considered".

The requirement of self-organisation perceivably appears in ecosystems. In that context, the formation of ecosystems can be seen as a process. Throughout the formation, ecosystem partners or vendors are gathered voluntarily. Moreover, the ecosystemic goals are defined through local interactions and negotiation among participants. The evolvement is continuous as connections are created and dissolved all the time (Peltoniemi & Vuori, 2004).

2.6 Adaptability Capabilities

For the semi-systematic identification process of adaptability capabilities, the literature listed in Table 18 has been used. This list contained academic literature on adaptability constructs, both on a higher, generic DBE level and more specific on adaptability, incorporating information from several reference disciplines, as illustrated in Figure 12. These papers proved useful for the identification of (higher-level) design requirements yet lacked sufficient detail and empirical data for identifying capabilities. This finding is further substantiated by Senyo et al. (2019), who present a classification on empirical and non-empirical research performed in the field of DBE research. From their figures, it becomes apparent that more than 50% of the published DBE research is not based on any research methodology or method and can, therefore, be categorised as 'non-empirical'. Therefore, the decision has been made to apply a semi-systematic approach for identifying capabilities, as was further elaborated in Section 2.1.3.

Table 18 listed a total of fifteen unique papers. The reviewing process resulted in the exclusion of three additional papers, as they lacked relevant information for the answering of this section's research question. The twelve remaining papers resulted in the semi-systematic identification of forty capabilities, as illustrated in Appendix B.5. SSLR - Adaptability Capabilities. The obtained capabilities contained different granularities and were not mapped onto the previously identified requirements. Moreover, most of the capabilities (78%) were merely mentioned once, which could be explained by the fact that the papers originated from numerous reference disciplines and were mostly based on their authors' conceptual orientation.

To ensure the generalisability and applicability of the method, the incorporation of these results was restricted to capabilities that were explicitly mentioned at least twice. This prerequisite resulted in the selection of the following capabilities:

1. (Platform) Independence

Fricke & Schulz (2005) describe the principle of independence as the ability to minimise the impact of changing design parameters. When described in the context of adaptive applications, Dantas & Borba (2003) argue that the general structure of an application should apply to a comprehensive set of systems, ranging from enterprise applications to embedded systems.

2. Agility

Agility is one of the adaptive principles proposed by Gill (2015). Being agile in the context of adaptive Enterprise Architecture implicates that it, as a design and practice, could enable flexible and timely responses to both expected and unexpected changes by adopting lean and learning techniques in support of adaptation (Korhonen et al., 2016).

1. Analytics

Yu et al. (2012) stress the relevance of adopting (data) analytics to advance the adaptiveness of enterprises. The capability enables organisations to obtain insights in their environments and internal operations more quickly and recognise potential needs for change so that appropriate actions can be taken in response. This statement is further substantiated by Korhonen et al. (2016), who define it as "the ability to monitor, collect, analyse, and interpret data and information for actionable insights or changes or decision making".

2. Autonomy

Fricke & Schulz (2005) mention that independence could be perceived as a prerequisite for autonomy. This capability is defined by objects, capable of providing basic functionality for ensuring their independence from, for example, embedded systems. This principle is key to achieving adaptability (Fricke & Schulz, 2005).

3. Leanness

In their study, Masuda et al. (2017) have categorised leanness as an element related to agility. Moreover, the element describes the operation of EA with minimal resources without compromising quality. Korhonen et al. (2016) acknowledge that observation and describes leanness as a principle of agility

4. Loose Coupling

This capability involves applying poorly coupled processing modules and an additional communication layer, allowing the digital entities in the digital ecosystem to be decoupled in time and space (Averian, 2018b). Furthermore, van de Wetering & Bos (2017) describe loose coupling as a design principle for modular systems resulting in efficacious adaptive enterprises.

5. Modularity

Modular architectures can support the reuse of elements, modules or an entire section of an EA, within a particular scope of functionality and defined interfaces (Fricke & Schulz, 2005). Modularity depicts the clustering of the system's functions into various modules, while moreover minimalizing the coupling amongst these modules and maximising their cohesion (Fricke & Schulz, 2005).

6. Security

Averian (2018b) stresses the fact that some areas of a digital ecosystem will imply a strong connection between the digital world and the physical world. The connection is made to realise a secure system, and the DE model should include multilevel security measures, including authorisation and identification of digital entities, users, protection of data and authentication.

2.6.1 Capability Relations

The definitions of the selected definitions presented in the previous section highlight several dependencies among multiple capabilities. These dependencies and an overview of the remaining capabilities are illustrated in Figure 16.

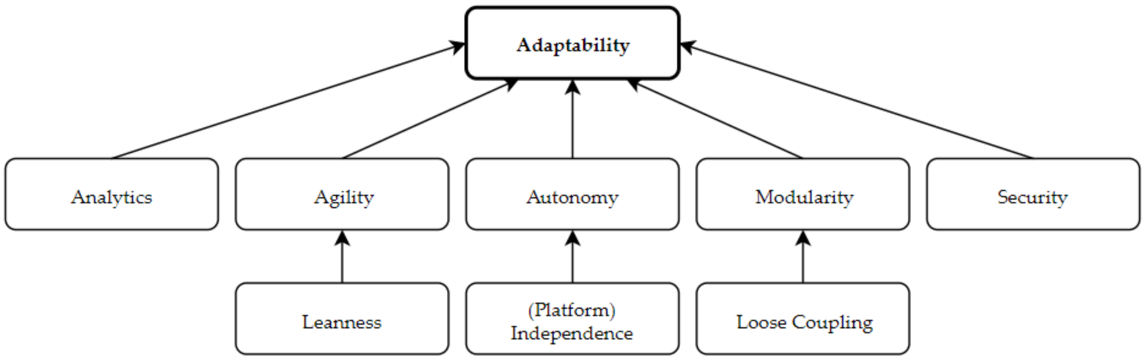

Figure 16: Semi-Systematic Capability Relations Overview

3 RESEARCH METHOD

In this section, the applied research methods for numerous steps of this research are addressed. In the first sub-section, the conceptual adaptability framework, interpreting the identified findings from the literature review phase, is illustrated and discussed. The following section described the conducted interview method for the collection of additional data. After that, the methods involved in the extension of an existing EA method are described, comprising an explanation for the selection of an existing EA method and the intended steps for the extension of the selected method. In the final section of this chapter, the validation method is addressed.

3.1 Conceptual Adaptability Framework

The literature review described in the previous chapter has provided essential insights into digital business ecosystems (DBE) and their relationships with their environments, Enterprise Architecture (EA) and adaptability constructs. The primary purpose of the conceptual framework, as shown in Figure 17, is to ensure that the interview participants interpret the presented findings from the literature review in a standardised way. This framework illustrates the characteristics of DBEs and provides insights into its context and how the adaptability constructs are constructed. Consequently, the goal of this conceptual adaptability framework is to enhance the communication regarding the findings of the literature review and allowing for a systematic and standardised data collection process on respective capabilities. For the development of this model, the meta-model provided by ISO/IEC/IEEE pertaining to architecture descriptions has been taken as a reference point (ISO/IEC/IEEE 42010, 2011).

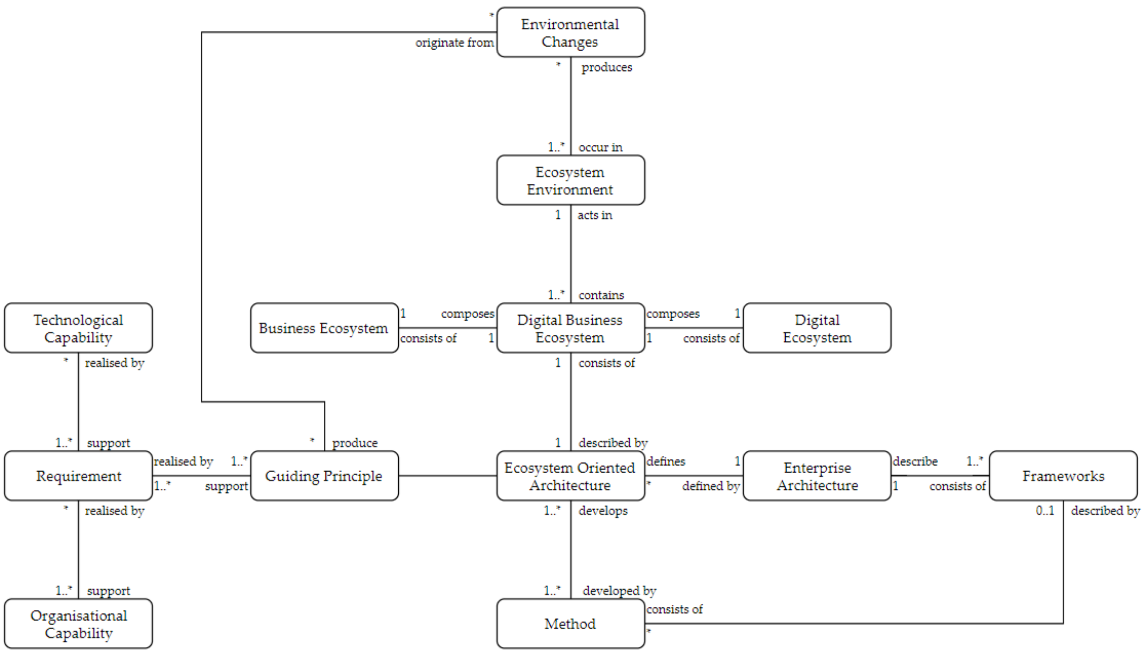

Figure 17: Conceptual Adaptability Framework

3.2 Interviews

The performed systematic literature review (SLR) has significantly contributed to the identification of DBE adaptability requirements. Moreover, by means of the SLR, an initial list of usable capabilities for the enhancement of DBE adaptability could be presented. Nevertheless, considering the novelty of the DBE area of research, the identification of capabilities proved insufficient and lacked completeness and mapping on the adaptability requirements. As such, capability-level data were qualitatively collected through interviews. The decision to employ interviews as a qualitative data collection method was made considering that the SLR provided insufficient information to draft, for example, a questionnaire.

Moreover, due to the novelty of the DBE area of research and the employment of DBEs in practice, limited cases where DBEs have been designed were available, excluding the available quantitative data collection methods (Rowley, 2012). Furthermore, interviews offer the possibility to uncover information that would not have been accessible using quantitative methods, such as questionnaires (Alshenqeeti, 2014). In line with that statement, Rowley (2012) points out that interviews are especially useful as a qualitative research method when the researcher is interested in collecting 'facts' and wishes to gain insights into understand respondent's opinions and experiences. Alshenqeeti (2014) furthermore point out that interviews allow for more accurate data as mutual understanding can be ensured, as the interview can rephrase, simplify or ask follow-up questions throughout the sessions.

3.2.1 Interview Design

There exists a range of formats for structuring interviews. Since the participants of the interviews originate, preferably, from different backgrounds concerning digital ecosystems, a degree of structure using predetermined questions can help to improve the results' generalizability and validity (Doody & Noonan, 2013). Nevertheless, allowing some flexibility by using additional sub-questions or prompts ensures that the central questions of the interview are explored sufficiently (Rowley, 2012). Therefore, semi-structured interviews, using open-ended qualitative questions, are considered most suitable for this context.

Rowley (2012) highlight the importance of interviewing a sufficient number of persons so that several sources of variability that could influence the findings, such as different respondent roles, experiences and background, are included in the study. Generally, Rowley (2012) suggest the execution of approximately twelve interviews of around thirty minutes. Several other authors have also acknowledged Rowley's statement. Guest, Bunce, & Johnson (2006) have analysed the number of interviews necessary to achieve code saturation (referred to as data saturation), the point wherein this research no new adaptability capabilities are identified. Their findings show that saturation generally occurs within the first twelve interviews, although basic elements could be identified in as little as six interviews. Galvin (2015) also substantiates the threshold of twelve interviews, by referring to 'theoretical saturation', the point where newly collected data no longer improves the researcher's understanding of research topics and the data no longer contributes to the researcher's ability to build theory. As such, for this research, a minimum of twelve interviews are executed to ensure the results' saturation and validity.

It is highly important to design an interview protocol (IP) in advance of the interviews, as the protocol allows the interviewer to collect responses (data) in a similar way (Doody & Noonan, 2013). For the design of the IP, essential concepts have been drawn from the Interview Protocol Refinement Framework (IPR) proposed by Castillo-Montoya (2016), as illustrated in Figure 18. In line with the first phase of the IPR, the questions of the IP were drafted. As such, the questions were categorised into four different focus areas for the interviews, as can be seen below. The first section served to properly introduce the respondent to the topic and the section after that aimed to validate the identified requirements so that the proposed capabilities of all respondents can be generalised. The third focus area mapped directly onto sub-question three. Finally, sub-question four was answered by the last focus area of the interview. By introducing the mentioned four-area categories, the interview analysis phase could be significantly simplified as the results required no further summarisation per research question.

1. Digital ecosystems (relevance and observed changes)
2. Adaptability requirements
3. Adaptability approaches
4. Role of Enterprise Architecture for designing digital ecosystems

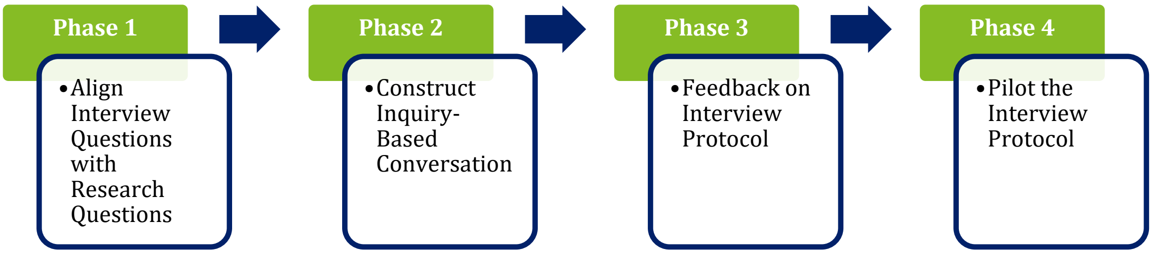

Figure 18: The Four-Phase Process to Interview Protocol Refinement (IPR) (Adapted from (Castillo-Montoya, 2016))

To construct an inquiry-based conversation, the interview questions (based on the research questions) were reformulated following social rules of ordinary conversations as proposed by Castillo-Montoya (2016). Moreover, optional follow-up and prompt questions were included in addition to numerous introductory, transitional and closing questions. Lastly, several scripts were drafted as part of the IP, that could guide the researcher throughout the interview so that a more natural conversational style could be achieved (Doody & Noonan, 2013). These steps enhanced the general flow of the interview and strengthened the reliability of the interview protocol as an instrument for data collection.

Whereas the first two phases primarily focus on the development of a 'healthy' interview protocol, the third phase served to put it to practice and received feedback on the protocol. Feedback on the IP is of utmost importance as it shows the participants' understanding of the interview questions and whether their understanding is close to what the interviewer intends (Patton, 2015). Due to time constraints, no IP checklist, as proposed by Castillo-Montoya (2016), was created. Instead, the interview protocol was first carefully evaluated with two EA experts, leading to the adding, removing and simplification of several questions and sections in the IP. Having developed an IP, the first two interviews served as pilots, as prescribed by the fourth and last phase. Due to time constraints, the results from both interviews were not excluded from the actual study, but instead, an additional thirty minutes was added to the interview sessions, allowing for an extensive evaluation of the effectiveness of the IP.

3.2.2 Interview Participants

Due to the novelty of Digital Business Ecosystems (DBE), this research is limited concerning the number of suitable organisations that can be included in the scope of the interviews. Nevertheless, in line with the threshold introduced in Section 3.2.1, at least twelve interviews must be executed to ensure sufficient saturation of their results. For this research, in light of the shortage of available organisation, DBE-related projects have been selected as the primary reference point instead. Considering that a single company can be active in involved in multiple DBE-related projects, this allows for the inclusion of a more significant number of respondents.

For this research' interview phase, eight unique cases, or DBE-related projects, were selected, as described in Section 4.2.2. These cases were, combined, part of four unique organisations (Section 4.2.1). Moreover, from these eight cases, thirteen respondents were interviewed as part of the research. These respondents, including some of their details, are listed in Table 6. Lastly, as some of the respondents were interviewed simultaneously, eleven separate interviews have been performed, as can be seen in Table 5. Due to time constraints of the respondents, the decision was made to do one interview collectively, limited the total number of interviews to eleven. Nevertheless, as was pointed out by Rowley (2012), flexibility is allowed between the total number of interviews and their respective duration. As such, the average duration of the interviews (Section 4.2) was almost twice the length as proposed by Rowley (2012), therefore reducing the limitations caused by the shortage of one interview.

3.2.3 Data Collection

For the initial, exploratory, interviews, the entire Semi-Structured Interview Protocol, as shown in Appendix D.4. Interview Protocol was used as a guideline. Nevertheless, throughout the following interviews, the researcher opted more frequently for the Interview Shortlist, as shown in Appendix D.5. Interview Shortlist, as that could enhance the 'natural' flow of conversation, by allowing for more interacting and fewer scripted information (Castillo-Montoya, 2016). The protocol, however, was still included as back-up, so that no questions were missed at any point. The interviews were conducted in a face-to-face setting and were, with the permission of the respondent, recorded for future transcription.

The first part of the interview contained several introductory questions with regards to the professional background of the respondent alongside several questions about the ecosystem that served as the case. The second and third section of the interview served to cover several definitions and validation questions with regards to digital business ecosystems (DBE) and adaptability, as defined using the collected academic literature. In the fifth section, the interviewer aimed to identify capabilities for adaptability and map these on the previously discussed adaptability requirements. During the sixth and last section, the role of Enterprise Architecture within DBE-related projects was discussed. Each of the above sections is addressed in detail in Appendix D.4. Interview Protocol and moreover briefly listed in Appendix D.5. Interview Shortlist.

3.2.4 Data Analysis

In the first place, the eleven interview audio-recordings have been carefully transcribed using the principles listed in the transcription protocol developed by McLellan, MacQueen, & Neidig (2003). Consequently, the transcriptions were nearly exact reproductions (verbatim accounts) of the actual interviews, structured and in similar transcription standards. As the majority of the interviews covered confidential and sensitive information, respondents were provided with the entire transcript for acknowledgement and possible comments or feedback, in line with the transcription guidelines addressed in Appendix D.4. Interview Protocol (McLellan et al., 2003). Moreover, the researcher could only continue to the analysis of the transcripts after explicit permission from the respondent had been received and, if available, comments were processed.

For the analysis of the interview data, three analysis phases were identified based on the Gioia Methodology for Inductive Research (Gioia, Corley, & Hamilton, 2012) and the Grounded Theory Method developed by Corbin & Strauss (2014). The analysis phases have been visualised in Figure 19. The first phase, referred to as '1st-order analysis' by Gioia et al. (2012), serves to identify all relevant information from the interview data (transcripts), adhering to the respondents' terms and minimising the distillation of higher-order categories. Subsequently, the 1st-order analysis phase produced a list of 1st order concepts surrounding the asked interview questions. The second step in the analysis process is to explore the similarities and differences among the identified concepts. Based on that, the list of concepts can be further refined into '2nd-order themes'. The 2nd-order should be greatly reduced in size and have become more manageable in terms of numbers (Gioia et al., 2012). Moreover, by means of the refinement into 2nd-order themes, utilising the findings provided by the experts from the area of DBEs, the concepts were split up into several sections:

- Theme 1: Awareness
- Theme 2: Continuity
- Theme 3: Flexibility
- Theme 4: Scalability
- Theme 5: Self-Organisation
- Theme 6: EA Role
- Theme 7: DBE Characteristics

As prescribed by Gioia et al. (2012), the select themes should moreover be described and labelled, providing the necessary structure for the third and last analysis phase. As part of the last phase, the 2nd-order themes must be analysed to see "whether it is possible to distil the emergent 2nd-order themes even further into 2nd-order aggregate dimensions" (Gioia et al., 2012). Having finished the last step, work can be conducted to develop a data structure for the identified capabilities.

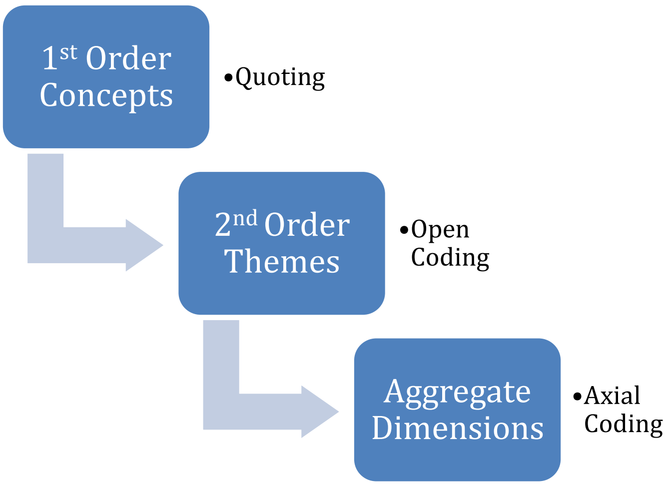

Figure 19: Data Analysis Phases Combined With Atlas.ti

The process described above uses the terminology provided by (Gioia et al., 2012). Nevertheless, throughout this research Atlas.ti™ is used as a qualitative data analysis tool, using a different terminology, similar to the notions used by Corbin & Strauss (2014), for describing the process illustrated in Figure 19. The decision to use Atlas.ti™ as qualitative analysis tool was made as it is a commonly used tool, as acknowledged by McLellan et al. (2003), that provides numerous features for extensive and in-depth analyses of qualitative data. In Atlas.ti™, the process of selecting 1st Order Concepts is done by quoting the developed transcripts. Thereafter, the process of 'open coding' leads to the identification of 2nd Order Themes. Lastly, axial coding comprises the final step of the analysis process and serves to aggregate the selected themes. The exact process, as conducted using Atlas.ti™, is described in detail in Section 4.1.

3.2.5 Interview Validity

The analysis process of the interview transcripts, as described above, has been frequently debated with regards to its subjectivity (Kvale, 1994). Nevertheless, several measures were taken to mitigate the claimed subjectivity of the analysis coding process. First, the aggregated dimensions have been carefully reviewed employing peers (Campuslabs, n.d.). Consequently, several capabilities were additionally merged, and inclusion thresholds increased. Moreover, the identified capabilities were verified with the preliminary findings from the Semi-Systematic Literature Review to support the researcher's interpretations and ensure that the findings were legitimate (Campuslabs, n.d.).

3.3 Method Selection

Throughout the past years, numerous EA frameworks have been developed, primarily to assist the implementation and utilisation of EA in many diverse ways (B. H. Cameron & Mcmillan, 2013). Although the available frameworks contain some overlap and address several similar views, generally, they have been designed to address specific needs or concerns (Urbaczewski & Mrdalj, 2006). Multiple academic studies have been devoted to comparative analyses of these architectural frameworks. As the main findings of this study are incorporated in a suitable method for the development of (ecosystem-oriented) architectures, the available comparative studies provide highly valuable insights into practical frameworks.

In their paper, B. B. H. Cameron & Mcmillan (2013) provided results of their comparative analysis of the five leading EA frameworks, which include DoDAF, FEA, Gartner, the TOGAF Standard and Zachman. The leading EA frameworks were selected based on survey responses provided by 271 participants and were mapped on twelve constructs defined through a careful analysis of the obtained open-ended responses. The results of their analysis are illustrated in Table 3 (B. B. H. Cameron & Mcmillan, 2013).

With regards to Table 3, it becomes apparent that the TOGAF Standard was categorised as 'very satisfied' most frequently. Moreover, the results show that the Standard is most used for its alignment with industry standards, availability of architectural knowledge, Architectural Development Method (ADM), interoperability, flexibility in using elements, process completeness and vendor-neutrality (B. B. H. Cameron & Mcmillan, 2013). Clearly, the ADM provided in the TOGAF Standard best reflects the EA SMEs requirements.

In line with the findings obtained from academic literature, the interviews executed as part of this research' data collection phase show similar results with regards to the most applicable EA framework or method that is currently available. The results, described in Section 4.3.3, show that numerous interview participants have, at least to some extent, used TOGAF throughout the design of a Digital (Business) Ecosystem. Consequently, it was concluded that, at this moment, TOGAF does not entirely cover the design of Ecosystem-oriented Architectures but is still frequently adopted throughout projects as its generic way of thinking and work process remains highly relevant.

Table 3: Comparative Analysis of Existing EA Frameworks
(Adapted from B. B. H. Cameron & Mcmillan (2013))

Attributes / Criteria	Zachman	TOGAF	DoDAF	FEA	Gartner
Business-IT Alignment / Business Focus	1	3	1	1	4
Taxonomy Guidance	4	2	2	3	1
Reference-Models	1	3	2	4	1
Process Completeness	1	4	1	2	3
Maturity Assessment	1	2	2	3	3
Governance Support	1	2	3	3	3
Interoperability / Flexibility	2	4	3	3	2
Knowledge Repository / Availability of Information	2	4	2	2	1
Standards (Architecture, Industry, Government)	2	4	3	3	1
Best of Breed / Best Fit	2	4	2	3	1
Integration / Linkage Between Various Layers	3	4	2	3	2
Vendor Neutrality	2	4	2	3	1

| 1: Very Dissatisfied | 2: Dissatisfied | 3: Satisfied | 4: Very Satisfied |

Concluding, the decision was made to adopt the architecture development method (ADM), as part of the TOGAF Standard, for the inclusion of this research' results. Since the ADM is not prescriptive on several aspects, including the level of detail, the extent of architectural assets leveraged and breadth of coverage, the method allows for personal interpretations to best suit a particular project (Tang, Jun Han, & Pin Chen, 2004). Therefore, the adaptability constructs are applicable to the method, as it allows for the design of generic, informative models.

3.3.1 The TOGAF® Standard

The TOGAF Standard is a framework designed for Enterprise Architecture. The framework was designed by The Open Group, who released its first version in 1995. Although the framework comes with extensive documentation, The Open Group expects an organisation to customise it during adoption, and individually select and exclude elements of the framework, dependent on the context it is applied to (The Open Group, 2018). The Standard is composed of six parts, respectively:

1. Introduction
2. Architecture Development Method (ADM)
3. ADM Guidelines & Techniques
4. Architecture Content Framework
5. Enterprise Continuum & Tools
6. Architecture Capability Framework

As this research results in the identification of adaptability constructs that can be incorporated in the design of Ecosystem-oriented Architectures, the focus of this research is on the ADM, a step-by-step approach to developing an Enterprise Architecture. The ADM comprises "a method for developing and managing the lifecycle of an Enterprise Architecture, and forms the core of the TOGAF standard" (The Open Group, 2018).

3.3.2 Architecture Development Method

The ADM is an iterative method, both over the entirety of its process as well as between and within its phases. The cycle furthermore consists of multiple phases, as illustrated in Figure 20. In Appendix J: Architecture Development Method Phases, a brief description of each of the phases of the ADM is given. As described by The Open Group (2018), the ADM is a generic method that can be used to develop architectures. As such, the method allows for modifications and extensions to suit the specific needs of the actor using it. Therefore, an essential task before applying the method is to review each of its components to determine their applicability, and subsequently tailor them as appropriate to the circumstance of the organisation.

The receptiveness of the ADM towards being modified or extended enhances its applicability towards ecosystems. Nevertheless, existing academic literature highlights several challenges that originate from the application of existing EA frameworks and methods on the forming of ecosystems[‡]. Since adaptability has been identified as one of the major challenges, the goal of this research was to identify constructs for enhancing the adaptability of DBEs. Considering the receptiveness of the ADM, this method can be used to operationalise the adaptability constructs to highlight how it could be incorporated in the method if adaptability was taken as principle for the design phase. The adaptability constructs proposed in this research primarily affect the design phase of DBE, and respectively the ADM. The design phase is covered by the following steps of the ADM (The Open Group, 2018):

- Preliminary Phase
- Phase A: Architecture Vision
- Phase B: Business Architecture
- Phase C: Information Systems Architecture
- Phase D: Technology Architecture
- ADM Architecture Requirements Management

Subsequently, the research will cover the above-listed ADM phases as they are primarily impacted if adaptability is incorporated as an architectural principle for the design of DBEs.

3.3.3 ArchiMate

Whereas the ADM provides steps and techniques to guide its user through the entire development process of EA, ArchiMate is the visual language providing support for modelling the EA (Visual Paradigm, n.d.). Both standards are managed by The Open Group and, although they originate from different background with different objectives, can be used in conjunction with each other (Jonkers, Proper, & Turner, 2009). By complementing the ADM with ArchiMate, consistent and integrated models can be created, depicting the existing TOGAF views (The Open Group, 2017).

[‡] Research previously issued in Research Topics by the same author (Verhoeven, 2019).

The phases listed in Section 3.3.2 correspond to several elements provided by ArchiMate. The 'Preliminary', 'Architecture Vision' and 'Requirements Management' phases are mapped on the 'Strategy & Motivation' elements provided by ArchiMate. Moreover, the phases B, C and D map neatly on the core layers of ArchiMate, the Business-, Application- and Technology Layers (Estrem, Gonzalez, & Serge Thorn, 2014; The Open Group, 2017). This mapping is also illustrated in Figure 20, which shows onto what ADM phases ArchiMate can be mapped. Consequently, the Strategy & Motivation extensions are used in combination with the Core Layers to visualise/operationalise the identified adaptability constructs and highlight how they can be incorporated in the design of EOAs.

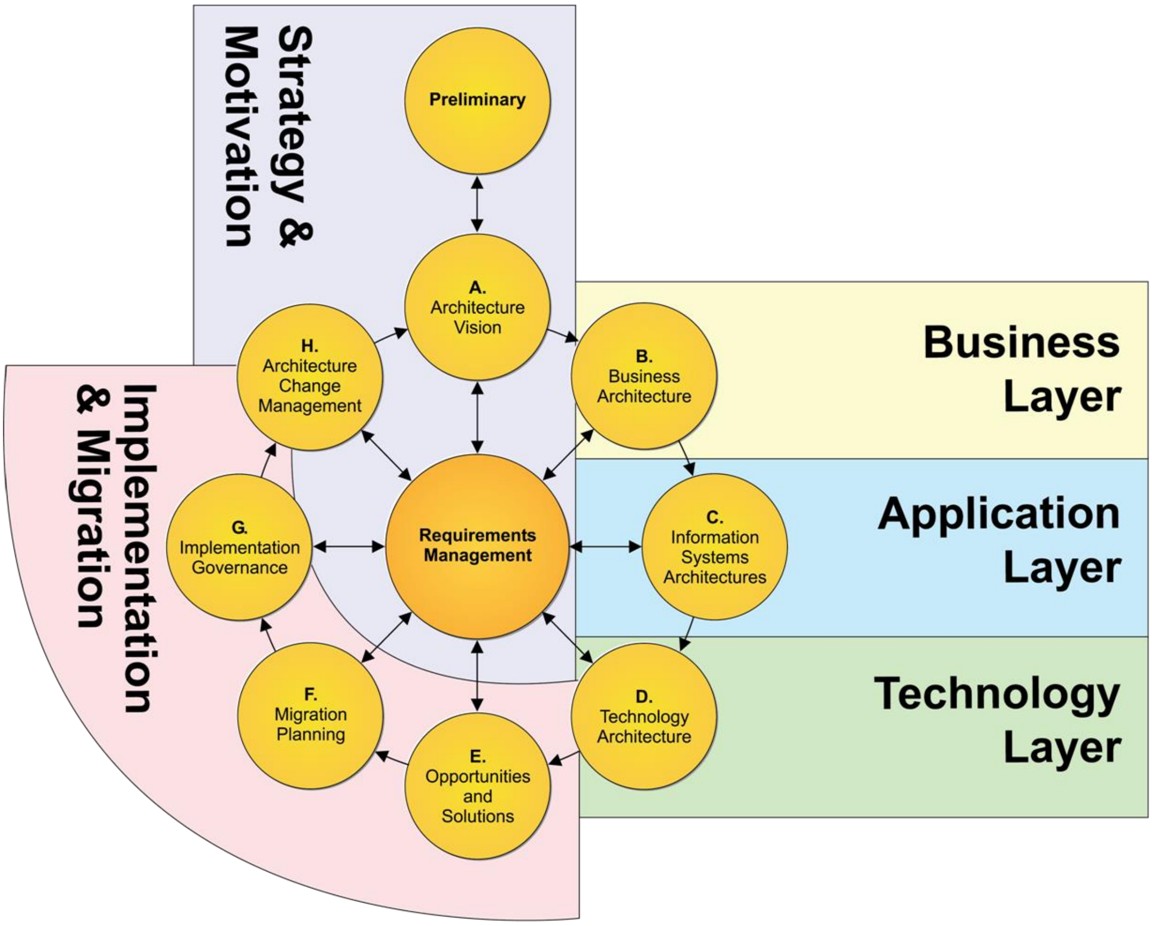

Figure 20: TOGAF ADM Mapped on ArchiMate
(The Open Group, 2018)

3.4 Method Extension

This section addresses the applied method for the answering of the last sub-question of this research, as can be seen below:

How can an EA method be extended to support the newly identified adaptability constructs?

This sub-question is essential for the answering of the main research question, stated in Section 1.3.4. The novel adaptability constructs referred to in the sub-question stated above, comprise the identified requirements and capabilities for the enhancement of DBE adaptability. Consequently, for an EA method to support the constructs, it must also support the development of EOAs. As a result, the TOGAF ADM is first extended to accommodate the development of EOAs and thereafter addressed and utilised to incorporate the novel adaptability constructs. In this section, the methodology used to achieve these objectives is addressed.

3.4.1 Method Extension

The TOGAF ADM, as illustrated in Figure 20, comprises a total of ten phases. By iteratively executing each of these phases, an architecture for an organisation can be developed. The adaptability constructs identified in this research are primarily applicable to the design phases of the ADM cycle. This is the case considering that, by incorporating adaptability as 'guiding design principle' for the development of an architecture in the initial strategy and motivation phases of the cycle, the subsequent architecture phases are thereafter affected. It is argued that the other phases, primarily subject of the Implementation & Migration phases remain unchanged by the inclusion of this principle and are too detailed and dependent on a specific case or project context. Thus, although the proposed adaptability constructs could, theoretically, be applied to all the phases of the ADM, in this research, the constructs are primarily incorporated in the phases involved in the design of the architecture. A description of each of the ADM phases, including the design phases, is provided in Appendix J: Architecture Development Method Phases. In the next section, the extension of the ADM design phases is addressed in more detail.

As listed in Section 3.3.2, the design section of the ADM comprises a total of six phases. To accommodate the identified ecosystemic adaptability constructs of this research, the phases must be extended to support both the development of EOAs for DBEs and the corresponding constructs. In this section, the current state of each of the phases is addressed, as well as the intended extension.

Preliminary

The first phase of the cycle contains several steps, as also described in Appendix J: Architecture Development Method Phases. In short, it is utilised for the description of the initiation and preparation activities required to meet the business objectives for a new EA. The level of detail addressed by this phase depends on the scope and goals of the overall architecture effort (The Open Group, 2018). Nevertheless, as in this research the aim is on incorporating adaptability constructs in the design of DBEs, several steps of this phase must be altered.

For the extension, the definition and establishment of architectural principles are limited towards the newly introduced principle of adaptability. Consequently, the next phases should be focussed on this principle. In addition, the Preliminary phase serves to establish an enterprise architecture team and organisation. As the to be developed architecture serves a DBE, rather than a single organisation, this step must be altered to fit the new organisational type. The scope and goals of the architecture, however, remain context-agnostic for this extension to be easily applied to different ecosystemic contexts.

With respect to ArchiMate, it is also recommended to develop an organisational model for the EA, or in this research: EOA. Consequently, the generic viewpoint illustrated in Figure 21 can be utilised. For this viewpoint of an ecosystem, ecosystem participants as categorised by Iansiti & Levien (2004) have been partially incorporated. Also, the distinction between partner and vendor was made based on the collected data from the literature review and the interviews.

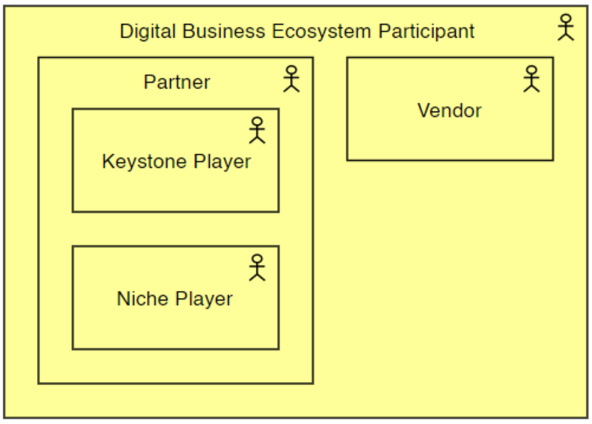

Figure 21: Generic Ecosystemic Organisational Model

Phase A: Architecture Vision

To a large extent, the Architecture Vision phase continues where the Preliminary phase ended. The phase contains several desired outcomes produced by related objectives and comprises the initial phase of the architecture development cycle. In short, the steps guide towards the development of a high-level vision of the to be delivered capabilities and business value. Furthermore, the phase serves to obtain approval for the (planned) architectural work that defines the program. In line with the previous phase, the principles, goals and drivers are further improved and worked out. For better insights, the objectives can be processed into a high-level representation, making use of the motivation extension provided by ArchiMate. Utilising that extension, an overview of the underlying motivation and drivers can be provided. Based on the identified adaptability constructs from the literature review and expert interviews, a generic motivation viewpoint which remains context-agnostic could be developed.

Besides the motivational details, it is also valuable to understand the baseline and target capabilities of the ecosystem and organisations. Nowadays, organisations and ecosystems are facing increasingly strong dynamic environments (Aldea et al., 2016; Korhonen et al., 2016; Valtonen et al., 2018). The changes originating from the environment force organisations to undertake more frequent transformations to maintain competitiveness and agility. Obtaining insight into what organisations and ecosystems can do (capabilities) can enhance the decision-making process (Aldea et al., 2016). Capabilities can provide high-level views of an organisation's current and desired capabilities, and relate to an organisation's strategy and environment (Ulrich & Rosen, 2011). Lankhorst (2016) subsequently defines a capability as "a definition of what an organisation needs to be able to do, in order to successfully achieve the outcomes that are defined as part of the corporate strategy". In a more specific ArchiMate context, capabilities are defined as "an ability that an active structure element, such as an organisation, person, or system, possesses (The Open Group, 2017).

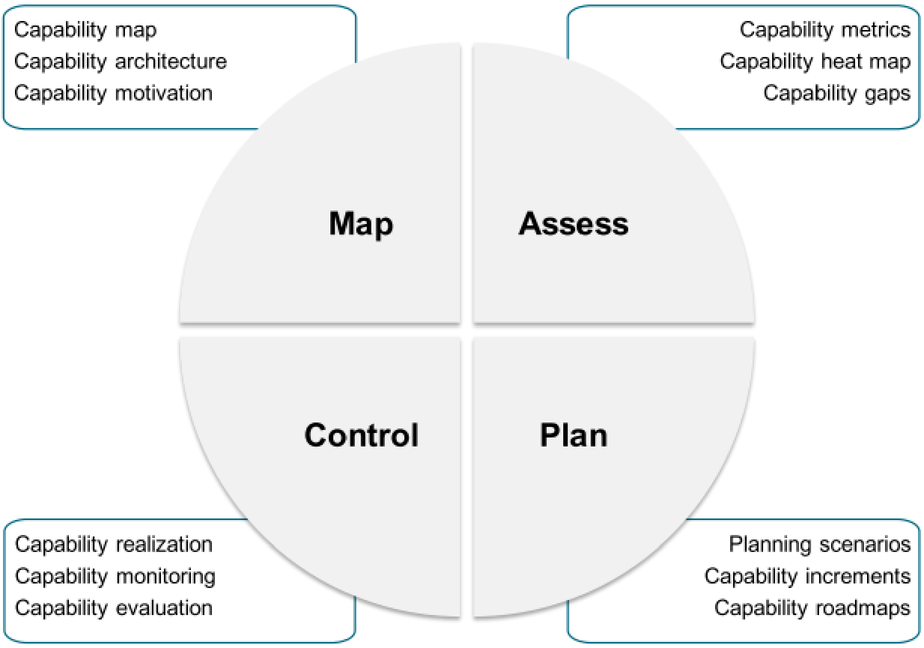

Figure 22: Generic Capability-Based Planning Activities
(Aldea et al., 2016)

Although primarily defined in the context of organisations, this research adopts the concept for application to digital ecosystems. Lankhorst (2016) proposed several guidelines for the successful definition of capabilities. Transitioned towards ecosystems, the following can be noted:

1. A capability defines what the ecosystem does or could do. It does not define how this is done or who is doing it. The same capability can be implemented in several ways, for example, manual or fully automated.
2. Capabilities are owned by the ecosystem and must be easily interpreted by the involved participants. They are defined as nouns.
3. Capabilities are unique and stable. They must be defined merely once and, preferably, should not change.
4. Capabilities may consist of sub-capabilities. Furthermore, a capability may use another capability.
5. Capabilities can be organised in a capability map. This map provides an overview of each capability in the ecosystem.
6. The maturity of an ecosystem can be assessed across several dimensions. For example, the EA capabilities shown in Figure 3 could serve as a basis for Capability-Based Planning (CBP).

Capabilities are most commonly used by means of Capability-Based Planning (CBP). This technique primarily focuses on the planning, engineering, and delivery of strategic capabilities (The Open Group, 2018). Numerous activities can be identified in CBP, as illustrated in Figure 22. These activities are generally executed in successive order. However, drivers of the planning cycle may require increased or decreased attention to several activities. As mentioned previously, the execution and possible order of the CBP activities can depend on the strategic plan defined within an organisation or Digital Business Ecosystem (DBE). If in combination with CBP, the Architecture Development Method (ADM), which have both been developed by The Open Group® is adopted for the design of Ecosystem-oriented Architectures (EOA), the relationship between the capabilities and ADM phases becomes clear. Considering that this research focusses on the design of adaptable digital ecosystems, phases A, B, C, D, commonly referred to as the Architecture Context and Architecture Delivery phases, are incorporated in the adaptability method. Therefore, Capability Increments and their designated Building Blocks (Figure 23) are excluded from this research. Moreover, as CBP requires an application on an existing organisational case and this research is not based on merely one case as it intends to produce a generically applicable 'Adaptability by Design' method, the exclusion of Capability Increments and Building Blocks is further substantiated.

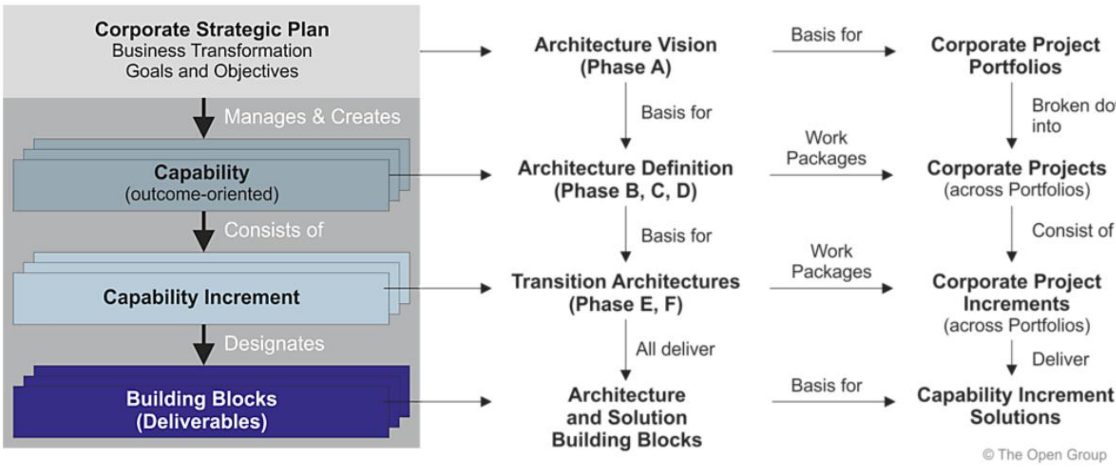

Figure 23: Relationship Between Capabilities, Enterprise Architecture, and Projects
(The Open Group, 2018)

In preparation towards continuing to the architecture phases of the ADM (B, C, D) it can be useful to develop high-level representations of the capabilities supporting the defined goals and objectives. Throughout the architecture phases, these capabilities can subsequently be incorporated in the architectural models so that increments can be better identified in the subsequent phases (E and F).

The capabilities obtained through a combination of the Semi-Systematic Literature Review (SSLR) and the interviews can be structured in a Capability Map, using the prescribed CBP technique. The capability map is used to model the required capabilities for a future state, specifically for enhanced adaptability in digital ecosystems (Lankhorst, 2016). For this mapping, a top-down perspective is adopted, as capabilities will be derived from the predefined strategic direction of the organisation (Figure 24). Lankhorst (2016) lastly mentions that there can exist main capability, that can be further decomposed into more specific capabilities. Although this perspective has been adopted in this research, another level was added as 'requirement', which have been identified throughout the Systematic Literature Review (SLR). Therefore, the decomposition contains requirements, capabilities and sub-capabilities.

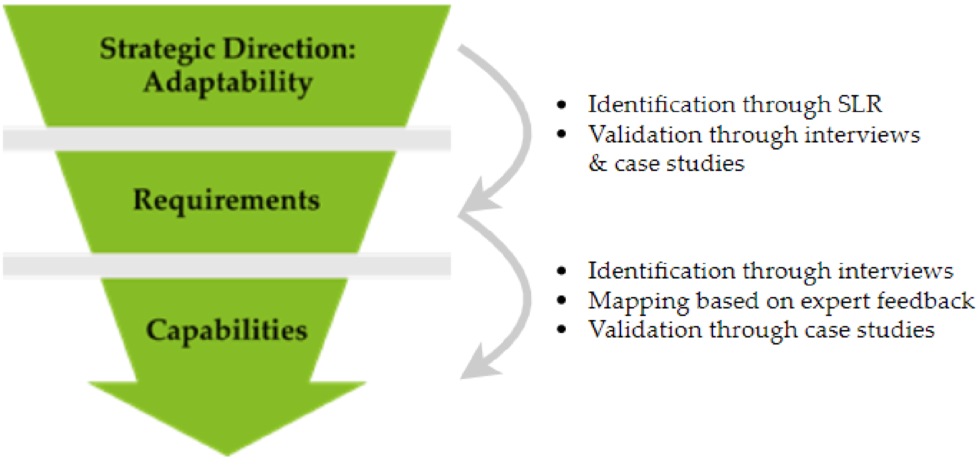

Figure 24: Top-Down Perspective on Capability Decomposition

Architecture Phases B, C & D

The following three phases of the TOGAF ADM focus on the development of architectures to support the previously defined architecture vision. Architects are free to choose reference models, viewpoints and tools that are best tailored to the project context. The three phases each have similar objectives. Firstly, a target architecture should be developed, describing the way enterprises, or ecosystems in this research's context, need to operate to achieve the business goals. Moreover, a candidate architecture roadmap should be identified based upon the gaps between the baseline and the target architecture.

The extension of the TOGAF ADM is conducted to facilitate a relevant guideline for the incorporation of adaptability constructs in the development of ecosystem-oriented architectures. As these guidelines are supposed to be context-agnostic, so that the generic information can be further tailored and applied to new DBE-related projects, no fixed baseline and target architectures can be developed. Instead, the research findings are extensively discussed and validated using a case study approach, as described in Section 3.5. The results of the validation sessions can subsequently be used for the development of a high-line baseline architecture and a corresponding target architecture that includes the proposed capabilities.

3.4.2 Modelling Language Extension

The ArchiMate® Enterprise Architecture Modelling Language, or simply ArchiMate, is an open and independent modelling language for EA (The Open Group, 2017). The language provides essential instruments to enable, for example, architectures to describe, analyse and visualise the relationships among business domains (The Open Group, 2017). Consequently, if used alongside the ADM, the cycle provides the steps and techniques for guidance throughout the development process, whereas ArchiMate can provide the corresponding modelling support. In this section, the method for extending the TOGAF ADM to facilitate the identified ecosystemic adaptability constructs is addressed. Consequently, a novel extension of ArchiMate must also be proposed to accommodate the induced changes towards the ADM.

Considering the design phases of the architectural development method, two extensions provided by ArchiMate can be identified: Strategy & Motivation and Core Layers. Below, the extension method for these ArchiMate extensions is discussed.

Strategy & Motivation Extension

The Strategy & Motivation extension provided by ArchiMate can be used to primarily support three phases of the TOGAF ADM, namely: Preliminary, Architecture Vision and Requirements Management. As prescribed by TOGAF, these phases can be used to establish high-level business goals, architecture principles, and initial business requirements. The ArchiMate extension subsequently allows for the modelling of business goals, drivers for change, principles, requirements and stakeholders.

For the adaptability extension, it is necessary to illustrate how both the Strategy and Motivation components can be extended to support DBEs and the adaptability constructs. As pointed out previously, this must be done on a high-level and context-agnostic level, considering the lack of a specific case. Thereafter, the case studies conducted as part of the validation phase can serve as a use case for the application of the extension and the development of architectural viewpoints using ArchiMate.

ArchiMate Core Layers

The last three phases involved in the design process comprise the architecture for the business, information and technology layers. Employing ArchiMate, these layers and their interrelationships, as defined by the TOGAF Framework, can be modelled. Nevertheless, no context-agnostic viewpoints for the core layers, incorporating the adaptability constructs for DBEs, can be developed due to their dependency on a case or project context. Consequently, as pointed out in the previous section, the validation case is utilised for the visualisation of potential viewpoints, incorporating the proposed constructs through data collected in the case studies.

3.5 Validation

The identified adaptability constructs and their mapping onto the TOGAF ADM must be carefully validated and evaluated on their quality, are the obtained findings to be utilised in practice and incorporated in the design phases of DBE projects. In their paper, Noble & Smith (2015) show that "qualitative research is frequently criticised for lacking scientific rigour with poor justification of the methods adopted, lack of transparency in the analytical procedures and the findings being merely a collection of personal opinions subject to researcher bias". Consequently, it is of utmost importance to demonstrate the rigour of the undertaken research. The Design Cycle, developed by Wieringa (2014) as part of the Design Science Methodology and adopted as primary methodology throughout this research, also includes a substantial section on 'Treatment Validation'. This section highlights the importance of justifying the contribution of the treatment to the goals of stakeholders when implemented in the problem context and verifying that the requirements for treatment are satisfied (Wieringa, 2014).

3.5.1 Validation Method Selection

There exist numerous methods that can be applied to validate academic research. The research by Wieringa (2014) facilitated a reduction of the available validation methods by carefully inspecting their characteristics. In Figure 25, the methods that resulted from the conducted cutback are illustrated. In the overview, the author furthermore categorises the research methods on their applicability towards validation research. Consequently, the methods marked in bold proved to be useful in validation research.

The key results of this research are summarised and listed below. Summarising, the research contributes important insights into constructs necessary to incorporate adaptability in the design of DBEs. Furthermore, the adaptability constructs are processed into an existing method for architectural development, providing essential guidelines for adaptability.

1. The current state of research on DBEs
2. Architectural requirements for incorporating adaptability in the design of DBEs
3. Organisation and technological capabilities supporting the requirements (+ mapping)
4. Extension of an existing EA method to support the incorporation of adaptability constructs in the development of EOAs
5. Extension of an existing EA modelling language to accommodate the proposed changes to the EA method

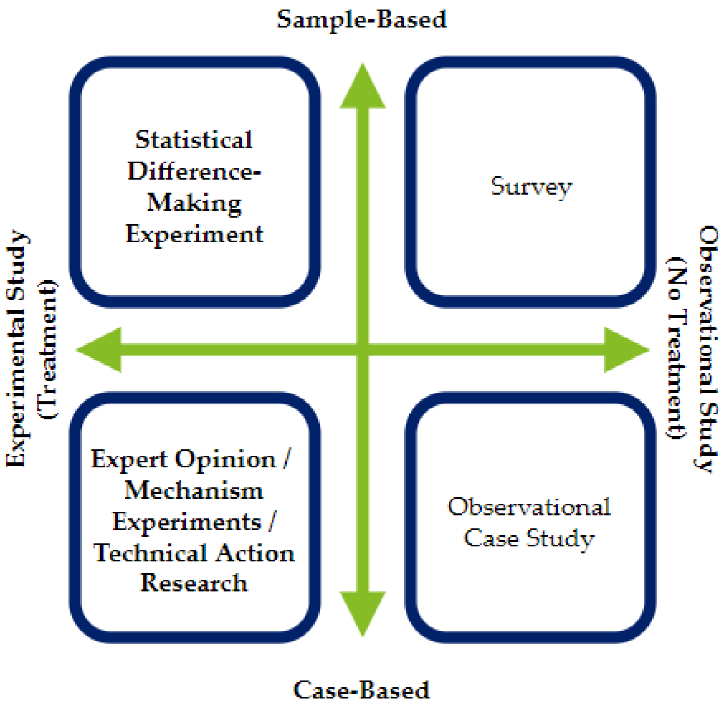

Figure 25: Empirical Research Methods
(Adapted from Wieringa (2014))

As a result, the validation process serves to validate the proposed extension of the TOGAF ADM, that incorporates adaptability constructs in the design process of Ecosystem-oriented Architectures. Due to resource limitations, for this research, it is not possible to adopt a sample-based research method. This is due to the novelty of the field of DBEs, resulting in a limited set of cases that are available for data collection and validation. Consequently, a case-based approach is adopted for the validation process. The method, or artefact, in this context serves as the case and can be used to retrieve information about its applicability and relevance. In addition, observational studies lack usefulness for validation research, as was pointed out by Wieringa (2014). Concludingly, for this research' validation method, the Expert Opinion Research Method was used. For the Expert Opinion Research Method, experts are asked about the perceived usability and utility of the new artefact in the contexts that they know first-hand (Wieringa, 2014). As furthermore pointed out by Wieringa (2014), several measurement instruments, such as interviews or questionnaires, can be utilised for this method. Furthermore, it is essential that the conducted scenarios with the experts are representative for the total population.

3.5.2 Approach Evaluation

As the Expert Opinion validation method includes a single case to validate the results of this research, an initial evaluation session could serve as a pilot for the Expert Opinion sessions and improve the structure and approach of the sessions. This is necessary to ensure that each validation session participant fully understands the presented information so that results (mechanisms) can be collected in a standardised way, enhancing their generalisability. Moreover, it could highlight any remaining unclarities and offers experts the opportunity to provide feedback.

3.5.3 Case Study

The 'Treatment Validation' phase prescribed by Wieringa (2014) as part of the Design Science Methodology is used to validate artefacts by applying it to their defined problem context. This is done to verify whether the artefact contributes towards a solution of the research problem, adaptability in this case.

Case Study Design

In their research, Yin (2013) identifies four main types of case study designs. These designs are separated based on the number of cases included and the number of units that are included in the analysis. The case study in this research follows the guidelines for a single-case design. In light of the novelty of the DBE area of research and practice, a limited number of DBE cases is available for analysis. Furthermore, as DBEs are comprised of multiple participants and vendors, it becomes more valuable to study multiple entities within one ecosystem, than multiple entities divided over an equal number of ecosystems. Yin (2013) describes five unique rationales that can justify the adoption of a single-case experiment. One of the proposed rationales highlights that, once the selected case is the 'representative or typical' case, a single-case study can be adopted. In the context of ecosystems, it could be argued that one ecosystem could represent a 'typical' ecosystem in its class. Moreover, the lessons learned from observing one ecosystem can be assumed to provide valuable information about the mechanisms in other ecosystems as well.

Besides the single-case design approach that will be adopted for the validation process, the case-study should include multiple embedded units of analysis. This is necessary to ensure that multiple participants of an ecosystem are involved so that the results can be compared and generalised. Moreover, it allows for the analysis of internal mechanisms and relations. Consequently, the adopted case study design for this research' validation session comprises a single-case and embedded design.

The goal of the case study is to validate the identified adaptability constructs (requirements and capabilities) and the subsequent extension of the TOGAF ADM towards a context of DBEs and incorporating adaptability as a design principle in the architecture vision of EOAs. This is done by applying the ADM extension to practice and subsequently observe its interaction with the intended DBE case context. The results of this study are presented to the interview participants through a standardised presentation. In addition to a description of the research and the validation session, this presentation contains an overview of the results, presented step-by-step utilising the design phases part of the TOGAF ADM. Moreover, the respondents are asked numerous questions with the main purpose to validate the relevance and applicability of the adaptability constructs with regards to the case. These questions, part of the validation guide, can be found in Appendix G: Case Study Guide. Although the guide contains scripted questions and scores that must be individually graded, at the beginning of the validation session it is pointed out that sufficient time is allocated for in-depth discussions to further substantiate the to be given scores.

For the quality of the validation results and given the single-case approach, at least two different ecosystem participants should be involved in the sessions. Moreover, participants should have matching 'roles' compared to the participants of the interviews. The results of the validation sessions are used to further refine and optimise the proposed adaptability constructs and their mapping onto the TOGAF ADM.

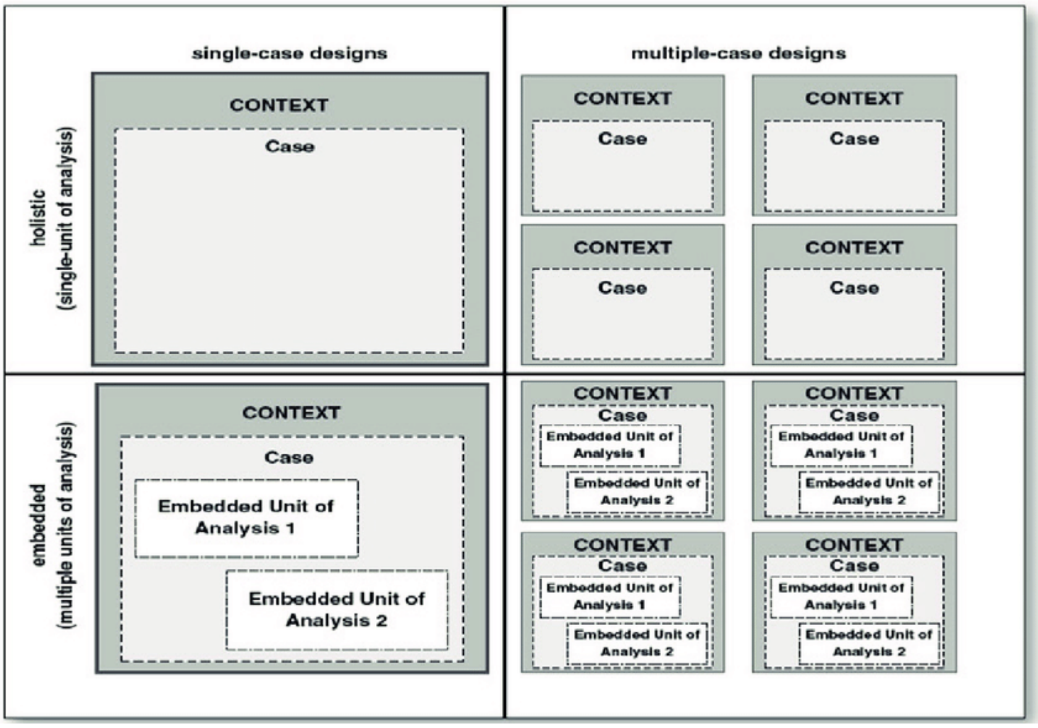

Figure 26: Basic Types of Designs for Case Studies
(Yin, 2013)

Case Selection

A large number of DBE cases and experts have been involved in the data collection phase of this research through the semi-structured interviews. Yin (2013) stress the importance of carefully screening the nominations of the case study as preparatory step in the final selection. The case of this study was screened to ensure that it had not been involved as case in the interview phase and that no interviewed SMEs were primarily active within the case. In addition, the case was mapped on this study's definition of DBEs to ensure that it matched the definition. Furthermore, the selected case study participants were screened on their professional background. To avoid bias, they were explicitly requested to answer the validation questions based on the selected case, ignoring their personal opinion or experience with other cases that could have been already involved in the interview phase. Moreover, interview participants were not eligible to join the validation sessions.

Lastly, the selected case was subjected to some other prerequisites. Firstly, the project must have completed its initial design phase, as the adaptability constructs apply to that phase. Moreover, the participants must be able (allowed) to share, anonymised, architectural details with the researcher so that these can be incorporated in the core layers of the TOGAF ADM as part of the viewpoint development.

Data Collection

Data was primarily collected employing a questionnaire, which can be found in Appendix G: Case Study Guide. The questionnaire contained both fixed scale and open-ended questions. Whereas the fixed scale questions served to score the results on their relevance and applicability to the selected case, the open-ended questions were developed to facilitate discussions and discuss the structure and architecture of the case in more detail. The questionnaire was filled in during the case study to allow for follow-up questions to the provided scores and insights. Moreover, the validation sessions were audio-recorded so that the interpretation of the results can be re-evaluated.

Data Analysis

As pointed out previously, data using the case studies was collected through a questionnaire, filled in by the researcher during the case study. The introductory part of the case studies comprised several professional experience related questions, as well as questions on the relevance and importance of adaptability for the case study. The obtained answers, which were obtained verbally and through open-ended questions, are summarised and described in Section 6. The scoring of each requirement and capability on their relevance and consideration can be processed into a table, containing the average scores for each construct, as can be seen in Appendix H: Adaptability Constructs Grading.

The verbal comments and additional findings that were obtained throughout the case studies have been informally summarised and were used as a basis for the development of DBE adaptability viewpoints. In these viewpoints, the case has been used as core and was subsequently extending using the proposed adaptability constructs.

Case Study Validity

The application of case studies as a method for validating the findings of the research leads to relatively strong internal validity but lacks sufficient external validity (Yin, 2013). To enhance the internal validity of the sessions, they were conducted in person and verbally over a timespan of two hours. This allowed for enough time to ask follow-up questions and clarification and explanations for the presented answers. Also, an attempt to improve the external validity of the research was made by involving experts active in multiple different companies, each active in the same DBE. As such, different perspectives and participants types were included, yet the results could be compared and generalised, considering that they each focussed on the same DBE and, thus, same case.

The conducted case studies can be utilised to highlight the applicability of the adaptability constructs to the selected case. Nevertheless, the results lack statistical significance and validation to be able to generalise to other types of DBEs. However, the guidelines for this validation method can serve as a reference for future, follow-up research, as addressed in Section 7.4.

4 INTERVIEW RESULTS

This section addresses the results obtained as a result of the performed interviews. Section 4.1 contains a brief overview of the interview analysis phase and corresponding figures. In the next section, an overview of the interviews is presented, including brief descriptions of the included organisations and cases. In Section 4.3, the results obtained throughout the interviews are discussed. The section covers the validation of the identified requirements, identification of corresponding capabilities and moreover provides new insights into the role of Enterprise Architecture (frameworks and methods) for the design of Digital Ecosystems (DE).

4.1 Analysis Overview

In this session, an overview of the performed analysis of the interviews is given. Firstly, it summarises the transcription phase, used for producing transcripts out of the audio recordings. Afterwards, it is shown how, using Atlas.ti™, the results are processed by means of the quoting, open coding and axial coding steps.

4.1.1 Transcription

In line with the described methodology in Section 3.2.3, the first phase of the analysis process consisted of producing transcripts of the interviews, using the audio recordings. The transcription process of the eleven performed interviews has resulted in 123 pages of verbatim transcripts, on average, eleven pages per interview. Subsequently, the interviews have been fully anonymised and sent to the respondents for approval. Once the respondents had given their feedback and approval, the transcripts could be used for further analysis. The transcripts, which are written in Dutch, are not attached to this report but can be requested separately.

4.1.2 Quoting

For the next stage phase of the analysis, Atlas.ti™ has been used as a qualitative data analysis tool. Subsequently, the transcripts have been quoted in correspondence with the Interview Protocol (IP) from Appendix D: Interview Guide. The quotation phase served to identify all relevant sections that contain potentially interesting information towards the answering of the research questions. Moreover, the quotes supported the separation of the transcripts into the pre-defined sections, as listed below:

1. Digital ecosystems (relevance and observed changes)
2. Adaptability requirements
3. Adaptability approaches
4. Role of Enterprise Architecture for designing digital ecosystems

The separated quotes for each of these sections significantly reduced the required work for identifying relevant information from the interviews, as merely the newly made quotations had to be included in the next analysis phase. Moreover, by initially going through the quotation phase, the quality of the subsequent codes could be further increased.

4.1.3 Open Coding

The next phase in the analysis process of the interviews' transcripts comprised the open coding phase. This analysis was done inductively and followed the 'bottom-up' approach (Wijngaarden, 2019). The interviews that had served as exploratory interviews were analysed first and used to develop a coding scheme so that no preconceived thoughts on the data could be superimposed on the open codes. Nevertheless, the coding scheme purely served to ensure that codes for each section were identified and categorised accordingly. Moreover, the coding scheme was revisited several times throughout the open coding of the remaining transcripts.

The open coding process resulted in 229 codes, that were equally often mentioned in the transcripts (Appendix C: Interview Results). Furthermore, the codes were subdivided into the four sections listed in Section 4.1.2. The number of codes per each section is summarised in Table 4.

Table 4: Open Coding Results

Interview Section	Codes
Digital ecosystems	49
• Relevance	36
• Observed changes	13
Adaptability requirements	0
Adaptability capabilities	148
Role of Enterprise Architecture	32

4.1.4 Axial Coding

The adaptability capabilities identified as open codes were further refined in the axial coding phase and moreover categorised into overarching, higher-level capability concepts. This allowed for a grouping of the open capability codes into subsets. In total, 26 higher-level axial codes were identified. In Table 22, shown in Appendix C.1. Axial Codes Overview the axial codes and their subsets are addressed in more detail.

4.2 Interview Overview

As part of the qualitative research phase, eleven separate interviews were conducted with thirteen Subject-Matter Experts (SME) experienced with the field of digital ecosystems, as listed in Table 5. Besides, these experts were active at four separate organisations, referred to as organisation A, B, C or D as anonymously described in Section 4.2.1. As the qualitative research served to identify specific capabilities used throughout projects related to digital ecosystems, the SMEs were interviewed based on a specific DE project (referred to as 'case'). Moreover, these cases served as primary information source and experts were selected based on them, to prevent multiple experts from a single case to corrupt the validity of the results. The made selection allowed for the collection of insights from, in total, eight different DE cases, that each resembled the description of DEs used throughout this research. These combined prerequisites have led to the list of interviews shown in Table 5 and, on average, took up 00:51:44, which matches the prescribed interview duration by Rowley (2012).

Table 5: Interviews Context Overview

Interview	Respondent	Organisation	Digital Ecosystem Case
I1	R1	O1	C1
I2	R2	O1	C2
I3	R3	O1	C4
I4	R4	O1	C3
I5	R5	O1	N/A
I6	R6	O2	C3
I7	R7	O1	C1
I8	R8	O1	C5
I9	R9	O3	C6
I9	R10	O3	C7
I9	R11	O3	C7
I10	R12	O1	C8
I11	R13	O4	C1

Although the DE Cases were taken as the primary reference for the selection of interview participants, the selection additionally focussed on selecting a wide-ranging group of respondent roles. As a result, three primary groups could be identified within the set of respondents, respectively: consultants, developers and business/technology leads, as is listed in detail in Table 6. This selection enhanced the overall generalisability of the obtained results, but also led to results originating from several different perspectives, causing difficulties throughout the axial coding phases. The methodology applied for the synthetisation of the interview results is addressed in more detail in Section 3.2.3.

Table 6: Interview & Respondent Details

Respondent	Duration	Role
R1	01:00:41	Enterprise Architecture Senior Consultant
R2	00:57:58	Enterprise Architecture Senior Consultant
R3	01:04:33	Enterprise Architecture Senior Manager
R4	00:54:02	Cloud Engineering Senior Consultant
R5	01:05:06	Enterprise Architecture Director
R6	00:48:31	Specialist & Technology Lead
R7	00:41:26	Enterprise Architecture Senior Consultant
R8	00:48:50	Enterprise Architecture Senior Manager
R9	00:53:43	Risk Information Manager
R10	00:53:43	Enterprise Architect
R11	00:53:43	Enterprise & Business Architect
R12	00:35:44	Blockchain & Risk Senior Consultant
R13	00:34:38	Solution Architect & Project Manager

4.2.1 Organisations

To enhance the generalisability and cross-industry applicability of this research, the eleven interviews were conducted at four different organisations originating from two industries. As a result of the novelty of the practice surrounding digital ecosystems, the number of industries was somewhat limited to and included Consulting- and Financial Services, as can be seen in Table 7. Since many industries were excluded as a result of the selected organisations, the cases were selected over a broader range of industries to enhance the external validity of the collected data. In Section 4.2.2, the selected cases are briefly discussed. Below, a short description of the four organisations is presented.

Table 7: Organisation Industries

Organisation	Industry
O1	Consulting Services
O2	Financial Services
O3	
O4	

Organisation O1

A large section of the respondents originated from Deloitte Netherlands. Also, the respondents were active in three departments within Deloitte, namely: Cloud Engineering, Enterprise Architecture and Risk Advisory. The respondents had furthermore been active at projects in different industries, which improves the generalisability of the interview results.

Organisation O2

This is a financial organisation active within 35+ countries worldwide. Recently, in light of the new PSD2 regulations, they have significantly increased their efforts towards building and participating in digital ecosystems.

Organisation O3

Organisation C is also a financial organisation, but considering its profits are only 12,5% the amount of organisation B, they describe themselves as “smart followers”. Therefore, this organisation is slightly more restrained in their DE efforts, but carefully analyses the market and works together with several FinTech’s.

Organisation O4

This organisation is part of a larger consortium and is mostly active in Germany. It functions as a separate entity from its parent company and strives to be a new financial organisation that challenges its larger counterparts. In line with this ambition, they have set up a new digital ecosystem.

4.2.2 Cases

The primary criteria on which respondents were selected comprises the DBE-related case in which they were active. As a result, the thirteen interview participants were active in a total of eight different digital business ecosystem projects, referred to as cases. In this section, each of the cases is, anonymously, introduced and described.

Case C1

Case C1 refers to a newly developed platform for wealth management released in a North-West European country. The new offering has been initiated by a large financial organisation and aimed to serve a new target audience. The platform integrates several separate technological platforms and organisations and has been developed by a collaborative group of vendors originating from at least three continents. The decision to adopt existing technological solutions, as ‘best of breed’ capabilities of each vendor, has been made with speed and time to market in mind.

Case C2

This case describes a newly developed banking application, offered by a multinational financial organisation located in North America. The application comprised a newly developed front- and backend and was developed and hosted using the specialities of several external vendors. Furthermore, the platform aimed for future collaboration with other organisations and aimed to serve an existing group of clients that needed to be merged.

Case C3

Due to confidentiality reasons, limited details concerning this case can be provided. Case C3 comprises a digital start-up, from the financial sector, which is built on an entirely new proposition using (i.a.) several external components and a mix of open source and paid SaaS services. The concept is based on an ecosystem, as it required substantial collaboration between vendors.

Case C4

The fourth case describes an ecosystem-oriented project for a Danish Ministry. The project, as part of the public sector, served to integrate several semi-public organisations, active in the field of mobility, to create one new offering. The project well-suited this research' definition of an ecosystem as numerous public organisations intended to merge their offering for a simplified product towards the clients.

Case C5

Case C5 describes a transitional project within the Technology, Media and Telecommunication (TMT) sector. The telecom organisation wished to enter a new market, as their current business model lost viability. The company identified the importance of joining new ecosystems and initiated work on a new offering, where collaboration with competitors and key partners is inevitable. The new platform, which bundles the forces of several competitive vendors, is expected to generate new income for the telecommunication organisation, as its current margins are decreasing as a result of, somewhat, failed past ecosystem-related projects which, albeit their popularity, failed to be profitable.

Case C6

Due to confidentiality reasons, limited details concerning this case can be provided. This case is not limited to one single project, but instead covers the entirety of innovations applied throughout the information management department of a major financial organisation in North-West Europe. The organisation has started with several ecosystem-related initiatives and carefully observes competitive initiatives from, mostly, smaller FinTechs.

Case C7

Like case C6, due to confidentiality reasons, limited details concerning this case can be provided. Nevertheless, this case focusses on the architectural landscape of a financial organisation in North-West Europe. The organisation describes itself as 'smart adopter' and actively seeks to join forces with successful, competitive, FinTechs. The organisation is highly familiar with ecosystem-related initiatives and observes the need to participate in such collaborative networks in light of regulatory changes, such as PSD2.

Case C8

This case corresponds to a blockchain initiative, in the context of ecosystemic collaboration. Blockchain as a technology ideally serves the purpose of ecosystems, and therefore, several initiatives have started. The initiative consists of a small start-up within a larger consortium, where blockchain is adopted for payment-related developments. Moreover, the project focusses on the sharing of competitive data, which lacks a clear owner within an ecosystem.

4.3 Interview Results

In this section, the results of the interviews are addressed.

4.3.1 Requirements Validation

The requirements identified throughout the systematic literature review originated from several fields of study, as mentioned in Figure 12. Therefore, the first phase of the interview served to validate these adaptability requirements for digital ecosystems, using SMEs. The experts expressed their opinion and thoughts about each of the requirements, which could then be scaled towards three categories: relevant, somewhat relevant or not relevant. This validation showed to what extent the experts agreed upon the relevance of the requirements when applied throughout the design phase of digital ecosystems. The detailed results and overall relevance scores can be found in Table 8.

Table 8: Requirement Relevance

	Relevant	Somewhat relevant	Not relevant	Overall
Awareness	8 / 13	1 / 13	4 / 13	65%
Continuity	9 / 13	2 / 13	2 / 13	77%
Flexibility	9 / 13	3 / 13	1 / 13	81%
Scalability	9 / 13	4 / 13	0 / 13	85%
Self-Organisation	11 / 13	2 / 13	0 / 13	92%

The mapping of the SME's opinion on the relevance of the requirements was done subjectively. To that extent, the interviewer did not use a questionnaire with fixed scales and multiple questions to identify the relevance scores of each requirement. Instead, the semi-structured approach of the generic interviews was followed, and the respondent could independently specify the relevance of each requirement and was furthermore asked to give multiple follow-up examples to underpin their opinion. Moreover, during the third part of the interviews, the respondent was asked to match the requirements to the applied capabilities, which served as a validation of their earlier expressed opinion.

From the requirements validation phase of the interviews, it becomes evident that all requirements were deemed relevant by the experts, with a relevance range between 65-92%. In line with the interview protocol from Appendix D: Interview Guide, respondents were asked to provide examples for each requirement and moreover score them according to their perceived importance. The provided examples can be found below.

Requirement 1: **Awareness**

Out of the five presented requirements for adaptability, awareness was acknowledged the least. For example, R12 and R13 pointed out that they encountered difficulty interpreting the requirement and corresponding definition. Moreover, both respondents highlighted that they preferred a 'broader' definition, such as governance or separate subtypes of awareness.

Nevertheless, the majority of the respondents agreed with the presented description, as they confirmed the importance of insights throughout the ecosystem, so that the available options are known, security is enhanced, and the most popular services can be more easily identified (R3, R4). Furthermore, R1 and R9 highlight that awareness is necessary to spot similar and competitive initiatives in the market and trace newly available technologies, as without awareness the ecosystem is prone to change too late or not at all.

Requirement 2: **Continuity**
With regards to continuity, the interview results showed a perceived relevance score of 77%. Several respondents mentioned the importance of being able to continuously change and maintain a steady uptime (R3, R9, R10). Another respondent stated that continuity is essential when collaborating with multiple partners and vendors, as new partners must be found quickly once existing partners or vendors do not function as expected (R4). Some other respondents did note that for achieving continuity, the holistic ecosystem must be interpreted, and that continuity becomes increasingly important for more mature and established ecosystems (R6, R12).

Requirement 3: **Flexibility**
The third requirement, flexibility, was found relevant by 9 of the 13 respondents. Flexibility was considered to be highly relevant as, from the perspective of an ecosystem, it is essential to adapt to changes and developments in the market. Respondent 12 furthermore noted that a common vision could further support the ecosystem flexibility. Respondents from Organisation C furthermore noted that flexibility demands 'higher-level' thinking and a deviation from monolith systems towards the working in organisational cells (R9, R10, R11). R3 expressed his thoughts by stating that, as time passes by, the recognition of value in the ecosystem shifts. It is hard to predict in advance what changes and where these are going to take place, and therefore it would be good to prepare for that.

Requirement 4: **Scalability**
A similar percentage of the respondents acknowledged the importance of scalability as a requirement for designing adaptable digital ecosystems. Several interviewed experts mentioned the difficulty of predicting upcoming changes in an ecosystem, making it necessary to ensure scalability in the initial design phase (R3, R4, R7). Furthermore, scalability was found relevant for changing the capacity of an existing offer and not necessarily providing new offerings (R1). Respondent 1 nevertheless argued that scalability is not always a prime design issue. Respondent 10 moreover mentioned that scalability would be most relevant when the ecosystem is still rather small, and market share must be grasped. Though both respondents remained positive about this requirement.

Requirement 5: **Self-Organisation**
Self-Organisation was scored relevant by the largest group of respondents. Several experts point out that within an ecosystem, each organisation or vendor has their interests and value drivers. Therefore, it is necessary to carefully oversee that there continues to be a balance amongst these interests so that every participant is sufficiently served (R1, R4, R13). Moreover, problems within the ecosystem directly affect every participant, making it important to allow for continues re-evaluations of the relationships between organisations and vendors once significant changes occur in the ecosystem environment (R4). Similarly, respondent 8 acknowledges the ability of an ecosystem to fill gaps that might occur in the ecosystem offering.

4.3.2 Capability Identification

Table 9 presents the final list of adaptability requirements and high-level capabilities, obtained through the analysis process described in Section 4.3.1. Moreover, the table presents the 'grounded values' for each capability. The denominator of this value is obtained through the number of respondents that have referred to this capability as a contributor to ecosystemic adaptability. Consequently, the numerator is calculated by the number of respondents that have acknowledged the applicability of this capability to the selected interview case, as listed in Table 5. Combined, these fractions define the degree of 'groundedness' of the capability codes obtained through Atlas.ti™. Using these values, the 'Prevalence' of the identified adaptability capabilities is calculated. In this context, the prevalence score of each capability describes the percentage of respondents that confirmed the applicability of the proposed capability on the pre-selected case for the interviews, out of all the participants that acknowledged the general importance of the capability towards influencing ecosystem adaptability. In Appendix C: Interview Results, a detailed overview of the codes is given.

Table 9: Identified Adaptability Codes

Requirement	Capability	Grounded	Prevalence
Awareness	Agility	$^{3}/_{8,5}$	35%
	Environmental Openness	$^{3}/_{8,5}$	35%
	Scenario Planning	$^{2}/_{8,5}$	24%
	Insights	$^{7}/_{8,5}$	82%
	Maturity	$^{5}/_{8,5}$	59%
Continuity	Agility	$^{3}/_{10}$	30%
	Alignment	$^{7}/_{10}$	70%
	Contingency Management	$^{10}/_{10}$	100%
	Integration Strategy	$^{4}/_{10}$	40%
	Version support	$^{7}/_{10}$	70%
Flexibility	Agility	$^{4}/_{10,5}$	38%
	Integration Configuration	$^{10,5}/_{10,5}$	100%
	Modularity	$^{4}/_{10,5}$	38%
	Partner Selection	$^{7}/_{10,5}$	67%
	White Label	$^{1}/_{10,5}$	10%
Scalability	Boarding Support	$^{3}/_{11}$	27%
	Cloud Technology	$^{5}/_{11}$	45%
	Ecosystem Loading	$^{4}/_{11}$	36%
	Elasticity	$^{6}/_{11}$	55%
Self-Organisation	Agility	$^{3}/_{12}$	25%
	Decentralisation	$^{3}/_{12}$	25%
	End-to-End Responsibilities	$^{5}/_{12}$	42%

	Governance	$^{8}/_{12}$	67%
	Interests Balancing	$^{5}/_{12}$	42%
	Maturity	$^{1}/_{12}$	8%
	Relationship Management	$^{4}/_{12}$	33%

4.3.3 Enterprise Architecture for designing Digital Ecosystems

During the interviews, the interviewer additionally addressed the role Enterprise Architecture, as described in Section 1.2.2, could play in the design of D(B)Es. Questions related to this topic served to identify whether existing EA frameworks and methodologies have proved to be sufficient when designing these ecosystems and what the role of Enterprise Architects is with regards to that.

Numerous interview participants acknowledge the important role existing Enterprise Architecture frameworks and methods can play when designing digital ecosystems. Several respondents pointed out that within their DE project, an architecture was designed upfront (R2, R3, R13), before initiating the implementation of the DE. Numerous other respondents point out that architectures must not be fully 'drawn out' in advance. Instead, they highlight the importance of shifting to working with architectural principles and requirements instead (R1, R4, R7, R9, R10, R11). It becomes apparent that, according to the interviewed experts, the added value from (enterprise) architectures shifts increasingly towards defining and aligning sets of base principles (R1, R6). Subsequently, those principles could serve as a starting point and 'handhold' throughout the following phases in the ecosystem design.

Besides, participants were asked if any existing EA framework or method had been used during the design phase of the digital ecosystem. Multiple experts, including respondents 3, 4, 5 and 8, point out that the most commonly adopted EA framework, TOGAF, in their opinion is insufficient when working with DEs. As said by one of the experts: "Enterprise Architecture is more important than ever ('for the design of digital ecosystems'), but simply not in the way current frameworks describe it" (R4). This statement was endorsed by another respondent, who mentioned that TOGAF currently lacks support for the co-creation process of ecosystems and that TOGAF considers the ecosystem environment to be static, whereas that is certainly not the case (R8). Furthermore, several other participants discussed the fact that existing EA frameworks are too slow and monolithic, that TOGAF lacks support for shorter cycles and that the TOGAF ADM as of today is insufficiently operationalised (R3, R4, R5).

Nevertheless, numerous participants acknowledged having used TOGAF, at least to some extent, throughout their DE projects. One participant mentioned that "Though TOGAF was not directly used, its way of thinking is, in my opinion, always used. In my job, I always try to keep it in the back of my mind" (R7). In line with this, respondents 2, 9, 10, 11 and 13 pointed out that TOGAF had been used throughout their projects, although loose interpreted and not overly strict. These insights show that, as of this moment, TOGAF does not entirely cover the design of Ecosystem-oriented Architectures, but is, nevertheless, still adopted throughout projects as its generic way of thinking and work process remains highly relevant.

Although still relevant, the interviews did clarify that the interpretation of the design phase described in the TOGAF ADM is shifting from fully worked-out architectures towards higher-level principles and requirements. Participant 4 acknowledged the importance of "touching upon all layers of the ecosystem architecture during the design phase, but not so much of subsequently drawing everything out in detail". Participant 2 furthermore showed that, indeed, an architecture was developed beforehand, although in the form of a Project Start Architecture (PSA) and not in too much detail. Other respondents referred to the value of setting up requirements for an architecture first and working with higher-level principles instead (R2, R3, R7, R9, R10, R11).

A shift can furthermore be observed for the enterprise architect itself. Given their professional backgrounds, architects are more likely to possess enhanced knowledge of ecosystemic design and, for example, suitable integration technologies that are relevant (R6). Whereas the importance of drawing out entire architecture reduces, architects are expected to be increasingly involved in managing, improving and extending architectural principles, describing features and making technological choices, in a growing role as SME (R4, R6, R7). Moreover, one of the respondents observed that the position of the architect moves more to within the teams and becomes increasingly collaborative (R6).

5 METHOD EXTENSION

In this section, an existing EA method, the TOGAF ADM, is extended to support the incorporation of adaptability constructs in the development of Ecosystem-oriented Architectures (EOA). Firstly, the previously identified results are synthesised to ensure their completeness. After that, each of the design phases of the ADM is addressed and extended where needed. In support, several context-agnostic viewpoints have been developed using the ADM's corresponding modelling language ArchiMate. The last section of this chapter provides an overview of the proposed extension and contains recommendations for how it can be best used by architects.

5.1 Results Synthesis

Before the results of the literature review and the interviews can be incorporated in an extension of the ADM, they must be merged and synthesised to ensure their completeness. First, the requirements identified in the literature review are synthesised. Thereafter, the capabilities primarily identified through the interviews with DBE experts are synthesised.

5.1.1 Requirements Synthesis

For the design of the adaptability method, first, the requirements identified and described in Section 2.5.2 were validated in accordance with the Interview Protocol (IP) addressed in Appendix D.4. Interview Protocol. The validation results, as listed in Table 8 showed that the presented requirements were considered relevant by at least 65% and on average by 80% of the interview participants. During the interviews, the SMEs were furthermore asked to share their view on the completeness of the requirements. This assessment showed that no additional requirements were proposed by at least 25% of the respondents and therefore none were added to the requirements list. Figure 27 provides a comparison of the prevalence scores of both data collection methods. The figure highlights some general similarities between both scores, with the exception of Self-Organisation, which is scored significantly higher during the interviews.

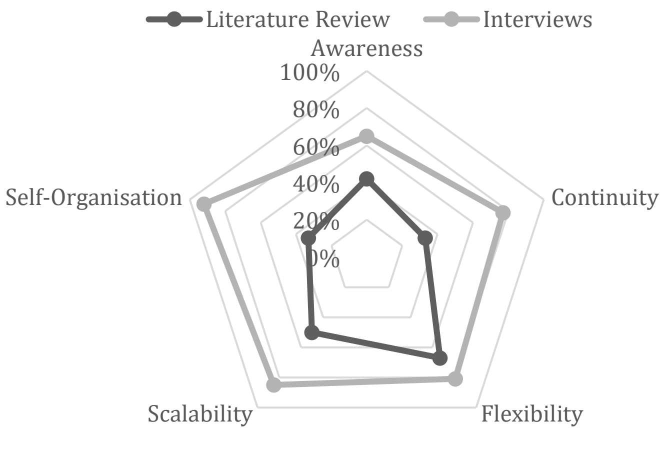

Figure 27: Literature Review & Interviews Prevalence Comparison

5.1.2 Capability Synthesis

Although a minimal set of literature focussed on methods (in this research referred to as 'requirements') for enhancing adaptability within the field of DBEs, sufficient information showed to be available when incorporating several closely related reference disciplines in the search scope. Moreover, the interviews served to validate the identified requirements on their validity within DBE research and practice. However, the literature review also unveiled a lack of research on adaptability capabilities. This is supported by the research of Senyo et al. (2019), who claimed that at least 50% of the research on DBEs lacked any empirical evidence and that up to 72% of the published research in the field of DBE research was not based on any theory at all.

Consequently, qualitative research by means of interviews was employed for the identification and mapping of adaptability capabilities, as applied throughout existing DE projects. Not only were interview participants requested to describe capabilities used in their case (i.e. project), in addition, they were asked to map those capabilities on the requirements presented in the conceptual framework of DE adaptability, as proposed in the Interview Protocol (IP) addressed in Appendix D.4. Interview Protocol. The interviews subsequently resulted in the identification of 37 adaptability capabilities. Moreover, the Semi-Systematic Literature Review (SSLR) unveiled an additional eight capabilities (Figure 16), that contained some overlap with the capabilities identified through the interviews.

With respect to the capabilities listed in Table 9, the following SSLR capabilities were included:

- Analytics was mapped on Awareness and incorporated in the technological 'Insights' capability.
- Agility was incorporated in the mapping on Awareness, Flexibility, Continuity and Self-Organisation as high-level capability.
- Autonomy was mapped on Self-Organisation and included in the Decentralisation capability, which already contained a sub-capability for 'autonomy'.
- Modularity was included as high-level capability under the requirement of flexibility.
- Loose coupling was found highly relevant and caused a shift in the synthetisation of the interview results as it moved the sub-capability from 'integration configuration' to 'modularity'.
- (Platform) Independence was incorporated in the capability synthesis as a sub-capability of autonomy, considering that combined with the interview results, this capability supersedes the imposed threshold.

Leanness and Security were not sufficiently mentioned throughout the interview phase and therefore failed to pass the threshold described below. The total number of identified capabilities is too large to be completely included in the method design. Furthermore, as several different SME roles were interviewed, there exists some deviation in perspective to the capabilities. To that extent, a large part of the capabilities is technological, whereas others are mostly organisational. Therefore, capabilities that were addressed by no fewer than 15% of the respondents or papers were excluded from synthesised set. This synthesis resulted in the exclusion of capabilities that were, to the utmost, only addressed by one or two interview participants or academic papers. This resulted in a final list of 34 capabilities, as can be seen in Appendix C.2. Adaptability Requirements & Capability Mapping.

5.2 TOGAF ADM: Phases

The utilisation of the TOGAF ADM to incorporate adaptability constructs in the development of EOAs (for DBEs) results in the proposal of several additions to accommodate the changed context of ecosystems and the newly identified adaptability constructs. In this section, the additions to the TOGAF ADM are discussed. The proposed additions incorporate the current definitions of each of the ADM phases, as described in Appendix J: Architecture Development Method Phases.

5.2.1 Preliminary

As one of the main objectives of this phase is to determine and establish the desired Architecture Capability for the organisation. As such, in this phase, the to-be done work and the means by which this is achieved should be defined. Considering that the 'Request for Architecture Work' comprises the main output of this phase, several of its outlines must be adapted. The set requirements for this iteration are limited to adaptability online. The extension consequently excluded any other requirements, to show what changes are required for the incorporation of this mere requirement.

In contrast to the traditional organisational type the ADM is frequently applied to, in this research, its organisational context is extended towards a competitive and collaborative group of organisations, active within a single ecosystem. As such, careful alignment between the architecture frameworks needed to support the development work must be executed. Though, in the context of an ecosystem, participants remain free to utilise any framework they desire, within the ecosystemic teams, agreements should be made with regards to how the decisions are made. Furthermore, as part of the organisational context, it is recommended to discuss the necessary internal structure in this phase. To that extent, it should be known what organisations shall participate as partner and which as 'neutral' vendors. Considering that adaptability is one of the underlying principles for the continuation of this development work. The organisation's ability to conduct the required changes must be carefully assessed.

5.2.2 Phase A. Architecture Vision

As the steps in this phase are mainly responsible for proposing the to-be-developed enterprise architecture and create a sense of direction to guide future work, a clear architecture vision is essential. The to be developed enterprise architecture must incorporate five requirements to effectively incorporate the adaptability principle in the design. Consequently, it is argued that the requirements of awareness, continuity, flexibility, scalability and self-organisation are carefully considered.

As prescribed by TOGAF, the subsequent solutions for the architecture work must be described. For these solutions, the descriptions provided in section 2.5 for each of the requirements can be considered. Summarising, the EOA must be developed in such a way that it allows for the continuous assessments of its own and the context's state and take decisions for establishment towards new goals. In addition, this phase is essential to realise the desired solution of increased absorptive ecosystemic capabilities. Moreover, in light of both expected and unexpected changes the architecture must remain flexibly and allow rapid responses. Fourthly, the performance of the ecosystem must remain effective and efficient while larger amounts of data or quantities are added. The final desired solution comprises the to be developed organisation, which must allow for the road mapping of goals through local interactions and without outside interventions. The following phases of the ADM subsequently must incorporate the realisations of each of these solutions.

As prescribed by the ADM, the concerns and requirements of each of the stakeholders must be identified. This step is substantiated by the requirement of self-organisation, in which the importance of interests balancing is stressed. Consequently, in the context of ecosystems, the concerns of stakeholders must be complemented by the identification of their interests. Also, the modelling support of ArchiMate, as introduced in the next section, plays an important role in the prescribed confirmation of the organisation's goals, drivers and constraints.

5.2.3 Phase B, C, D: Architecture Development Phases

The steps prescribed for the following three ADM phases each contain significant similarities. Consequently, as this extension intends to be generally applicable and is thus prescribed on a high-level, they are merged into one step.

One of the key objectives of these phases is the development of the target architectures, showing how the developed vision can be achieved and how the gap between the baseline and target can be bridged. For the development, the capabilities mapped on each of the requirements and listed in Table 23 should be incorporated and realised through the design. Naturally, for each ecosystem, a selected of these capabilities can be included to best tailor the architecture to the set-out vision. As these phases should reuse reference models as best as possible, both context-agnostic and case-specific viewpoints are included to substantiate the proposed extension. These viewpoints are respectively proposed in sections 5.4 and 6.4.

5.2.4 Requirements Management

The design phases of the TOGAF ADM also include a phase on Requirements Management. This phase is present for the provision of an architectural requirements managing process and their allocation. This step can be useful for the successful implementation of the proposed requirements, as mentioned previously. Nevertheless, no other changes are proposed for this phase, as these descriptions are limited to the mere inclusion of adaptability in the architectural development process.

5.3 TOGAF ADM: Strategy & Motivation

The process of incorporation the identified adaptability constructs in the development process of EOAs has been introduced in the previous section. Nevertheless, to better guide the architects involved in the process, in this section, generic and context-agnostic viewpoints are introduced to be used as reference points in future DBE-related projects with adaptability as one of the main principles.

5.3.1 Motivation Extension

The identified adaptability constructs provide detailed insights into how adaptability is defined for digital business ecosystems (DBE) and what capabilities are essential in order to incorporate the concept in the design and architecture of this type of ecosystem. The results from the literature review and the expert interviews can be visualised and represented in a high-level motivation viewpoint. The viewpoint, illustrated in Figure 26, provides insights on the drivers underlying adaptability.

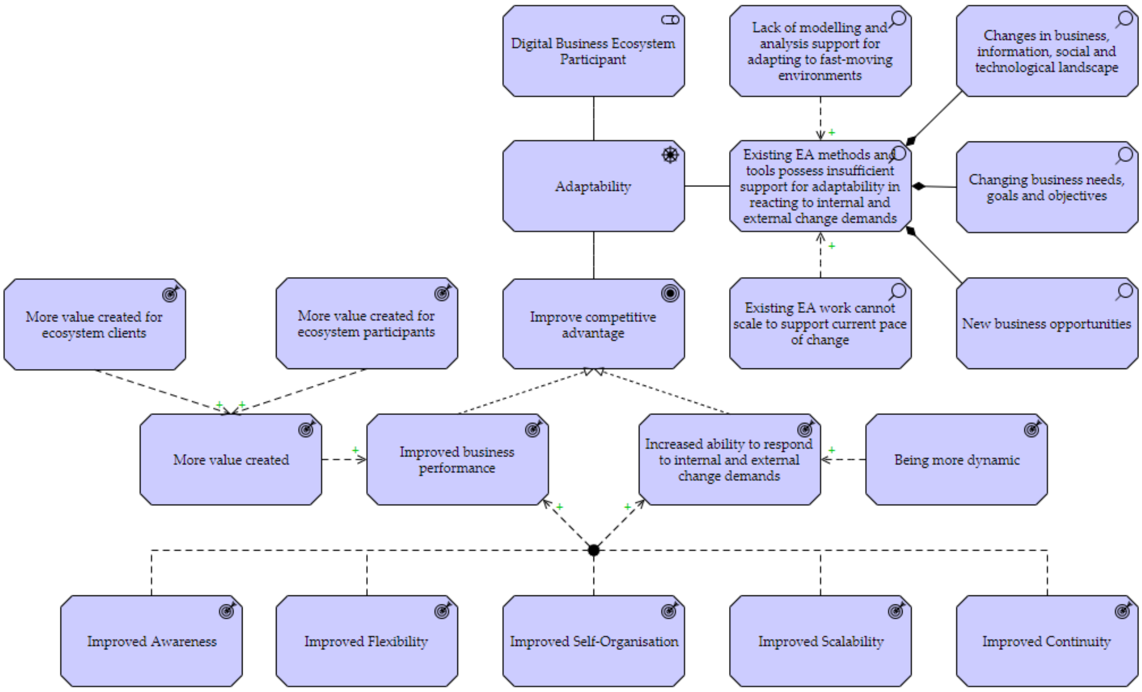

Figure 28: Adaptability Motivation Viewpoint

5.3.2 Strategy Extension

The proposed adaptability requirements, visualised as 'outcomes' in the motivation viewpoint illustrated in Figure 28, can be further substantiated through mapping capabilities. Whereas the requirements are essential for the development of the architecture vision and support the initial development of the architectures, the capabilities can directly benefit the business, information and technology layers by providing generic patterns for implementation. In this section, for each of the identified adaptability requirements, a context-agnostic and high-level strategy to capability mapping is visualised. The viewpoints are developed using the requirements and capabilities mapping, found in Appendix C.2. Adaptability Requirements & Capability Mapping.

The first viewpoint, mapping onto awareness, is visualised in Figure 29. The viewpoint contains four high-level capabilities that positively influence the awareness requirement through an equal number of desired outcomes, part of the strategy extension. Three capabilities and their sub-capabilities are identified as being organisational. The remaining capability, Insights, was identified as technological. Architects involved in the design process of a digital business ecosystem can incorporate some or all of the proposed awareness capabilities in the design to (partially) improve the adaptability of the ecosystem.

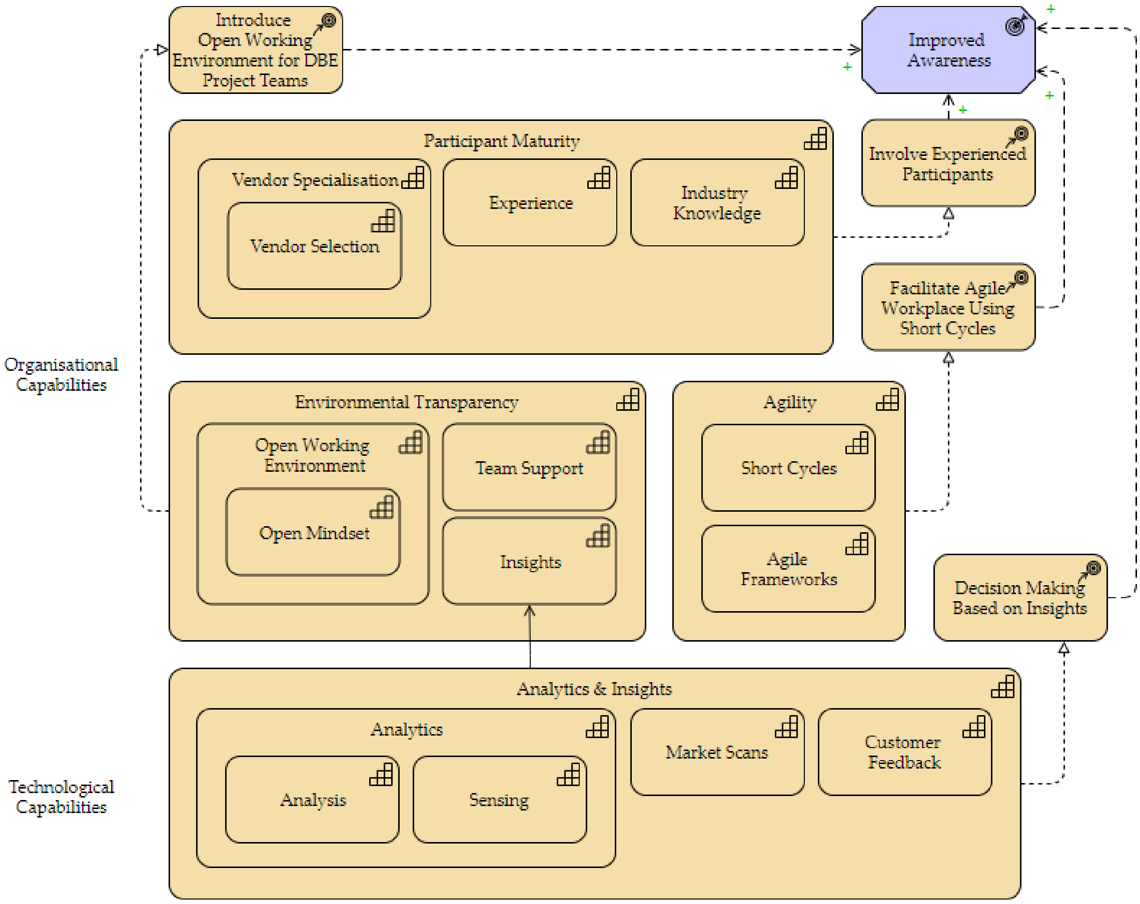

Figure 29: Awareness Strategy to Capability Viewpoint

The capability map for the second requirement, continuity, has been illustrated in Figure 30. In total, the viewpoint contains five main capabilities, as identified through interviews with DBE experts. Whereas Contingency Management and Alignment can be defined as organisational capabilities, Version Support and Integration Strategy describe technological capabilities that should be incorporated in the design of DBEs.

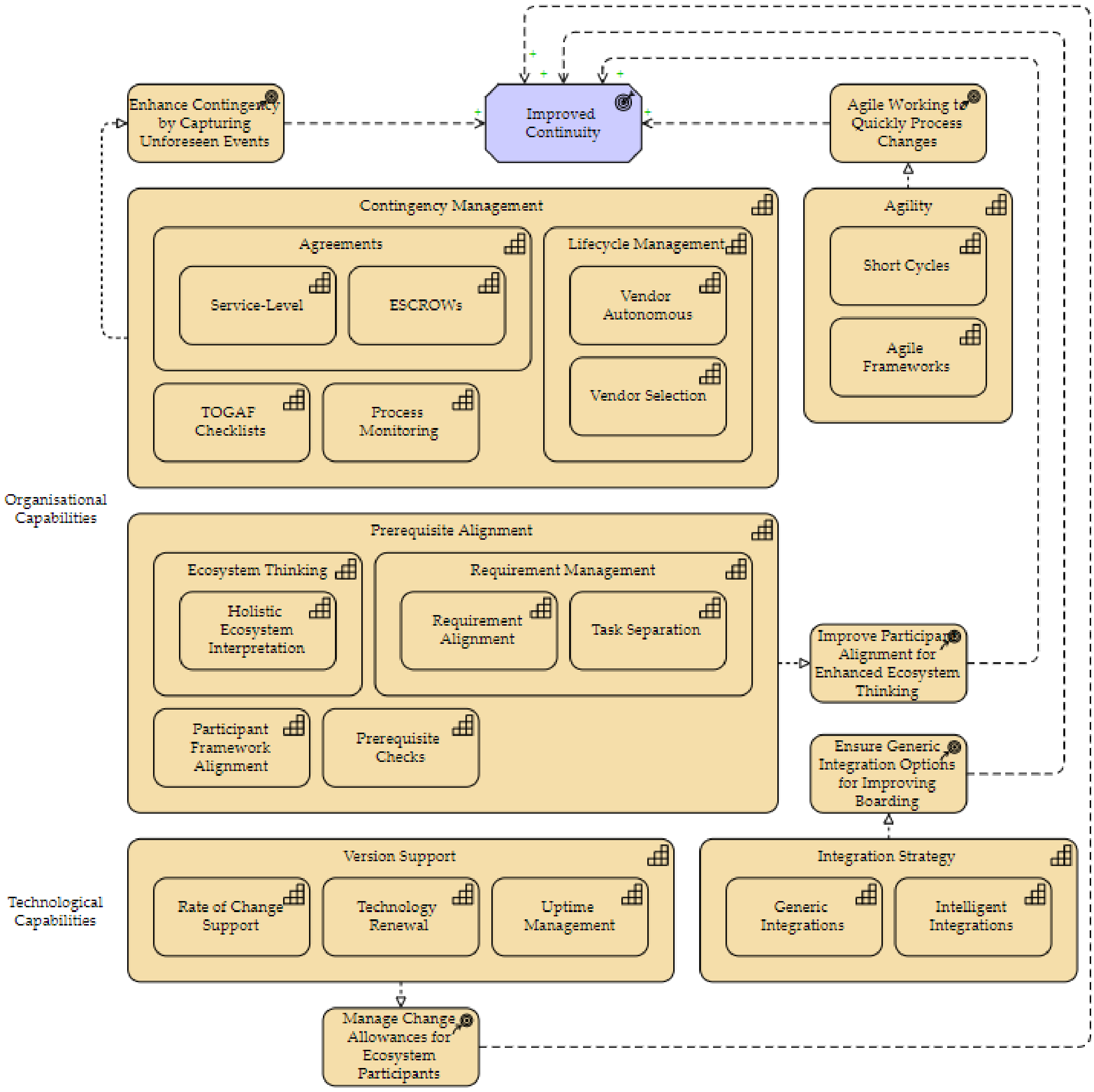

Figure 30: Continuity Strategy to Capability Viewpoint

Flexibility (Figure 31), the third requirement of adaptability, comprises four distinct capabilities, each containing several sub-capabilities. Similar to the previous two requirements, agility has been proposed by the DBE experts as an important capability. Furthermore, two capabilities describe the integration techniques and modular design that should be incorporated in DBEs. Lastly, the experts point out the importance of a capability for Partner Selection, as they can significantly support the realisation of the DBE (platform) or further enhance the offering of the ecosystem.

In Figure 32, the scalability capabilities are mapped onto the eponymous requirement. Scalability is realised mostly by technological capabilities, as can be seen in the viewpoint. Consequently, the viewpoint comprises the capabilities: Elasticity, Ecosystem Loading and Cloud Technology. Nevertheless, experts also referred to the importance of boarding support for adaptable DBEs. Combined, these four courses of action influence the requirement of scalability.

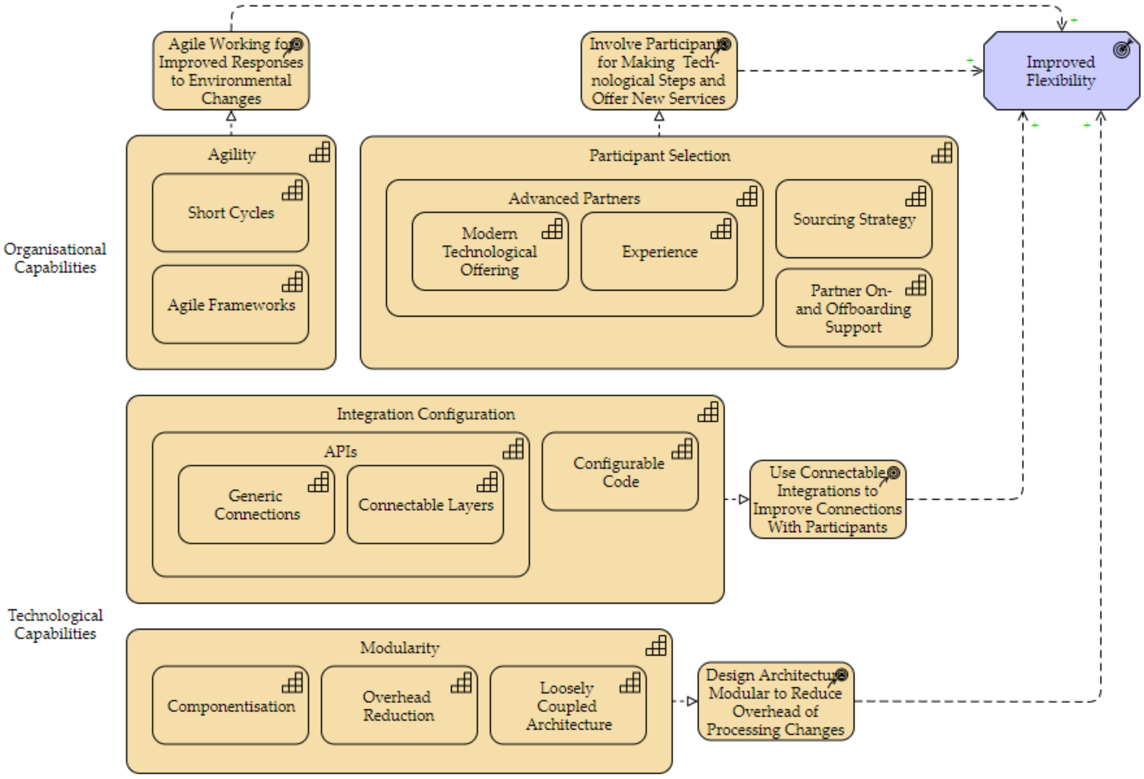

Figure 31: Flexibility Strategy to Capability Viewpoint

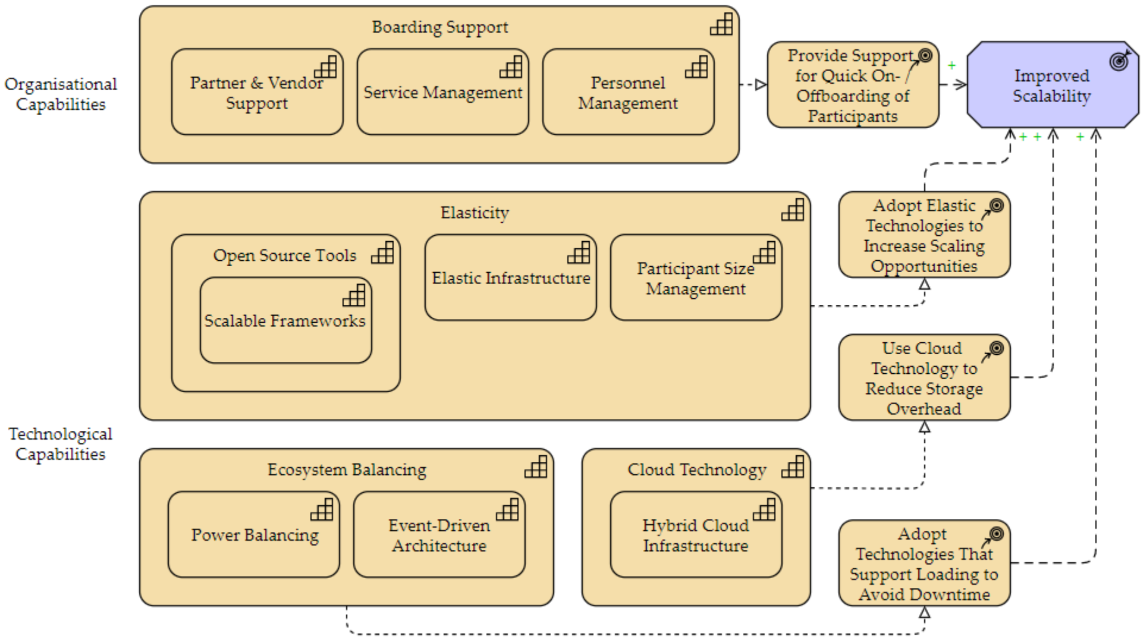

Figure 32: Scalability Strategy to Capability Viewpoint

The final context-agnostic viewpoint that is proposed as part of the extension of the TOGAF ADM towards adaptable DBEs is that of Self-Organisation. Naturally, this viewpoint contains mostly organisational capabilities, including Agility, Interests Balancing, Relationship Management, Governance and End-to-End Responsibilities. Each of these capabilities is substantiated with at least two sub-capabilities and are linked to the Self-Organisation requirement through courses of action. Lastly, decentralisation of the IT architecture was frequently referred to by the interviewed experts, comprising the sole technological capability of this viewpoint.

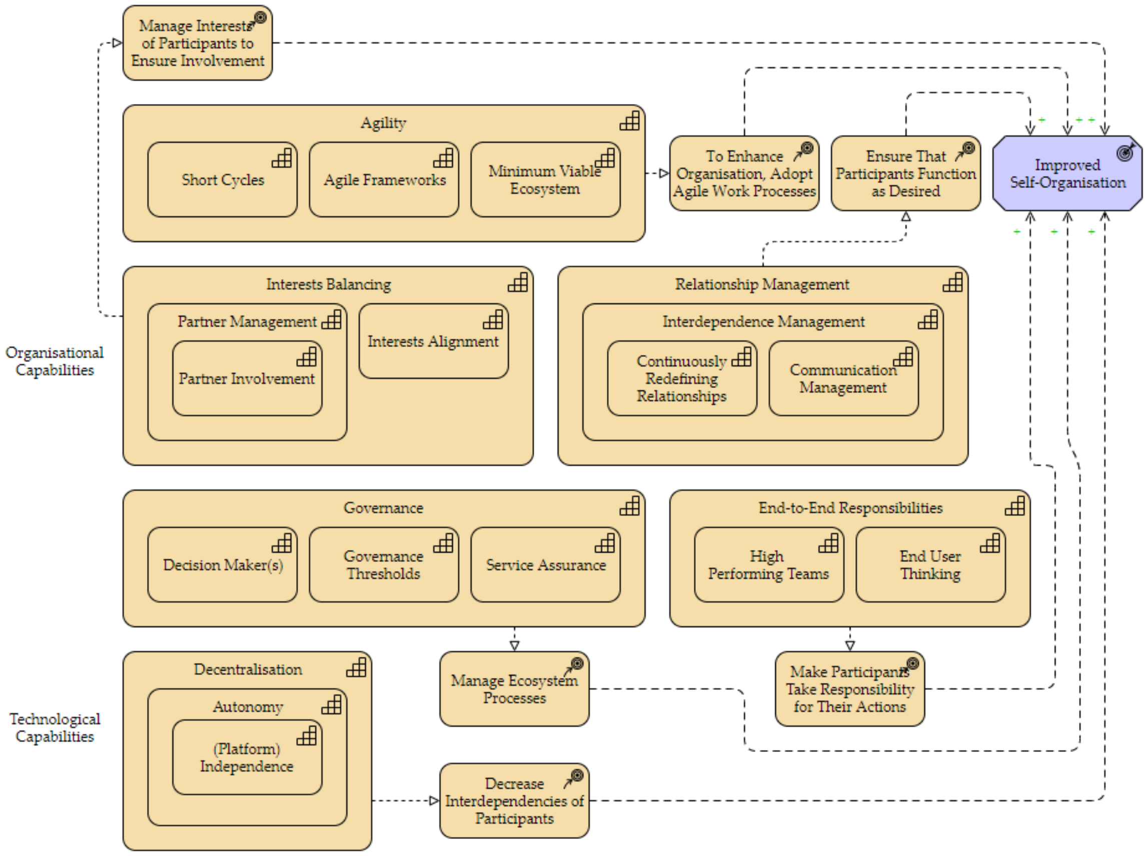

Figure 33: Self-Organisation Strategy to Capability Viewpoint

5.4 TOGAF ADM: Core Layers

Having extended the first two phases part of the TOGAF ADM, utilising the proposed context-agnostic strategy and motivation extensions provided by ArchiMate, there remain three other phases in the design part of the architecture development cycle. The three remain cycles, business-, information systems- and technology architecture, comprises the so-called core layers (The Open Group, 2017). In short, the objective of these phases is to develop Target Architectures for the domains they are involved in.

Currently, there exist countless different types of digital business ecosystems. There exist significant differences between the DBEs, considering that each can involve different participants, serve different goals and adopt differing technologies. Consequently, the value of proposing context-agnostic, high-level core layer viewpoints is limited. Due to this, this research refrains from discussing these generic implementations of the adaptability constructs. Nevertheless, by extensively validating the results of the research through multiple case studies, as described in Section 6, use case viewpoints are developed based on the information provided on a single case. These viewpoints provide valuable insights into how the identified adaptability constructs can be incorporated in the baseline architecture of a DBE case.

5.5 Method Extension Overview

In this section, an overview is provided of this research's proposed extension, as illustrated in Figure 34. It must be noted that several of the propositions are introduced as a result of the application of the method to the case studies, described in Section 6.4. As pointed out previously, the extension excludes the phases E until H due to their context-specific dependencies. As a result, these phases have been greyed out in the figure overview. As moreover visible in the figure, the proposition has been categorised into four separate parts.

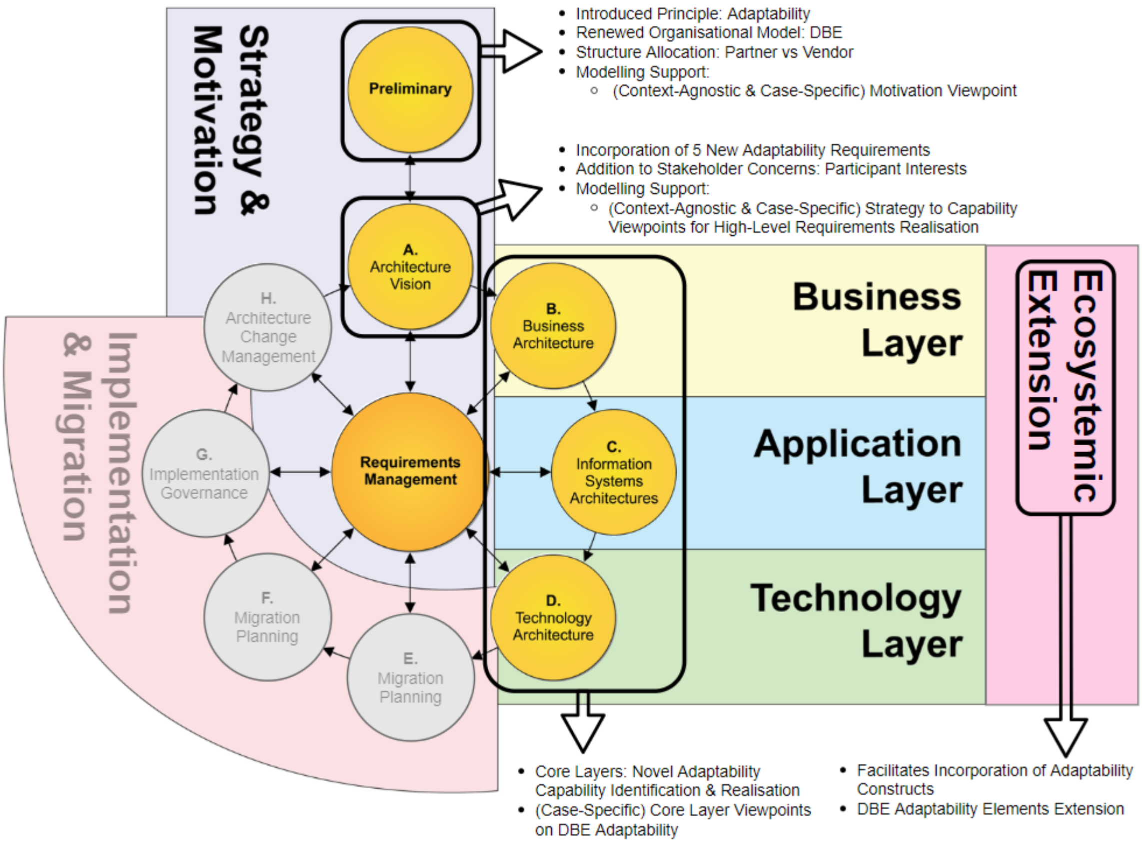

Figure 34: TOGAF ADM Method Extension

Firstly, several steps in the Preliminary phase were reinterpreted and refined. Moreover, additions were based on the new ecosystemic organisational structure. The following phase, Phase A, incorporates the newly identified adaptability requirements. In the architecture development phases, which have been merged due to significant similarities in steps, contain the newly introduced adaptability capabilities, mapped on the requirements from the previous phase. Lastly, to accommodate the changes made to the ADM, an ArchiMate extension for Ecosystemic Support has been proposed to facilitate the new constructs and ecosystemic context. In addition, as visible by the mapping of ArchiMate onto the ADM in this figure, several context-agnostic and case-specific viewpoints were developed to serve as a guide for future DBE-related projects.

5.5.1 Application Recommendations

As prescribed by The Open Group, the TOGAF ADM is primarily targeted at architects in IT user enterprises. Consequently, the primary user group of the proposed extended version of the ADM is expected to also comprise IT architects, either active for an organisation participating in an ecosystem or directly under the governance of the ecosystemic board.

Similar to the traditional application of the ADM, the steps, as prescribed in the TOGAF Standard can be followed and interpreted to best tailor the respective organisation. If applied for the development of EOAs, the proposed additions and altered steps, as described in this chapter, should be considered. In addition, the viewpoints proposed in this research served to assist the architects in their work. Consequently, the IT architects can utilise the viewpoints to tailor to their specific DBE.

Naturally, it is not necessary to incorporate each individual requirement and capability. Instead, the architect can select those constructs deemed relevant for the considered DBE's context. Furthermore, for each of the selected constructs, relevant viewpoints are available to select realisation techniques from the generic examples and patterns provided.

6 VALIDATION

In this chapter, the validation process of this research is addressed. Firstly, the evaluation session and its results are discussed. Thereafter, details of the case studies are provided, and the obtained findings presented. Furthermore, the proposed extension of the TOGAF ADM is applied on a use case, utilising data collected throughout the case study. The final section of this chapter covers the subsequent extension proposed for ArchiMate, covering the shortcomings encountered during the use case.

6.1 Evaluation Session

Due to constraints in terms of available cases for participation in the case studies, no pilot case study could be conducted as that would further limit the number of participants in the actual case study. Therefore, before initiating the validation sessions, the case study guide and presented were evaluated in an informal round-table session with two senior Enterprise Architecture (EA) consultants. Through these sessions, feedback was collected on the understandability of the effectiveness of the case study approach. As a result, the session resulted in several changes with respect to the presented information:

- Based on the evaluation session, the decision was made no to use a questionnaire as a means for collecting capability relevance scores. Instead, feedback showed that to obtain richer and more accurate information for the development of adaptability viewpoints, in-depth discussions, allowing for follow-up questions, would be preferable.
- A second refinement that was included in the case study approach comprised several simplifications to the created presentation. As the goal of the presentation was to standardise the to-be delivered information and inform each participant in a similar manner, the refinements focussed on enhancing its understandability for each (different) type of respondent role, including an architect, consultant and project manager.
- Lastly, through the evaluation session, the decision was made to audio-record the case studies, so that the sessions could be revisited later on once newly themes were discovered.

6.2 Case Study

In this section, the selected DBE-related case for the case study is introduced. Consequently, the first part of this section covers the employed case selection process. After that, the participants involved in the case study are introduced and described. Lastly, a description of the selected case is provided.

6.2.1 Case Selection

As mentioned in Section 3.5.3, a large number of DBE cases and experts have already been involved in the semi-structured interviews conducted as part of this research's data collection phase. From the set of the available cases for the interviews, one case was on purpose excluded for involvement in the validation phase. As such, the case selected for the validation has not been involved in earlier phases. One of the interviewed experts had in fact been involved in a project related to this case (R3), but as the interviews were focussed around one case specifically, the expert was requested to exclude his involvement with the validation case so that minimal bias would occur.

As such, an existing mobility-related digital business ecosystem currently active within several Dutch organisations has been selected as case. Not only does this case perfectly match this research's definition for DBEs, but it has also gone through most of its design process. The ecosystem currently consists of almost five participants. The ecosystem participants are furthermore competitors. However, for each of the organisations, the collaboration with competitors proved more valuable than the opposite.

6.2.2 Case Study Participants

For the case study, in total, four experts of three different companies involved in the selected DBE mobility case have been selected. Not only do these experts originate from different organisations participating in the DBE, also, they comprise four different expert roles. These roles were also interviewed as part of the interview phase of this research.

Participant No.	Role	Ecosystem Participant	Experience with EA	Experience with DBE
Participant 1	Senior Architect	Mobility Partner (National)	20+ years	10+ years
Participant 2	Business Consultant	Mobility Partner (National)	8 years	5 years
Participant 3	EA Consultant	Vendor	5+ years	4 years
Participant 4	Senior Project Manager	Mobility Partner (Regional)	0 years	3+ years

Through the interviews, three main participant types of the selected validation case could be identified, as is illustrated in Figure 35. The case studies showed that, primarily, there exist two distinctly different types of participants. On the one hand, there are mobility partners. This notion comprises the organisations, active in the ecosystem, that physically possess and use (public) transport vehicles. On the other hand, there are mobility service partners, who do not actually own these vehicles, but instead own a platform for clients to rent these vehicles (for example, peer-to-peer ridesharing platforms).

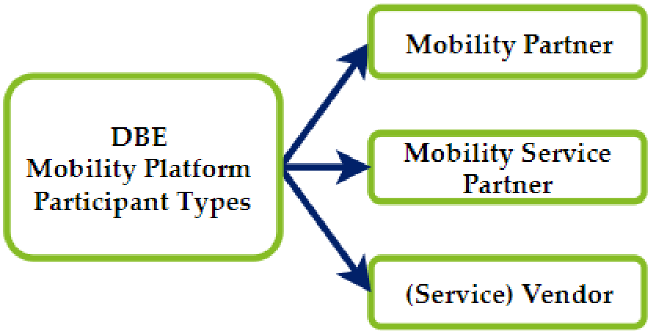

Figure 35: DBE Mobility Platform Participant Types

6.2.3 Case Description

Both public transportation companies interviewed as part of the case study acknowledge that the demands and needs of their customers are changing rapidly. An increasing number of clients no longer desires 'standalone' products or subscriptions, but instead look towards complete mobility service packages. In addition, one of the experts mentions that it was found that travellers increasingly inclined to make use of the public transport offering once the public transportation companies support them in travelling from departure to arrival location, instead of from station to bus stop. Consequently, one of the interviewed public transportation companies has introduced a new corporate strategy, stating that the control over their mobility offering must be enhanced. In line with this strategy, the organisations aim to serve their customers a door to door service to the best of their ability. Similarly, another expert pointed out that the public transport company the expert worked for aimed to actively deal with the current pace of change in its market.

Both companies acknowledge having observed that currently, numerous parties are in active development of similar propositions. Moreover, they find themselves insufficiently capable of exploiting each available shared mobility initiative and therefore have decided to outsource such initiative to specialised third parties. The intended DBE mobility platform should, in that context, serve as a gateway for the transportation companies to link with these third parties and form partnerships. Furthermore, the interviewed public transportation companies' experts highlighted that they found that individually they were insufficiently capable of producing that DBE platform. As such, they connected and decided to bundle forces and, albeit their competitive relationships, work towards developing a new mobility platform, integrating each of the existing initiatives. It was pointed out that the vision of this novel platform included a principle stating that, initially, the platform was only developed to serve the founding participants. Nevertheless, in a later stadium it should also provide support to other mobility and / or service partners wishing to cooperate.

For the nationally active public transport organisation, the adaptive capabilities of its existing mobility offering were deemed insufficient. Also, each of the interviewed experts acknowledged the growing importance of incorporating adaptability in the design of digital business ecosystems. Subsequently, the national public transport operator had initiated the search towards something more flexible and changeable. To that extent, the new mobility platform should offer its clients the possibility to arrange all necessary steps for a complete journey through merely one application or platform. In addition, the ecosystem participants have decided, after careful internal analysis, that they could not develop this ecosystem themselves. Consequently, the decision was made to search for an external vendor, specialised and proven effective in developing these types of platforms, for the white-label development of the DBE mobility platform.

6.3 Adaptability Constructs Refinement

One of the goals of the case study was to validate the adaptability constructs on their relevance and applicability, with respect to the selected validation case. The questions asked to fulfil this goal can be found in Appendix G: Case Study Guide. Moreover, the exact scoring of each of the constructs on their relevance and applicability is listed in Appendix H: Adaptability Constructs Grading. In this section, the feedback and comments provided by the case study experts are processed, leading to a final refinement iteration for each of the requirements and their mappings onto the identified capabilities.

6.3.1 Awareness

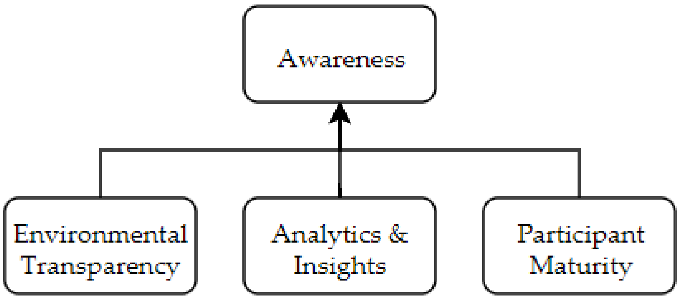

Figure 36: Refined Awareness Constructs

The majority of the experts argued that agility should be excluded from all the requirements, except for self-organisation, as the capability focusses mostly on the organisational aspect and is managed from there. Moreover, the case study led to several name changes with respect to the proposed capabilities. Consequently, Environmental Openness was renamed to Environmental Transparency, Insights to Analytics & Insights and Maturity to Participant Maturity.

6.3.2 Continuity

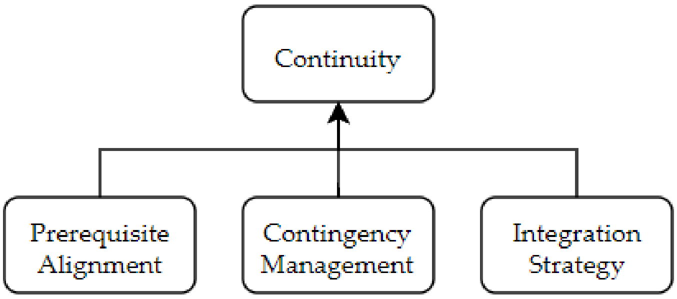

Figure 37: Refined Continuity Constructs

In line with the refinement of awareness, the capability of agility was excluded from this mapping. Moreover, the capability of Alignment was rephrased to Prerequisite Alignment. Lastly, the interviewed experts believed that Version Support was on a different granularity level than the other proposed capabilities and, consequently, it was merged into Integration Strategy.

6.3.3 Flexibility

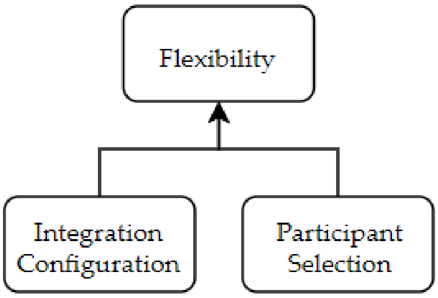

Figure 38: Refined Flexibility Constructs

In line with the previous requirements, the capability of agility was excluded from this mapping. Moreover, due to the high degree of similarities, the interviewed experts argued that the Modularity capability should be merged with Integration Configuration. Lastly, due to a conflict with the existing participant types in the DBE mobility platform, Partner Selection was rephrased to Participant Selection.

6.3.4 Scalability

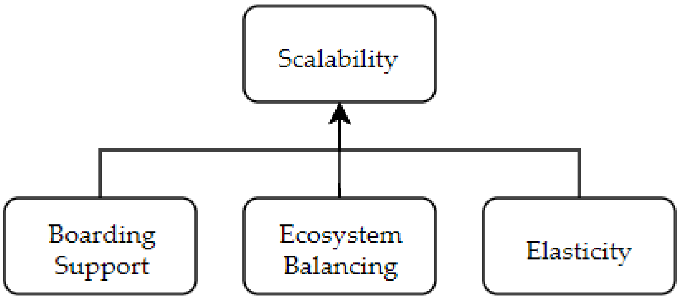

Figure 39: Refined Scalability Constructs

For this requirement, minimal comments were received from the experts. Nevertheless, most of the experts argued that once more there existed a granularity conflict. Subsequently, the very specific Cloud Technology capability was merged with the capability of Elasticity. Moreover, the majority of the experts requested the rephrasing of Ecosystem Loading to Ecosystem Balancing.

6.3.5 Self-Organisation

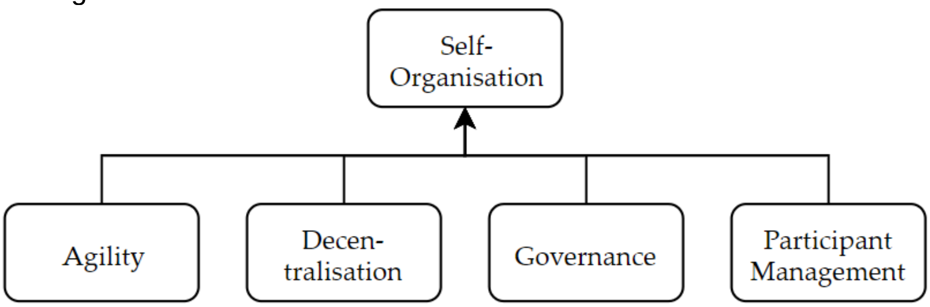

Figure 40: Refined Self-Organisation Constructs

As mentioned in Section 6.3.1, the experts proposed to exclude the capability of agility from each requirement, except for Self-Organisation, due to previously mentioned reasons. Moreover, the capabilities of Decentralisation and End-to-End Responsibilities were merged into a new and larger Decentralisation capability. Lastly, due to them sharing many similarities, Interests Balancing and Relationship Management were merged into a new capability, defined as Participant Management.

6.4 Adaptability Method: Use Case

In this section, the conducted validation sessions serve as use case for the development of relevant viewpoints, highlighting the proposed extension of the TOGAF ADM and incorporating the introduced adaptability constructs. The core layers of the use case are, in this Section, visualised in their entirety and described accordingly. Please note that elements of the information presented in the developed viewpoints are subject to Deloitte Intellectual Property.

6.4.1 Motivation Extension

Adopting the high-level and generic adaptability motivation model proposed in Section 5.3.1, a motivational model can be developed tailored to the Mobility DBE Case of the validation phase. The Mobility DBE motivation model has been illustrated in Figure 41 below. In line with the goal of this study, adaptability has been selected as main driver for the validation case. With regards to the driver, several assessments were highlighted by the case experts, including a high level of change in the current public transport market and the lack of adaptability of the current mobility offer provided to travellers.

Similar to the generic motivation viewpoint, the ability to improve the organisations' competitive advantage has been taken as the primary goal. To achieve that, a new mobility offer is being developed by several public transport companies, integrating external parties to offer a new and complete door-to-door mobility service to their clients. These desired outcomes should generate more value towards both the clients and ecosystem participants.

As proposed in this research, the desired increase in the ability to respond to internal and external change demands, in this case, solved by developing a new Mobility DBE, can be realised (positively influenced) by five unique adaptability requirements. The identified adaptability requirements are, respectively: awareness, flexibility, self-organisation, scalability and continuity. This research subsequently argues that, by enhancing and incorporating each of these requirements, the adaptability of the Mobility DBE can be effectively enhanced to better respond to changes in the market.

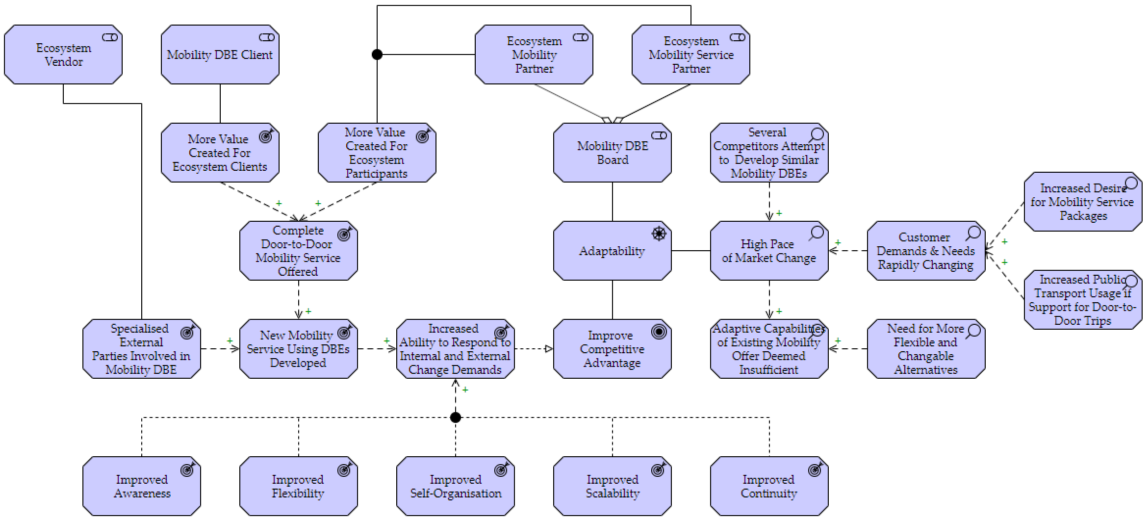

Figure 41: Validation Case - Motivation

6.4.2 Awareness

By means of the conducted case studies, as described in Section 3.5.3, sufficient information about the selected DBE Mobility Platform could be collected so that (anonymised) core layer visualisations using ArchiMate could be modelled. Moreover, the information allowed for the incorporation of the proposed adaptability constructs of this research. The layered viewpoints proposed for each of the requirements furthermore contain relations to the previously discussed Strategy & Motivation extension, through realisation relationships with the ArchiMate Capability Elements.

In Figure 42, a layered viewpoint of the Awareness requirement is visible. The core of the model is comprised of the DBE Mobility Platform, part of the application layer. The first capability mapped onto awareness is Environmental Transparency. In the viewpoint, there are two business processes introduced for the realisation of this capability. The 'Decision Implementation' process describes how the approved roadmap, as part of the Self-Organisation viewpoint, is implemented by the ecosystem participants. This process was pointed out during the case study, where it was noted that decisions with regards to the ecosystemic roadmap were made through open, combined project teams. Consequently, combined project teams are formed by the mobility and mobility service partners of the ecosystem to ensure an open working environment and broad consensus amongst all participants. In addition, the Board Meetings process has been included to illustrate the role each participant has in the decision-making process. As such, each of the partners has the right to 'veto' decisions, which do not fully support their interests.

In addition, the Analytics & Insights capability of Awareness has been integrated into this viewpoint. One of the components of the core DBE Mobility Platform is Data Management. As visible in the model, the Data Management component realises the ecosystemic Analytics Services. To ensure grounded decision makings, these services run on a data object realised through numerous data sources, including data generated by market scans, experienced vendors, mobility sensors and customer feedback. Lastly, the model shows the application of industrial knowledge for the collection of technical data, as prescribed by the Participant Maturity capability.

6.4.3 Continuity

Like the requirement of Awareness, for Continuity a full layered viewpoint has been developed, as illustrated in Figure 43. Firstly, it should be noted that in this viewpoint, the technology layer has been excluded. This decision was made in light of the identified capabilities for this requirement that do not directly influence the physical aspects of the DBE Platform. Consequently, for simplicity, it has been excluded from the viewpoint.

Nevertheless, the viewpoint does provide interesting insights into both the business and application layer. Once more, the DBE Mobility Platform component has been taken as the core for the viewpoint. As part of this platform, a Participant Management component has been visualised. In this case, this component is responsible for managing several aspects of the ecosystem participants, including their requirements, used frameworks and agreements applicable to them. One of the capabilities, Prerequisite Alignment, has been visualised through a basic business process. The Standardise Backlog process highlights how the tasks and requirements of each participant are collected and aligned towards the development of a roadmap. Naturally, this is realised by the Ecosystem Board, comprising involved mobility and service partners. In addition, the viewpoint contains a Service Level Agreement process, that defines the undertaken steps in the ecosystem to create and manage the participant's requirements through Service Level Agreements (SLA). Unlike the first process, the latter serves to realise the capability of Contingency Management.

Finally, the viewpoint includes an extensive section on the Mobility Platform application layer. The Integration Strategy capability, identified through expert interviews, is realised by several components, including the Travel Management and Product Management ones. The first is illustrated by means of the DBE Journey Planner and shows how numerous external platforms and services provided by mobility and mobility service partners are using the DBE Mobility Platform native journey planner through generic integrations and interfaces. Also, there could exist a native, standalone mobility app, realised through the (unused) Journey Planner Service. Another sub-capability of Integration Strategy relates to the Uptime Management of the platform. Consequently, an application process for the Version Support has been visualised, showing how updates are processed and the supported rate of change for partners to adapt to these changes.

6.4.4 Flexibility

The third viewpoint that has been realised to visualise how the identified adaptability constructs can be incorporated in the base design of a DBE Mobility Platform is Flexibility. The viewpoint, as visible in Figure 44, includes the two distinct capabilities of this requirement: Integration Configuration and Participant Selection.

The first capability is illustrated through the usage of APIs and connectable layers, in addition to the outsourcing of several services as part of the modularity sub-capability. The Travel Management component, which has been identified as being vital for the DBE Mobility Platform, shows how the ecosystem participants can choose to incorporate the Journey Planner into their services and not as external standalone mobility application. The viewpoint shows how this can be achieved through the usage of a Planning Service Interface. By means of this interface, mobility partners can incorporate the ecosystem service through APIs into their website or application.

Another business-oriented, capability that was identified in this research is Participant Selection. Experts involved in the case study have pointed out the procedures surrounding newly interesting mobility partners that would like to participate in the ecosystem. Naturally, it is the board of the ecosystem that decides whether this new mobility provider should be onboarded or not. To decide this, specific properties of the provider, including its reach and value, are analysed to determine whether it is worth the effort to onboard this organisation. If positive, the existing ecosystem participants can choose to onboard the new organisation, as is illustrated in a process part of the Scalability viewpoint.

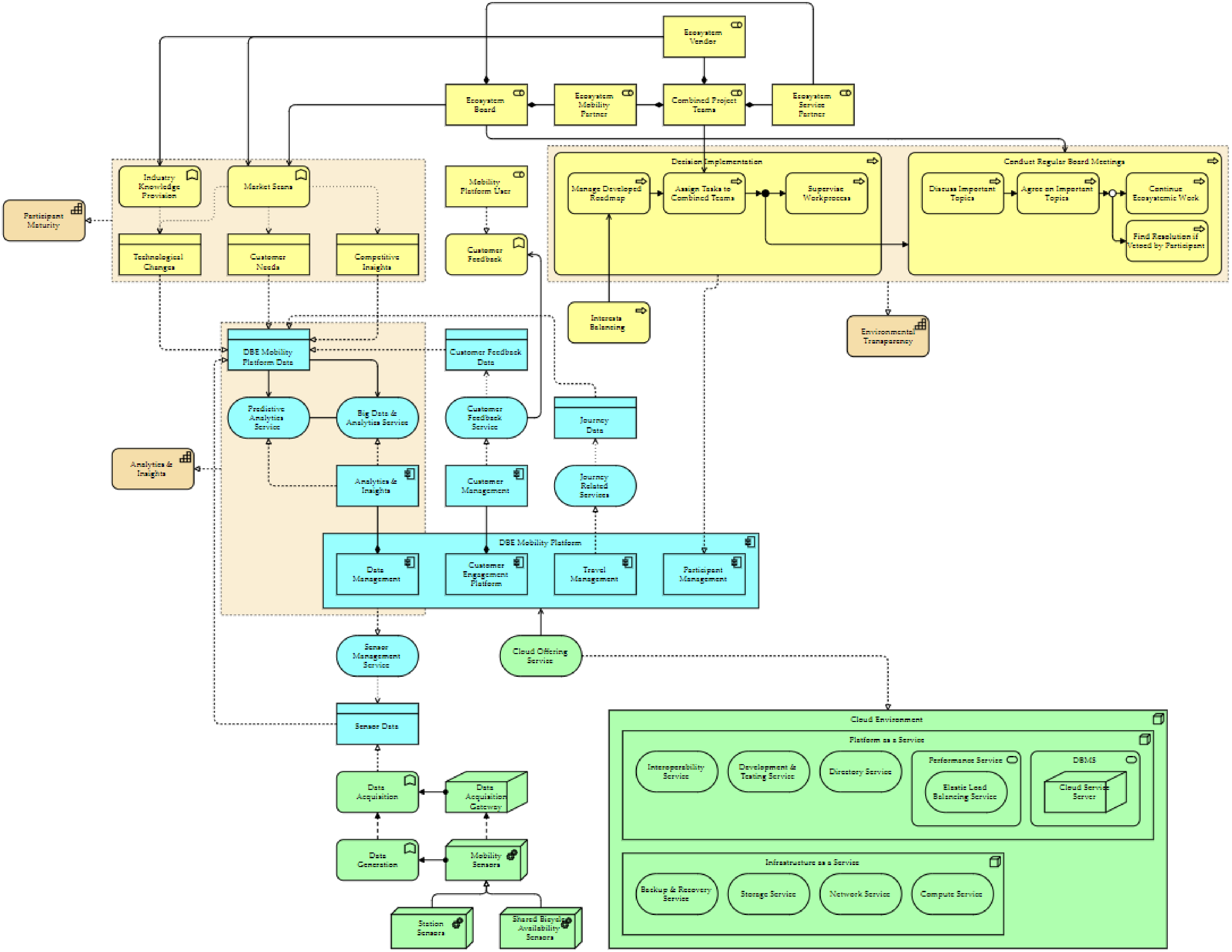

Figure 42: Awareness - Core Layers

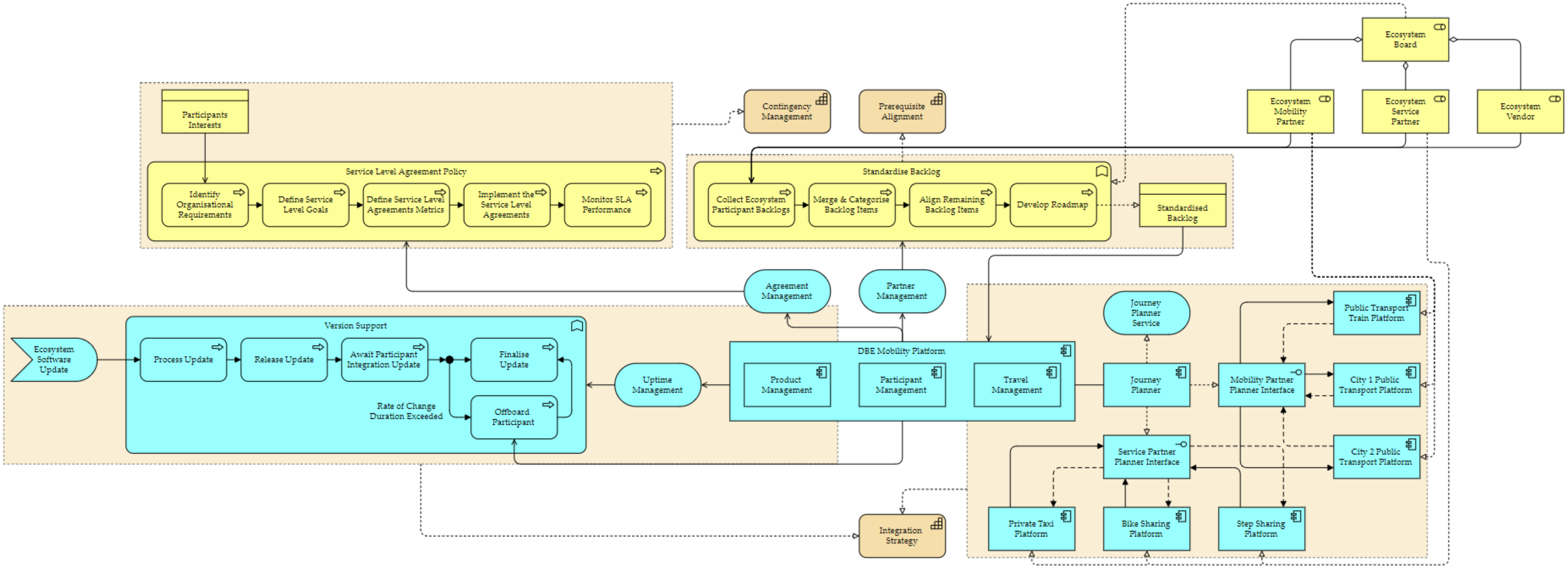

Figure 43: Continuity - Core Layers

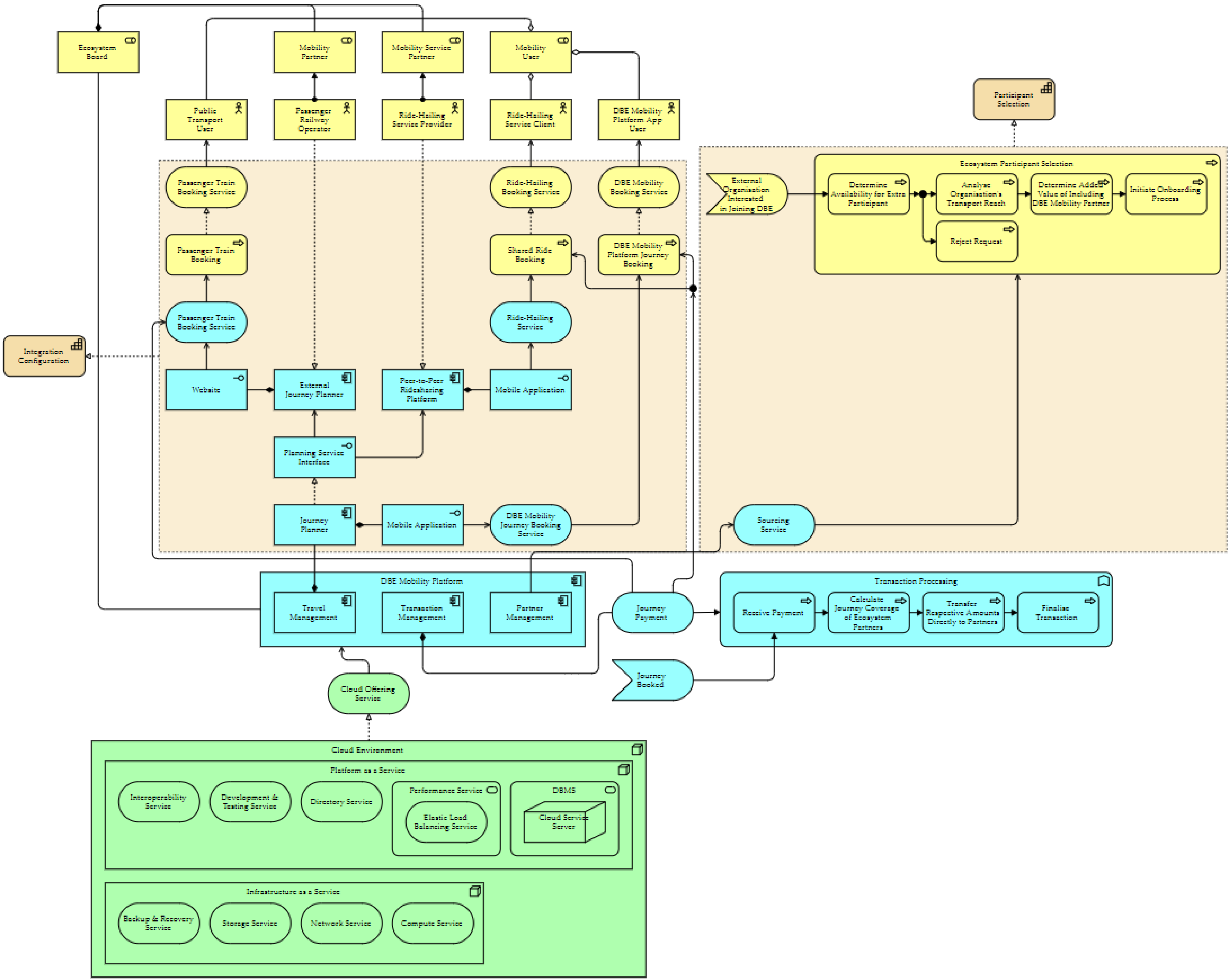

Figure 44: Flexibility - Core Layers

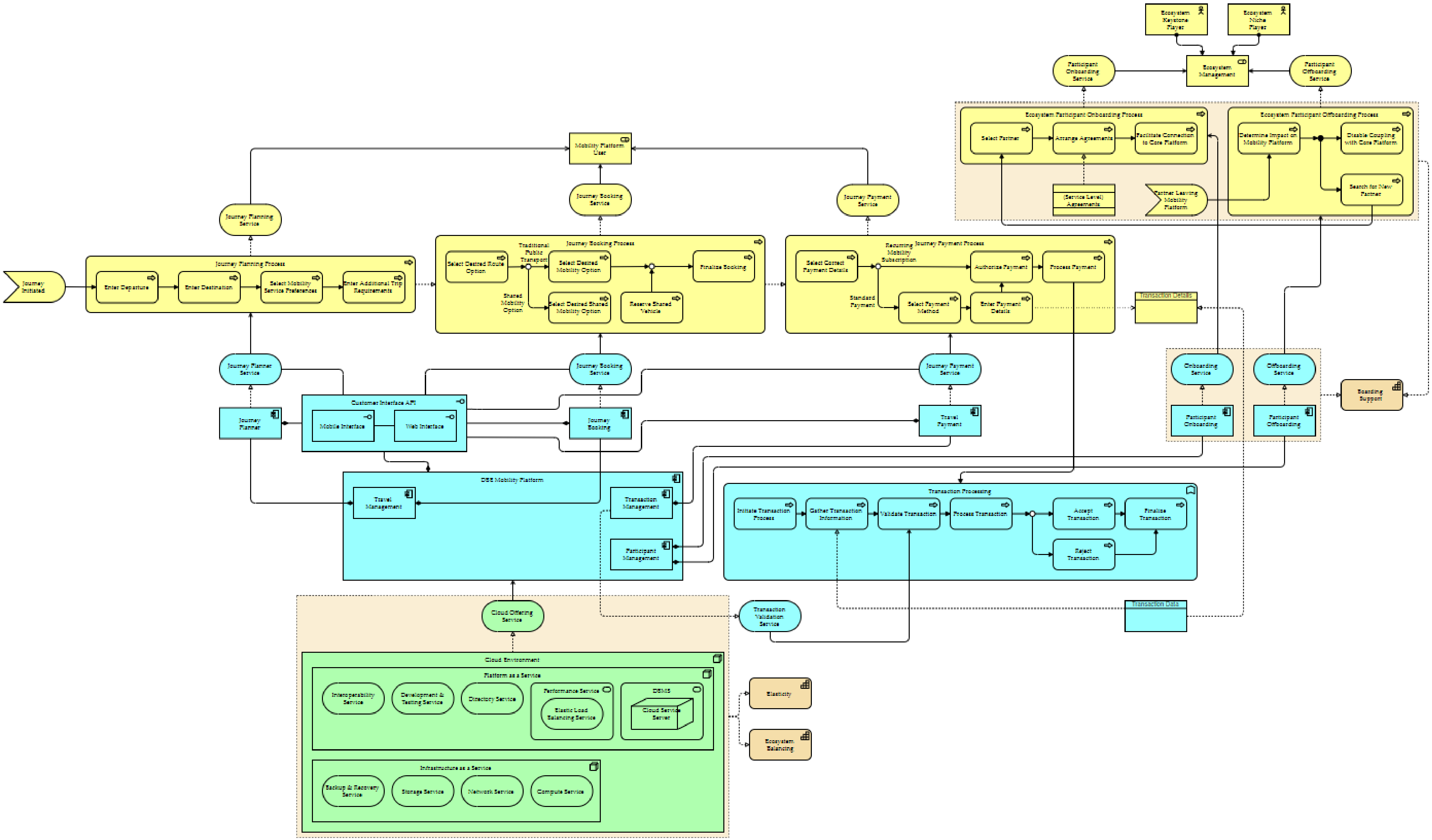

Figure 45: Scalability - Core Layers

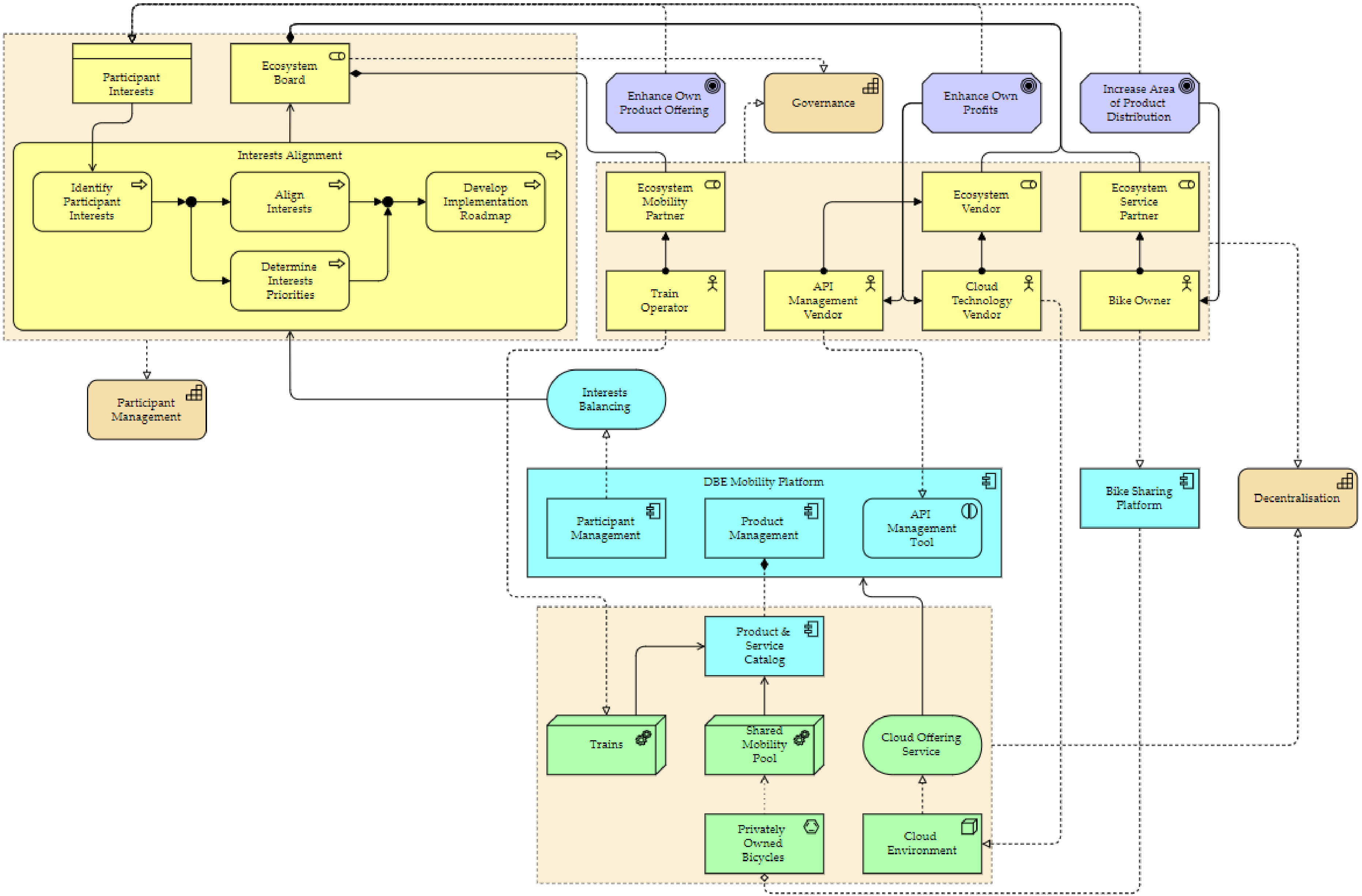

Figure 46: Self-Organisation - Core Layers

6.4.5 Scalability

The fourth layered viewpoint comprises the Scalability requirement. To model the proposed capabilities, the Journey Planner functionality, as referred to from several other viewpoints as well, is fully worked out. As a result, the viewpoint contains three business processes that were found relevant in the planning and booking of a journey by means of the DBE Mobility Platform. With this process in mind, the capabilities have been incorporated in the viewpoint.

For enhancing the DBE offering, improving functionality or introducing new products, external partners and vendors can be linked to the ecosystem (platform). The capability supporting this process is Boarding Support and, as visible in Figure 45, is visualised by means of the Participant Onboarding and Offboarding processes, realised by services offered by the Participant Management component of the Mobility Platform. The Boarding Support processes furthermore require some degree of agreements, which has been visualised in the viewpoint for Continuity.

Although the case study showed that, at this stage in the development of the DBE Mobility Platform, there exists no need for incorporating cloud technologies, experts did acknowledge that during future development of the platform it could still be included.

6.4.6 Self-Organisation

The final layered viewpoint that has been developed based on the conducted case studies is that of the Self-Organisation requirement. In the viewpoint, the Decentralisation capability is identifiable through a large number of business roles and actors that have been separately involved for providing services and applications, including API management tools, shared bike platforms, cloud environments and public transport vehicles. In addition, each of these participants is individually responsible for upkeeping their side of the made agreements. If not, this risk being disconnected or offboarded of the DBE platform.

In addition, the viewpoint provides minimal insights into the governance capability, proposed as part of Self-Organisation. Several experts pointed out that within the ecosystem there must exist some ‘decision-maker’, consequently, the viewpoint contains the ‘Ecosystem Board’ business role, which is comprised of several ecosystem participant types. Naturally, the board is the ‘theoretical’ owner of the Mobility Platform. However, as can be seen in the viewpoint, it is also responsible for aligning the interests that each ecosystem member might have to ensure the agreed-upon roadmap serves all the available participants and their interests to their best. The process of aligning the interests and managing the ecosystem participants and partners has been described by the Participant Management capability, which has also been visualised in the viewpoint.

6.5 ArchiMate Extension

The development of the layered viewpoints for each of the five adaptability requirements and their respective capabilities, utilising the information collected throughout the case study sessions has led to the identification of several limitations with regards to the ADM’s modelling language ArchiMate. Consequently, several ecosystemic ‘patterns’ were modelled using workarounds due to limitations in support of elements part of the ArchiMate core. In this section, an overview of the identified limitations is provided alongside the introduction of new concepts selected from the overview. Moreover, a novel extension of ArchiMate is proposed, resulting from the developed viewpoints from Section 6.4 and furthermore visualised to illustrate their relation to the core elements of ArchiMate.

6.5.1 Limitation Identification

The case studies were conducted to identify the structure and processes of an existing DBE with regards to the proposed adaptability requirements and capabilities of this research. The performed sessions consequently resulted in the acquisition of eight hours of ecosystemic process-related data, usable for the development of the novel adaptability viewpoints illustrated in Section 6.4. Nevertheless, the process of modelling the layered viewpoints unveiled several limitations with respect to the core elements provided by the ArchiMate Standard 3.0. Below, these limitations are discussed:

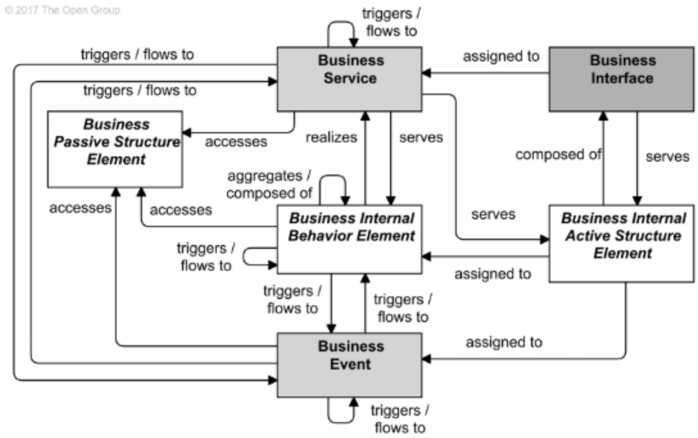

Figure 47: ArchiMate Business Layer Metamodel
(The Open Group, 2017)

1. **Modelling 'External' Elements**
   The ArchiMate Business Layer is commonly used for modelling the business architecture of an enterprise (The Open Group, 2017). Also, concerning the metamodel provided by The Open Group, it becomes apparent that the layer primarily serves to cover internal structures and behaviours (The Open Group, 2017). Consequently, the ArchiMate core is limited in its support for modelling 'external' elements such as ecosystem vendors or partners. In addition, it cannot directly be used to distinguish between ecosystemic processes and other, for example client-related, 'business' processes.
2. **Differentiation Between Ecosystem Participant Types**
   The Business Layer can also be used to model the static structure of an organisation, containing the subjects that perform behaviour such as business processes (The Open Group, 2017). Nevertheless, the layer can only be used to visualise internal active structure elements, such as business actors and roles. Consequently, the ArchiMate core lacks support for modelling and differentiating between different types of ecosystem participants. This differentiating is highly useful, as it can support the categorisation of different participant types, such as partners and vendors. Using the available core elements, these can each be only modelled as (internal) business roles and actors.
3. **Modelling Ecosystem Board**
   The limitations described above also lead to great difficulty in modelling the 'organisation' or 'governance' of the ecosystem, in this research referred to as 'Ecosystem Board'. The traditional ArchiMate core restricts the architect to model this entity through business roles and actors. However, although the entity does exist 'internally', it would be better to separately highlight which ecosystem participants influence the ecosystem board through a new entity.

4. **Modelling Ecosystemic Collaboration**
   Furthermore, it proves to be very difficult to model the 'collaboration' (or: relationship) between the involved ecosystem participants and their assets, such as external applications and services that are linked to the standalone, ecosystem components. Consequently, ArchiMate currently offers no direct support for modelling relationships between ecosystem participants and the contribution of their applications and services towards the core ecosystemic offering.
   a. **for Externally Owned Components**
      Partially, this limitation is caused by the fact that there exists no direct relationship type that can be utilised to illustrate what components of a certain ecosystem platform were internally and jointly developed by the participants or separately provided and owned by ecosystem participants (and subsequently linked to the DBE platform).
5. **Participant Interest Alignment**
   As pointed out by several respondents of the case study, especially with regards to the proposed requirement of Self-Organisation, within an ecosystem it is essential to carefully balance and align each of the interests of the participants of the ecosystem, as part of an extensive Partner Management programme. Nevertheless, ArchiMate currently does not offer any element to model the interests (or possibly, drivers) that drive each of the participants of the ecosystem to participate and contribute to it. Consequently, a workaround can be achieved by using the motivation extension and its 'goals' for this, although being ambiguous.
6. **Differentiation Between Internal and External Components**
   A sixth limitation originates from the application layer elements and relationships proved by the ArchiMate 3.0.1. Specification. Similar to the first two limitations mentioned in this section, the layer is typically used for modelling the information systems architecture of a single enterprise, in contrast to that of an entire ecosystem that comprises multiple enterprises (The Open Group, 2017). Consequently, it proves troublesome to use the layer for differentiating between internal (ecosystem) applications, components and services and external ones, provided and owned by ecosystem participants. In the context of an ecosystem, external components are equally important for the successful continuation of the ecosystem but are managed and developed by external partners.

6.5.2 ArchiMate: Ecosystemic Concepts

In the previous section, several ecosystemic concepts have been addressed. In this section, these concepts are revisited to discuss to what extent they are already represented by the core elements of the ArchiMate 3.0.1. Specification, and their respective extensions.

Concept 1: External Elements

As pointed out in Section 6.5.1, the business layer of ArchiMate primarily serves to cover internal structures of enterprises. Consequently, for example, external business processes, functions and objects can be modelled as usual, 'internal' concepts through the existing ArchiMate elements and relationships. To illustrate that they are external entities, business roles could be used to refer to ecosystem participants' ownership.

Concept 2: Ecosystem Participants

Currently, the only option provided by ArchiMate to model different types of ecosystem participants is through the utilisation of business roles. Nevertheless, this leads to unnecessarily complicated viewpoints, as each of the common types of ecosystem participants has to be separately modelled as business roles in every viewpoint. Furthermore, by modelling internal roles/entities as business role, they might be confused with other roles involved in the ecosystem, such as clients and governments.

Concept 3: Ecosystem Board

Similar to the second concept, the board of the ecosystem (or: organisation) frequently comprises several ecosystem participants. The existing Specification of ArchiMate could be used to model this group of participants through the existing elements for business roles and actors. Nevertheless, this does not prevent the superfluous incorporation of a similar ecosystem board pattern in each viewpoint, to merely define its composition and members.

Concept 4: Collaboration

Several functionalities and services offered by the case involved in the case study have been realised through the collaboration of several external components owned and developed by several ecosystem participants. Consequently, it is of utmost importance to incorporate the collaboration behind these offers. In essence, the core elements of ArchiMate can provide support for this need with its 'Application Collaboration' and 'Business Collaboration' elements. However, as they focus on the collaboration among internal enterprise applications or business entities, it disregards the need for potential contingency-related agreements and requirement integration configurations, which could vary significantly per collaboration instance in the ecosystem.

Concept 5: Participant Interests

The available Motivation Extension, part of the ArchiMate 3.0.1 Specification, could be used to model the interests of each ecosystem participant. For example, the 'Goal' element, describing a statement of intent, direction, or desired end states for an organisation and its stakeholders could be used to model the interests of the participants (The Open Group, 2017). Nevertheless, as the element is also used to model other concepts in motivational viewpoints, it could cause some confusion to use a single element for multiple purposes.

Concept 6: Application Elements

Currently, the modelling of external applications, services and components is not supported by the ArchiMate core, nor by its extensions. Consequently, the applications active in the ecosystem each contain a similar look and cannot simply be distinguished. Of course, by linking it to an API or interface, it becomes apparent that it is a separated entity, but this does lead to the increased complexity of the viewpoints.

6.5.3 Extending ArchiMate with Ecosystemic Concepts

As pointed out by Iacob, Quartel, & Jonkers (2012), for the extension of ArchiMate with ecosystemic concepts, several essential principles must be followed. Below, these principles are listed.

- **Reuse**
  Concepts and ideas from existing valuation techniques and models should be reused.
- **Alignment**
  The proposed ArchiMate Extension should be aligned with its current metamodel specification.

- **Parsimony and ease of use**
  The number of proposed extension elements should be kept to a minimum. Whenever possible, existing ArchiMate concepts and relationships should be reused or specialised. In addition, the novel concepts must be easy to learn, understand and use.
- **Model-based valuation techniques**
  The proposed concepts must easily accommodate model-based valuation techniques.

ArchiMate Metamodel Extension

The identified limitations of ArchiMate with regards to the modelling of DBEs have been transferred to new concepts through the proposed concepts in Section 6.5.2. Moreover, the proposed concepts have been related to existing ArchiMate concepts to ensure consistency with existing language concepts, as prescribed by Iacob et al. (2012). The relationship between the proposed concepts and the existing ArchiMate concepts has been illustrated in an adapted metamodel fragment of the software, as can be seen in Figure 48.

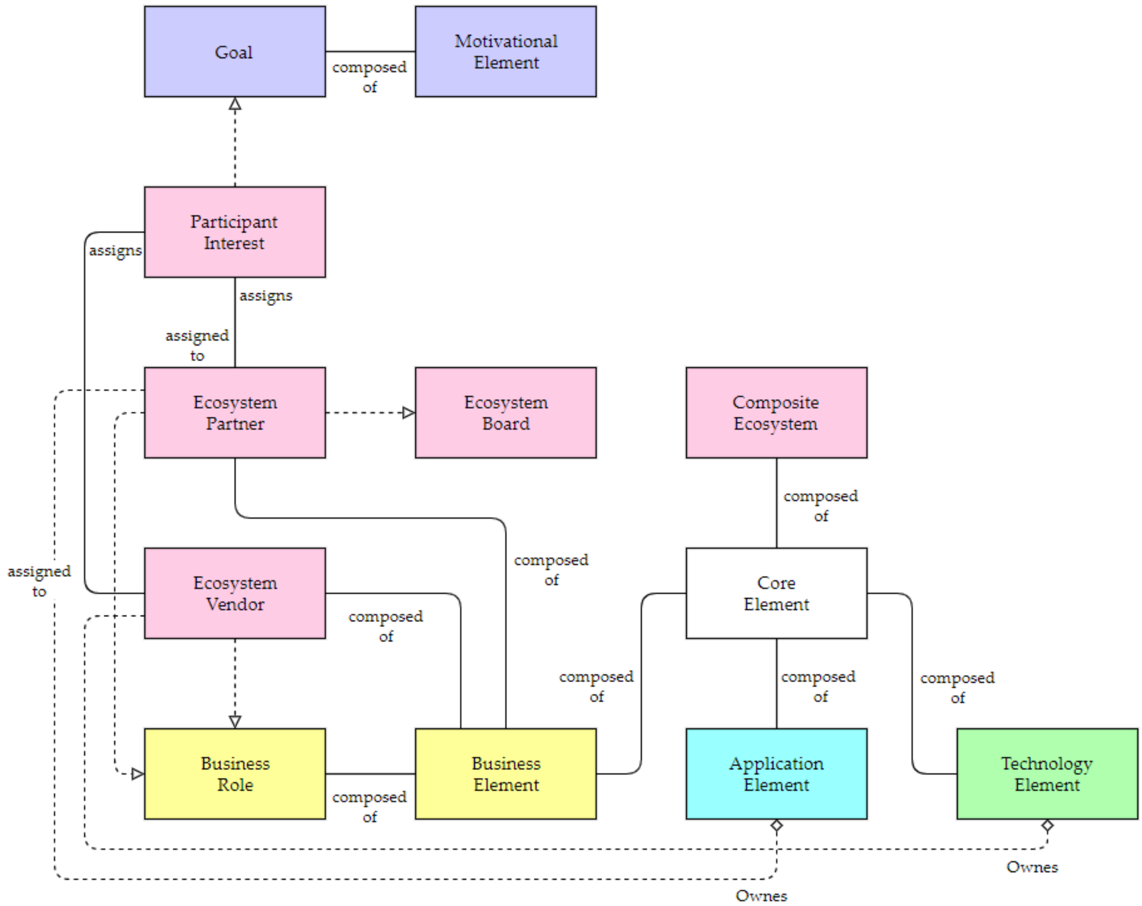

Figure 48: Abstract Syntax (Metamodel Fragment) for Ecosystemic Concepts

The concept of **'Composite Ecosystem'**, or simply 'Ecosystem', has been introduced so that differentiation is possible between what is internally part of the ecosystem and what is not. To that extent, the concept could comprise a range of ArchiMate elements, including business processes, application components, application services and technology nodes. Through this concept, in viewpoints parts of an ecosystem platform can be labelled as internal and are, consequently, developed as components commissioned by the board of the ecosystem. On the contrary, application components that are not part of this composite element are no 'internal' components of the ecosystem and could be owned and managed separately by ecosystem participants but remain important to the ecosystem through generic integrations.

To reduce complexity and enhance the overview of the ecosystemic structure, two ecosystem-specific subtypes have been introduced as a new concept. Consequently, the concept of **'Ecosystem Vendor'** was introduced to define the participants of an ecosystem that do not actively contribute to the ecosystem by, in the context of this research's validation case, offering mobility services or similar mobility products. Although categorised as ecosystem participant, the vendor is not actively involved in decision-making processes and holds no strong interests, as was pointed out by the case study respondents. Nevertheless, the ecosystem participant that could be involved in the decision-making process and has its interests in joining an ecosystem and subsequently actively contributing to it is visualised by the concept of **'Ecosystem Partner'**. Both extensions introduced in this section are, although novel, not introduced in the modelling language as an independent concept. Instead, they are a specialisation of the Business Layer Element 'Business Role', as in essence it represents some subtype of these roles.

The **'Ecosystem Board'** concept is introduced to label the governing entity within a digital business ecosystem. It is frequently comprised of a number of partners that significantly contribute to and benefit from the ecosystem (dynamics). As visible in the metamodel, this concept is realised merely by the newly introduced Ecosystem Partner concept. The board of the ecosystem is primarily responsible for the internal decision-making process and the commissioning of ecosystemic processes and tasks. As can be seen in the Self-Organisation viewpoint (Figure 46), one of the ecosystemic processes governed by the board is Interests Balancing. This also leads to the introduction of the final extension concept, **Participant Interest**, as seen in Figure 48. As became apparent throughout the case studies, each of the ecosystem partners is driven to join and actively participate in an ecosystem by specific interests. Though similar to the Goal element provided by ArchiMate's Motivational Extension, a goal represents a high-level statement of intent, direction, or desired end state for an organisation and its stakeholders, whereas an ecosystemic interest describes the high-level intent for an organisation to join and participate in an ecosystem (The Open Group, 2017). Consequently, the element is assigned to the Ecosystem Partner element and can be modelled as a specialisation of the goal element.

Element Notation

For each of the proposed ArchiMate concept extensions, a graphical notation can be proposed to support the process of visualisation. The graphical notations for each of the concepts are shown in Figure 49. The relationships between the proposed graphical notations and the core layers of the ArchiMate® 3.0.1 Specification is visualised and addressed in more detail in Appendix K: Relationship ArchiMate Extension to Core Layers.

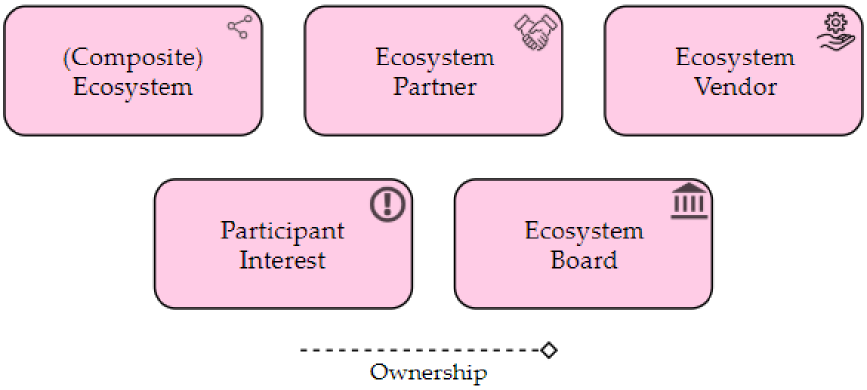

Figure 49: ArchiMate Extension Notation

6.5.4 ArchiMate Extension Viewpoint

If applied to one of the previously developed viewpoints for the adaptability requirements, Figure 50 illustrates how the new elements could be incorporated into the 'smallest' viewpoint of Self-Organisation.

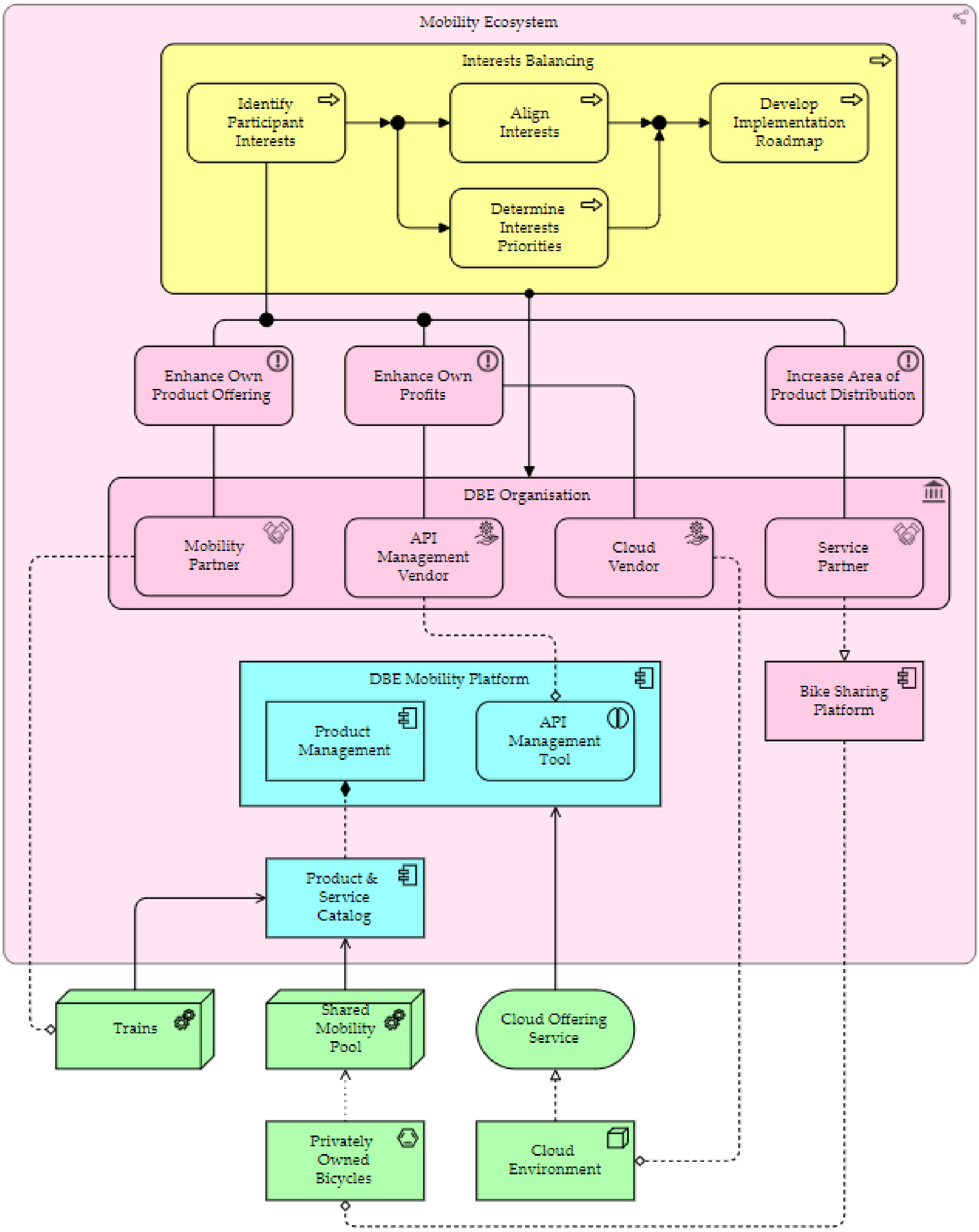

Figure 50: Self-Organisation – Core Layers Extension

6.5.5 ArchiMate Extension Limitations

The proposed extension for the modelling of the identified adaptability constructs in EOAs was developed using the findings collected throughout the case studies. Furthermore, the answering of the research questions does not directly imply the need to extend the ADM's corresponding modelling language. Nevertheless, the development of DBE adaptability viewpoints highlighted several complex and unavoidable limitations. Consequently, in this research a novel extension of

ArchiMate was proposed to accommodate the encountered limitations and allow for future research. As such, the extension has not been validated due to time and resource constraints. In future research, the proposed extension can be further analysed, and its validity validated.

Future Research

In this research, one of the previously identified challenges, adaptability, has been selected[§]. As a result, a method to resolve the shortcoming of adaptability for the development of EOAs has been proposed. From this, several new elements for ArchiMate were proposed. Naturally, this implicates that research on the other challenges could also lead to the identification of limitations with respect to its current specification. Also, these might substantiate the elements already proposed. As such, future research could be focussed on further substantiating the proposed extension by possible resolving other identified challenges.

Validation

As mentioned previously, the presented extension has not been validated in this research due to constraints in terms of time and available resources. Furthermore, the extension of ArchiMate was only proposed after the planned case studies were conducted, consequently limiting the available validation options. Therefore, it is recommended to further validate these findings as part of future research. In line with the overview of available validation methods, as seen in Section 3.5, by means of expert opinion or case studies, the applicability and relevance of the proposed elements can be validated (Wieringa, 2014). Furthermore, it is recommended to involve a large number of DBE projects and their respective participants in the validation sessions to ensure the generalisability of the findings. This is highly important as the research currently remains qualitative and, to generalise to other types of DBEs, these should be included in the validation sessions.

[§] Research previously issued in Research Topics by the same author (Verhoeven, 2019).

7 DISCUSSION

In this section, the findings of this research are discussed. The presented discussion iterates over the taken steps in the design of a method extension to incorporate digital business ecosystem (DBE) adaptability constructs in the development of Ecosystem-oriented Architectures (EOA). This chapter furthermore serves to explain the findings of this research and accurately interpret their meaning. Furthermore, the credibility of the results of this study is addressed. Lastly, the limitations of this research and possible steps for future research are reviewed.

7.1 Adaptability Constructs

The first steps towards the design of a method extension comprised the identification of adaptability requirements and capabilities. In this section, those findings are discussed and interpreted.

7.1.1 Requirements Identification

As mentioned, the first step towards the extension of an existing EA method comprised the identification of relevant requirements for DBE adaptability. The necessity of the identification of these requirements originated from the fact that the initial two phases of the TOGAF ADM, as illustrated in Figure 20, are intended to guide towards the development of a high-level vision of the to be delivered capabilities. Consequently, design principles, goals and drivers, as comprised by the adaptability requirements identified in this research, must be defined in advance of the latter ADM phases involved in the design section.

To identify the requirements, an extensive Systematic Literature Review (SLR) was conducted. By systematically analysing a selection of fifteen core papers (Table 18), fifteen requirements enabling adaptability were identified. Considering that the total number of requirements would be too extensive to be all incorporated in the method, it was decided to reduce the number of the found requirements to a set of five. The decision is further substantiated by the fact that, in light of the novelty of this area of research, adaptability requirements were also deduced from academic studies focussed on related topics of research to broaden the sources of information. Consequently, seven out of the fifteen identified requirements were proposed by the selected literature in merely one study. Their apparent influence on adaptability can hence be negated. As a result, an inclusion threshold of 25% was introduced alongside the prerequisite that the identified requirements must have been mentioned by a minimum of two out of the total of three research topics involved in the SLR.

It should be noted, however, that throughout the SLR, the requirements were identified based on the work of merely one researcher. Nevertheless, by following the refinement criteria, as stated in Appendix A.3. Literature Review Protocol, the degree of subjectivity has been reduced to a minimum. Moreover, the detailed protocol allows for a high degree of repeatability (or: test-retest reliability). Interestingly, several requirements that were listed in Table 20 and failed to pass the set thresholds reappeared later on in the research as capabilities. For example, the requirement of modularity was mentioned in 25% of the studies but was not referred to be at least two out of three research topics. Consequently, the requirement was excluded. Nevertheless, it was afterwards mapped on the flexibility requirement (Table 23) as a result of the conducted expert interviews. This finding can be explained by the fact that there exists some degree of ambiguity between the definitions of requirements and capabilities. Consequently, some authors might have proposed ‘modularity’ as being a requirement, yet considering the definitions adopted in this research and presented during the interviews, were identified as capabilities.

7.1.2 Capabilities Identification

The identified requirements are too generic to be incorporated into the design of DBEs. Consequently, the identification of capabilities is of utmost importance to facilitate sufficient insights for the practical realisation of the proposed requirements for adaptability. Due to the high degree of non-empirical and conceptually oriented studies in available academic research, this research refrained from conducted an extensive SLR for the answering of the particular research questions. Instead, employing a Semi-Systematic Literature Review (SSLR), a broad set of (initial) capabilities could be identified and refined to serve as coding scheme for the subsequent collection of adaptability capabilities through expert interviews.

Although numerous capabilities were identified (Table 21), the majority was mentioned merely once and therefore excluded. The resulting set of non-empirical capabilities was illustrated in Figure 16. Nevertheless, to obtain state of the art insights from practice, the core of the adaptability capabilities was collected through interviews with SMEs experienced with the field of DBEs. The interviews resulted in 148 codes reflecting potential adaptability capabilities. Naturally, this large number of capabilities would not be Mutually Exclusive, nor would it be Collectively Exhaustive (MECE). Moreover, it would defeat the purpose of the method extension, as such an extensive amount of capabilities would make it unpractical. Consequently, the set was refined from 148 codes to 26, also including the results obtained through the SSLR. Arguably, this refinement process was conducted in a subjective manner. However, through reviewing sessions with several experts, this risk has been mitigated to a large extent.

Interestingly, the capabilities identified by the SSLR (Appendix B.5. SSLR - Adaptability Capabilities) have only limited overlap with the capabilities identified through the interviews. To be precise, 10 out of 41 SSLR capabilities matched the results from the interviews. A possible explanation for this finding is that a large part of the analysed academic studies lacks a focus on DBEs. Consequently, many of the results are too specific for application on DBEs. In contrast, the interviews did focus on the adaptability of ecosystems and therefore resulted in a large number of less context-specific capabilities.

7.1.3 Credibility

The evaluation of the quality of the conducted research is essential if findings are to be utilised in practice (Noble & Smith, 2015). In this research, numerous strategies have been incorporated to ensure the credibility of the findings. Unlike quantitative research, where statistical methods can be used to establish credibility, for qualitative research credibility can be achieved through the incorporation of methodological strategies (Noble & Smith, 2015). In existing academic literature, numerous criteria for credibility have been introduced (Malterud, 2001). In this research, the terminology proposed by Noble & Smith (2015) is used to assess the credibility of the findings. Their terminology is briefly illustrated in Figure 51.

Validity

As this study concerns empirical research, there exist multiple realities to how the results can be interpreted. Concerning the identification and refinement of the adaptability constructs, its subjectivity could result in different mappings if executed by other researchers. Nevertheless, the identification process of both types of constructs has been conducted through a detailed Literature Review Protocol (Appendix A.3. Literature Review Protocol) and Interview Protocol (Appendix D.4. Interview Protocol). Moreover, the refinement of both constructs has been carefully documented, so that in future research the conducted steps can be reproduced.

Concerning the 'truth value' of this research's findings, a large group of DBE experts was selected and interviewed in-depth and for one hour to carefully clarify the interview's findings. Furthermore, the interviews were audio-recorded so that they could be repeatedly revisited once now themes and constructs emerged. Due to this, it is believed that the methodological bias has been reduced to a minimum.

Reliability

To ensure reliability, or consistency, of the research findings and the conducted analytical procedures, each of the applied research methods has been described clearly in Section 3 and in more detail throughout several sections of the Appendix. Also, the undertaken research methods for the identification of the adaptability constructs, including the SLR, interviews, data analysis and mapping have been evaluated beforehand with several experts from the academic field and Enterprise Architecture, to ensure their correctness. The highly systematic research process applied to identify the adaptability constructs is believed to have enhanced the clarity and transparency of this research (and its findings).

Generalisability

The final factor for credibility includes the generalisability, or transferability, of the findings. To improve generalisability and improve the applicability of the findings across different types of DBEs, the selected list of core literature was obtained from a broad set of research topics (Figure 13) and the interviews were conducted at different organisations, focussed on a large number of DBE-related projects and lastly included several different types of stakeholders. As a result of this approach, the findings can be generalised over different DBE-related projects.

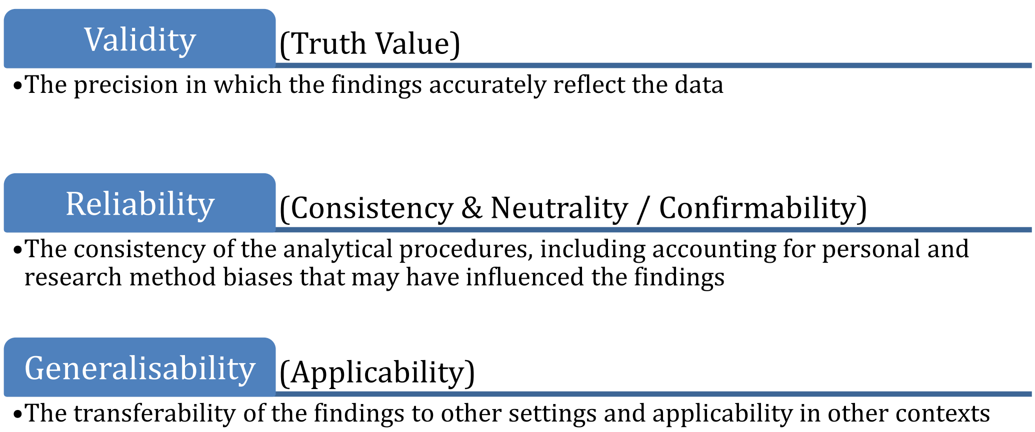

Figure 51: Credibility Terminology & Criteria
(Adapted from Noble & Smith (2015))

7.2 Method Extension

Having identified the adaptability constructs, the next steps towards the extension of an EA method comprised the selection of an existing EA method and its subsequent extension. Furthermore, as mentioned in Section 6.5, an extension for ArchiMate was proposed following the limitations identified during the extension process of the EA Method.

7.2.1 Method Selection

The research documented in the previous section has led to extensive insights into the area or DBE research and the identification of relevant requirements and capabilities for adaptability. These findings are highly important for the development of a method for designing adaptable DBEs so that architects or similar practitioners are provided guidelines on how the findings must be adopted and processed. To analyse whether demand for such a method exists, the last section of the interviews have been devoted to this, as can be seen in the Interview Guide (Appendix D.4. Interview Protocol). Interestingly, the interview results showed that, indeed, existing EA frameworks and methods had been used during the design phases of DBE-related projects. However, a large part of the respondents also noted that they would prefer an extension to an existing EA method more than the development of, yet another, new method. Consequently, to meet the observed demand from practice, the decision was made to instead extend an existing EA method.

For the selection of an appropriate method for the extension, in the interviews several exploratory questions regarding most-used and preferred methods were asked. Thereafter, a literature search was conducted to identify the most complete and applicable method available in current academic literature. As addressed in Section 3.3, both the literature and interviews showed that the method that best matched the defined criteria was developed by The Open Group, namely their Architecture Development Method (ADM). The selection of the ADM for the incorporation of the research findings limits their applicability to the phases described by the method. However, it is believed that the ADM is able to mitigate that limitation as the method is less prescriptive and allows for personal interpretations on several levels. As such, the results are not merely limited to the ADM but remain applicable to other EA frameworks and methods as well.

7.2.2 Method Extension

As mentioned previously, the decision was made to select the TOGAF ADM as 'core' method for the DBE adaptability extension. Considering that the adaptability constructs apply primarily to the design phase of DBEs, this research is restricted to an extension of the subsequent design phases of the development method. This decision was furthermore made in light of the requirements for the execution of the remaining phases (E, F, G and H). In essence, it is believed that these phases cannot be 'generically' covered as they are strongly dependent on the context of the involved case. Moreover, the changes caused by incorporating adaptability constructs in the design do not reach as far as the phases that are not part of the design process, as the actual implementation and project execution is not influenced.

Before incorporating the requirements and capabilities in the method, they have been carefully synthesised. The synthetisation was conducted to validate the applicability of the requirements, based on the interview results and subsequently reduce the total number of capabilities. As a result, an exclusion threshold of 15% was introduced. This threshold could have been set higher but considering the fact that they were to be once more refined as a result of the case study, it was deemed sufficient for this synthesis. Using the findings and the descriptions of the design phases of the ADM, context-agnostic and generic viewpoints have been developed. Utilising these viewpoints, ADM practitioners are guided in their incorporation of adaptability constructs. The decision was made to exclude the core layers from this generic viewpoint development since, at this stage, no information was available to 'apply' it to. Although the information and viewpoint development could have been based on a fictional case, the proposed patterns and obtained findings would have been worthless to experts from practice.

Nevertheless, case-specific viewpoints could have been developed as a result of the conducted case studies for the validation of this research's findings. Although the core layer viewpoints provided novel insights to the application of the capability constructs onto an actual DBE case, it showed merely parts of the entire DBE structure and was subsequently dependent on the interpretation of the researcher. As the case study data was collected through interviews, the researcher individually interpreted these and incorporated them in the design of layered viewpoints. Naturally, this incorporation of case study findings leaves room for personal interpretation.

7.2.3 Modelling Language Extension

Although not proven to apply to other sub-types of DBEs, the visualisation of the core layers did unveil several limitations in the ArchiMate language. As a result, in this research, several new elements have been proposed to mitigate these shortcomings and improve the modelling of ecosystem architectures in the future. It should be noted, however, that the extensions of ArchiMate have been proposed based on the findings of a case study with one case only. Consequently, it would be most valuable if future research continued on these findings and empirically validated the specification of the ArchiMate extension.

7.2.4 Credibility

Once more, for the second half of the steps conducted for the extension of an EA method, the quality of the performed research is evaluated in this section.

Validity

The selection of an existing EA method for the extension has been based primarily on the work of two researchers (B. B. H. Cameron & Mcmillan, 2013). Although the decision to select the TOGAF Standard as a method for the extension has also been confirmed by a large number of interview participants, it remains debatable whether other frameworks should have been selected instead. Nevertheless, the adaptability constructs are also applicable to other EA frameworks, and therefore future research could show how these can be incorporated in other frameworks as well.

Furthermore, the proposed extensions of the ADM and ArchiMate have been developed by merely one researcher. Consequently, an extensive validation phase has been incorporated in this research to ensure that the proposed findings match the expectations of experts originating from one case. Due to resource constraints, no other cases could be involved in these validation sessions. To further enhance the validity of this research's findings, it is recommended to incorporate additional case in the validation phase in future research.

Reliability

To enhance the reliability of the proposed extensions, the performed steps have been extensively documented in this research. In addition, each of the case studies comprised at least 1 hour and 45 minutes to ensure that the findings could be discussed in sufficient details and enough time would be available to obtain a deep understanding of how these capabilities would have implicated the design phase of the selected case.

Generalisability

The adaptability constructs and method extension have been based on the findings of the literature reviews and interviews. Nevertheless, to further enhance the generalisability of the proposed method, it has been applied to an actual case through the case study sessions. Consequently, the applicability of the method on an existing DBE-related case was illustrated. However, considering that only one case was incorporation in the validation phase, it remains debatable whether it is also applicable to other types of DBEs. As such, to enhance the transferability to other contexts, future research could expand the number of case studies.

7.3 Recommendations

The findings of this research can have several implications for EA in practice and to EA practitioners. As pointed out previously, adaptability has been identified as one of the major challenges of the application of EA towards the development of EOAs. An insufficient degree of adaptability can, consequently, endanger the success of a digital business ecosystem. Therefore, this research attempted to illustrate the importance of adaptability and propose means to incorporate the notion more clearly in the design processes of DBEs.

Through existing academic research, the importance of adaptability has been illustrated as an important factor for success, and competitive advantage of respective organisations. Although the benefits of being adaptable are known, this notion should, and can, never be a goal on its own in the design process of ecosystem-oriented architectures. Consequently, during the design phase of DBE-related projects, practitioners can add the principle of adaptability to other, necessary principles, such as compliance with regulations, simplicity or customer-centricity. Combined with all other necessary principles, the process, from vision to development can be executed in accordance with an existing EA method.

To EA practitioners, the findings of this research on the constructs of adaptability provide guidelines on how these principles can be realised. Since the mapping is generically applicable, numerous broad requirements and capabilities have been proposed. Therefore, it is recommended to leverage the presented mapping and constructs during the formulation of the architecture and project vision, so that specific constructs, that are best tailored to the DBE-related project contexts, can be selected and included in the roadmap for their realisation. Consequently, the design process could contain all or only parts of the proposed constructs.

Although the method extension has been proposed based on the TOGAF ADM, it is not strictly necessary for practitioners to also adopt this method. One of the primary reasons for the selection of the ADM comprises its receptiveness towards being modified and extended to suit specific needs, in addition to its allowances for the in- and exclusion of framework elements and the combination with other frameworks. Therefore, the findings are not merely limited to the ADM. Instead, it is also recommended to practitioners to follow the main, and generally applicable, rationale of the ADM and utilise that to set out a process for incorporating DBE adaptability constructs using different frameworks or methods.

Furthermore, this research still implicates the ADM by proposing the described extension. As mentioned previously, practitioners are not limited to the mere application of the ADM for incorporating the presented adaptability constructs in their DBE projects. Nonetheless, the method can still be utilised one-on-one. If so, it is recommended to the practitioners to regard the proposed ArchiMate viewpoints, corresponding with the TOGAF ADM extension, during the realisation. Through the viewpoints, detailed insights into the realisation and implementation of the adaptability constructs are accessible. Furthermore, it provides practitioners with the option to utilise the existing core specification of ArchiMate for modelling ecosystemic environments and illustrates the utilisation of new graphical notations that are currently not yet integrated with the core of ArchiMate.

The final noteworthy implication traces back to the composition of the teams, active in the development of an architecture for a digital business ecosystem. The collaboration and decision-making process in an ecosystem is driven by the ecosystem participants themselves. Consequently, the design process must become a self-organised process, where the interests and drivers of each participant are carefully governed and balanced. In support, the initial strategy and motivation phases of the ADM prove highly effective, and it is therefore recommended to, at least, consider these phases during DBE-related project (design phases).

Concluding, the identified constructs and the corresponding method extension can be leveraged to effectively incorporate the principle of adaptability in the design process of DBEs. Ultimately, this can support EA practitioners in the delivery of increasingly successful DBE platforms, potentially enhancing the competitive advantage of the participating organisations.

7.4 Limitations

Naturally, this subject is subject to several limitations. In this section, the limitations of this research are addressed.

The first limitation of this study originates from its qualitative approach. Data for this research was qualitatively collected and analysed. Consequently, the coding processes conducted for both the literature review and the interviews was, arguably, subjective. The subjectivity can be traced back to the fact that the codes were identified and refined through the work of merely one researcher. Indeed, the subjectivity could have been reduced by incorporating additional researchers in this process and reviewing the conducted work. Nevertheless, due to the nature of this research, the number of involved researchers was constrained to one. However, the validity of the coding process has been enhanced by following detailed literature review- and interview protocols. In addition, the results have been evaluated through multiple sessions to ensure their correctness. Finally, a case study with participants excluded from any other phases of this research was conducted.

For each of the requirements, matching capabilities were obtained through the interviews with DBE experts. Consequently, the mapping of the capabilities onto the requirements was deduced from the order in which interview participants proposed the capabilities. Due to time constraints, the decision was made not to conduct an extra round of interviews, but instead incorporate the validation of the mapping in the case study validation sessions. As a result, the design of the method extension could contain some bias. Nevertheless, it is believed that these were still refined by means of case studies.

A third limitation of this research is caused by the chosen sample sizes for both the interviews and the case study. Several researchers have stated that approximately twelve interviews are sufficient to achieve saturation, as mentioned in Section 3.2.1 (Galvin, 2015; Guest et al., 2006; Rowley, 2012). Nevertheless, for this research, only eleven interviews were conducted. Although one of the interviews contained three respondents, the findings are still subject to potential limitations in terms of whether the desired levels of saturation are achieved. Consequently, by including additional interviews, the risk of missing potential adaptability constructs can be reduced. Nevertheless, by carefully monitoring the diversity of the involved cases and organisations, attempts have been solved to mitigate any risk of a shortage in saturation.

Next to the conducted interviews, an extensive validation approach has proven highly valuable for enhancing the credibility of this research's findings. However, in this research, due to resource constraints, the decision was made to make use of an embedded single-case design. Consequently, four experts active in three organisations, each part of a single case have been extensively interviewed in two-hour sessions to validate the research findings. Nevertheless, the quality of the validation could have been strongly improved by incorporating other cases as well. However, as mentioned before, due to constraints in resources and the novelty of the current DBE practice and field of research, no remaining cases (that were not involved in the initial interview data collection phase) were available.

A final limitation of this research can be traced back to the developed architectural viewpoints. For the design of the method extension, the provision of context-agnostic and generic architectural viewpoints (or: patterns) is of utmost importance. Nevertheless, although these viewpoints can be developed for the Strategy and Motivation extensions, to provide such perspectives on the core layers of an EOA, case-specific data is required. Consequently, the viewpoints were modelled once more using the validation case. However, as that case currently is still in its design process, information on the base architecture of the ecosystem remains somewhat limited and prone to change. In addition, this information had to be extracted from four expert interview sessions where it was verbally provided. As a result, although providing novel insights into a possible implementation of the identified adaptability constructs, the viewpoints remain subjective and cannot be extensively validated.

7.5 Future Research

This research has led to several new opportunities for consolidation of the proposed findings and future research on additional topics involved with the adaptability of DBEs.

The qualitative nature of this research combined with the constraints in resources has led to some limitations in terms of quality of validation. Consequently, future research can be employed to further validate the presented findings. This could be done by extending the existing case study base from embedded single-case designs towards embedded multiple-case designs (Yin, 2013). Not only does this different type of case study design improve the generalisability of the results by incorporating multiple participants from multiple ecosystems. Also, it could provide valuable insights into the applicability of the research findings on the several types of DBEs and the numerous industrial sectors they can be employed in.

On the contrary, future research can also employ a quantitative approach for the enhancement of the data collection or validation of the research findings. In the first scenario, the findings of this study can be used as a basis for developing robust quantitative data collection methods, for example, questionnaires, for the obtainment of larger datasets to deduce additional adaptability constructs that might have been missed in this research. Moreover, this approach allows for validation methods through statistical tools and approaches. To that extent, it would, for example, be intriguing to incorporate:

- Confidence intervals. To indicate the reliability of the validation propositions.
- Regression analyses. For the evaluation of linear relationships between test results, for example, categorised on DBE type, stakeholder role or industry application.
- Hypothesis tests. Future research could design theoretical hypotheses based on the findings of this research and verify them using the newly collected quantitative data. Through this method, the benefits and application of the identified adaptability constructs through an extended EA method can be determined and verified.

Several experts involved in the interviews and case studies correctly noted that this research omitted the cost factor of the proposed adaptability constructs. The decision to disregard that factor in this research was made due to its dependency on DBE-related contexts and projects. As such, the costs could be substantially higher for financial ecosystems were legislation requires numerous additional security features in contrast to smaller, commercial DBE projects. Future researchers could extend the findings of this research by analysing the cost factor, possibly for multiple different industries or DBE types.

Concludingly, as a result of this research, several new opportunities for future analyses have been identified. Clearly, the value of continuing research on this topic and developing new theories contributing to the DBE area of research has been shown.

8 CONCLUSION

This research has resulted in a number of findings regarding the adaptability of Digital Business Ecosystems (DBE). Consequently, the findings, categorised per research question, are addressed in this chapter. In addition, the contributions of this research are presented in the second section of this chapter.

8.1 Conclusions

The goal of this research is to provide an answer to the following main research question:

How can adaptability constructs be incorporated in an existing Enterprise Architecture method for the design of Ecosystem-oriented Architectures?

To answer the above questions, several sub-questions have been formulated. In this section, the obtained results for the answering of each of the sub-questions are briefly summarised.

8.1.1 Digital Business Ecosystems

How are digital business ecosystems defined by relevant academic literature?

To effectively incorporate the identified adaptability constructs in the development of Ecosystem-oriented Architectures (EOA), an initial assessment of the existing terminology utilised in the DBE area of research is necessary. This necessity originates from the conducted Scoping Search (SS), which showed that, currently, there exists a broad terminology for describing similar, or even identical, types of DBE-related collaborative networks. Consequently, for the answering of this research's sub-question and the identification of the existing DBE types, an extensive Systematic Literature Review (SLR) was conducted, as described in detail in Appendix A: Literature Review Protocol. The literature review, which primarily followed the SLR guide proposed by Okoli (2015a), covered and analysed a total of 223 academic studies in line with the defined protocol. This analysis and refinement process, as shown in Figure 54, resulted in a list of nineteen core papers for the answering of this research question (B.2. Selected Core Papers). Utilising these core papers, a large number of ecosystem types was identified, as listed in Table 19.

Considering the prevalence of each of the identified types, a top-3 of primary ecosystem types was selected (Figure 10), comprising:

1. Business Ecosystems (BE)
2. Digital Ecosystems (DE)
3. Digital Business Ecosystems (DBE)

Subsequently, through the identified literature, definitions for each of the ecosystems could be introduced. Nevertheless, considering the focus of this research, the definition for DBEs proposed by Senyo et al. (2019) was adopted and is as follows:

> “A socio-technical environment of individuals, organisations and digital technologies with collaborative and competitive relationships to co-create value through shared digital platforms” (Senyo et al., 2019).

The definition provided by Senyo et al. (2019), was further acknowledged by Nachira et al. (2007), who broke the structure down in three distinct stacks: The SME Networks, Evolutionary Environment (EvE) and the Execution Environment (ExE). Using these stacks, the first comprised the participating organisations and individuals of the ecosystem as a whole. The second served to illustrate the coevolution of capabilities and roles in the ecosystem, and the latter depicted the technical infrastructure of the DBE.

Concluding, this research provided a novel analysis of the current state of research of the field of DBEs, presenting an overview of the most frequently mentioned types of collaborative ecosystems and their characteristics. Furthermore, DBEs have been selected as primary research subject for this research and have been defined as shown above.

8.1.2 Adaptability Requirements

> Which architectural requirements influence digital business ecosystem adaptability?

The first step towards the incorporation of adaptability constructs in the design of DBEs comprised the identification of relevant architectural requirements influencing adaptability. Considering that the first iteration of the SLR, as described in the previous section, lacked a sufficient focus on the topic of adaptability, the decision was made to conduct a second iteration with a focus on that topic. Once more, the review followed the guidelines as proposed by Okoli (2015a). Nevertheless, due to the novelty of the area of research, as pointed out by Senyo et al. (2019) and the subsequent lack of sufficient literature, for this iteration, reference disciplines, such as Enterprise Architecture and Adaptive Enterprises, related to the field of DBEs were included to enhance the quality of the overall academic findings. The included reference disciplines are subsequently illustrated in Figure 12. Throughout the second iteration of the SLR, 116 papers were analysed and refined utilising the predefined criteria, resulting in the selecting on ten novel academic studies on the topic of adaptability. Combined with the previously identified papers focussing (partially) on adaptability, this resulted in a core list of fifteen papers, as listed in Table 18.

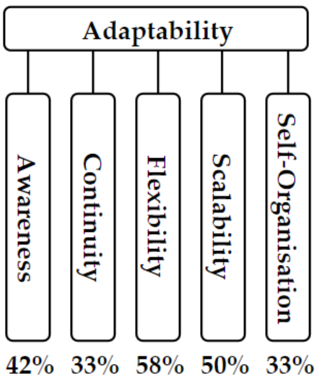

Figure 52: Selected Adaptability Requirements

The analysis of the selected core papers resulted in the identification of fifteen main adaptability requirements. Nevertheless, as including such a large number of requirements into a method would lead to unnecessary complexity and redundancy, in this research, this number was further refined to the five requirements illustrated in Figure 52. The respective refinement was based on several criteria. Firstly, the requirement had to be proposed in at least 25% of the analysed literature. Furthermore, out of the three identified main research topics, the requirements must have been mentioned in at least two of those topics. Consequently, five adaptability requirements were identified: Awareness, Continuity, Flexibility, Scalability and Self-Organisation.

By means of the interviews with thirteen experts from the field of DBE, in the following phase, corresponding capabilities for each of the requirements were to be identified. To present the requirements in a standardised manner to each of the interview participants, they, alongside other findings from the SLR, were structured into a Conceptual Adaptability Framework, as illustrated in Figure 17. Using this framework, respondents were able to validate the proposed requirements and subsequently score them on their relevance with regards to their DBE case. The scoring of the requirements has been listed in Table 8 and illustrates a minimum relevance score of 65% or higher for each requirement. In addition, the findings collected through the interviews were utilised for a final enhancement of the descriptions of each of the requirements.

To conclude, the conducted SLR has resulted in the identification of five high-level requirements for DBE adaptability: awareness, flexibility, continuity, scalability and self-organisation. These requirements were subsequently validated by means of interviews with DBE experts and received a minimum relevance score of 65%.

8.1.3 Adaptability Capabilities

What are capabilities substantiating the adaptability requirements?

The conducted SLR has significantly contributed to the identification of DBE adaptability requirements. Nevertheless, the performed review also confirmed the novelty of the DBE area of research. As a result, this sub-question was answered through a less rigorous Semi-Systematic Literature Review (SSLR), providing an unstructured, initial list of potential adaptability capabilities. In total, the SSLR resulted in the identification of eight initial adaptability capabilities, yet these lacked sufficient details and empirical data in support.

Therefore, in this research, interviews were chosen as a prime method for the collection of relevant data in order to identify potential capabilities, corresponding to the previously identified requirements. Although due to the novelty of the field, limited DBE-related cases were available, eleven interviews were conducted with thirteen respondents, active in four different organisations. Furthermore, the primary criteria for the selection of respondents were the DBE-related projects they were active in. Consequently, during the interviews, eight different DBE-cases were covered (Table 6). The conducted Semi-Structured interviews provided a large number of findings, divided over several themes as listed in Table 4. The analysis of the interviews covered a total of 123 pages of transcripts and followed three main steps of analysis, as illustrated in Figure 19.

The quoted transcripts were subsequently analysed, resulting in 229 open codes containing relevant information concerning the adaptability capabilities. Thereafter, these codes were further analysed and refined through the axial coding phase, resulting in 26 high-level axial adaptability codes. These findings are listed in Table 9 and furthermore contain the level of ‘groundedness’, calculated as the prevalence for each capability. The prevalence scores were calculated as the percentage of the respondents that confirmed the applicability of the proposed capability on the pre-selected case for the interviews, out of all the participants that acknowledged the general importance of the capability towards influencing ecosystem adaptability.

After the interviews, the SSLR capability findings were synthesis with the capabilities identified through the interviews, resulting in the inclusion of six capabilities. Other SSLR findings were not included considering their lack of occurrence in the literature. After that, the capabilities were validated through the conducted case studies. The case for these sessions was purposely excluded from the interview phase to prevent any bias. Through these case studies with four respondents from three different organisations, each active in the same DBE-related project, the capabilities were further refined and merged. This led to the final selection and mapping of the adaptability requirements and capabilities, as listed in Appendix I: Final Adaptability Constructs Mapping.

Thus, through the eleven interviews that were conducted in total, 26 DBE adaptability capabilities were identified, realising the previously identified requirements. Furthermore, through four case study session, the proposed capabilities were further refined to fifteen, resulting in a final mapping presented in Appendix I: Final Adaptability Constructs Mapping, and below in Figure 53.

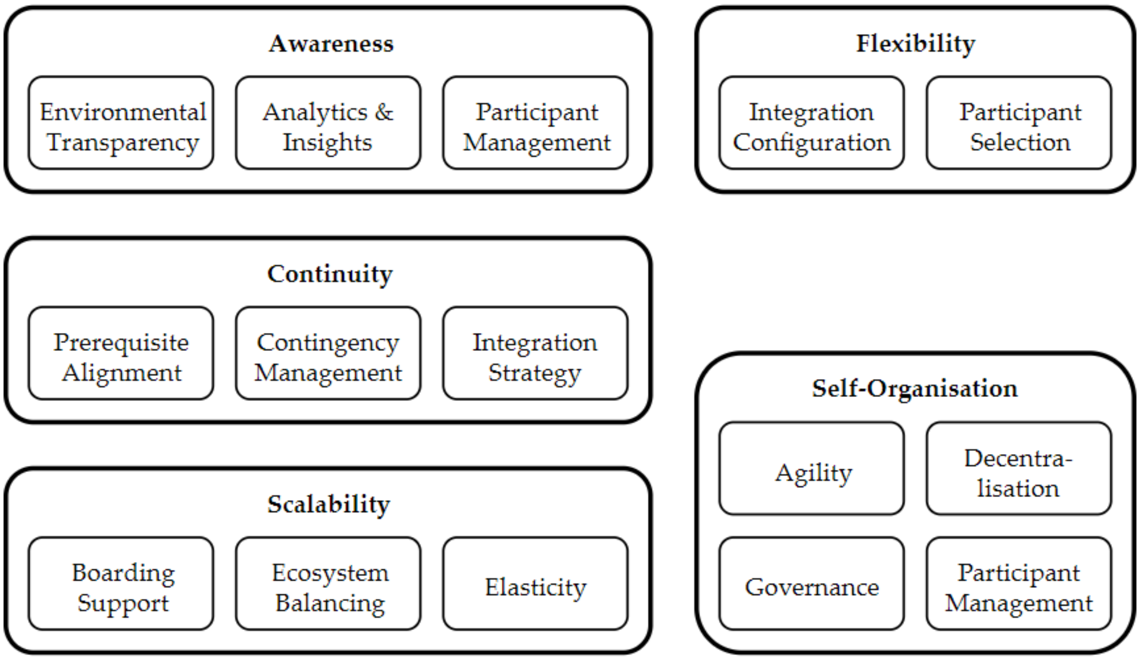

Figure 53: Summarised Adaptability Constructs Overview

8.1.4 Enterprise Architecture Frameworks

To what extent are the identified adaptability requirements for DBEs compatible with existing EA frameworks?

The identification of the adaptability constructs has illustrated what could be incorporated in the development of EOAs to facilitate adaptability. Nevertheless, these findings do not illustrate how the constructs can be included in the development. Consequently, an existing EA Method could be utilised for that process. For the answering of this question, the extent to which existing EA frameworks supported this process was analysed.

Currently, there exists a large number of EA frameworks that can assist in the implementation and utilisation of EA in numerous ways (B. B. H. Cameron & Mcmillan, 2013). Also, the utilisation of EA practices to support strategic and business-IT alignment in DBEs has been proposed by numerous authors, as described in Section 2.4. To that extent, the utilisation of EA can support organisations towards quicker reconfiguration and adaptation to changing circumstances in their environments. Considering that the main findings of this research are to be incorporated in an existing EA method and for the subsequent answering of this sub-question by determining the degree of compatibility, existing EA frameworks have been compared for the selection of the 'most widely-applicable' framework, to be used for the analysis.

Consequently, the comparative analysis performed by B. B. H. Cameron & Mcmillan (2013) showed that, currently, the TOGAF Standard, is used the most and receives the highest scores in a predefined list of criteria. In line with these findings, in the conclusions of the conducted interviews with experts from the field of DBEs, the primary utilisation of TOGAF was acknowledged. Therefore, it was concluded that the TOGAF ADM, its subsequent method, would be adopted for the mapping onto the identified constructs.

The identified requirements were shown to be most applicable to the design phases of the ADM, as listed below. In addition, considering the genericity and receptiveness of the method, modifications and extensions to suit specific needs were allowed.

- Preliminary Phase
- Phase A: Architecture Vision
- Phase B: Business Architecture
- Phase C: Information Systems Architecture
- Phase D: Technology Architecture
- ADM Architecture Requirements Management

To achieve compatibility with the identified adaptability constructs, several aspects involved in the design phases of the ADM, listed above, must be altered. It is believed that the other phases involved in the ADM remain unchanged, due to their level of detail and dependency on a specific project context. Firstly, to accommodate the changes towards the incorporation of the adaptability constructs, the establishment of the architectural principles, as part of the Preliminary phase, must be limited towards the newly introduced adaptability principle. Furthermore, to accommodate the DBE adaptability constructs, it is argued that these require two separate high-level changes: the facilitation of the incorporation of adaptability constructs and the extension of the ADM context from siloed organisations to DBEs, comprising a new type of organisational model. Consequently, a new organisational model for the EA must be developed, which can be illustrated using ADM's corresponding modelling language ArchiMate. Furthermore, for the organisational model, it is recommended to carefully categorise the types of participants involved.

For the following phase, Architecture Vision, it is once more recommended to make extensive use of the ArchiMate language to model and visualise the underlying motivations and strategies, as these can differ significantly due to the changed organisational context. In addition, to apply the ADM to ecosystems, the usage of Capability-Based Planning to primarily enhance the decision-making process has been stressed. The exact application of and alterations to the CBP technique are discussed in Section 3.4.1.

Finally, several alterations to the architecture phases of the ADM (B, C & D) are recommended for compatibility with the DBE requirements. Nevertheless, these recommendations originate from the application of the method on an actual case, as part of the case studies, and highlighted several limitations in terms of modelling support of ArchiMate for the development of core layer viewpoints. Consequently, this is discussed in more detail in the next section.

To conclude, for the identification of existing EA framework (method) compatibility, one has been selected due to time constraints. As a result, the TOGAF ADM was selected for the analysis, considering its performance on numerous criteria. The receptiveness of the ADM towards being modified allowed for an extension to support the identified DBE adaptability constructs. As a result, several steps were altered or proposed to allow for the shift towards ecosystems and the incorporation of adaptability constructs.

8.1.5 Method Extension

How can an EA method be extended to support the newly identified adaptability constructs?

The last and highly important step towards the answering of the leading research question comprised the extension of the selected EA method, the TOGAF ADM, to support the incorporation of novel adaptability constructs in the development of EOAs. In this research, the extension has been conducted on two levels. Firstly, context-agnostic alterations were proposed, broadly applicable to enhancing the adaptability of DBEs. Thereafter, case-specific extensions were proposed through the obtained findings from the case studies.

The conducted case studies included four participants working for three different organisations, each involved in the same selected case. By presenting the findings and proposed extension to the participants, their relevance and applicability could be determined. Furthermore, respondents were asked to share detailed insights for each of the presented constructs, so that the resulting findings could be used for the development of the case-specific extension, serving as the actual application of the proposed changes.

For the Preliminary phase of the ADM, changes to the 'Request for Architecture Work' step were proposed. As such, the organisational context is extended, alignment between participant frameworks is required, the ecosystemic internal structure must be discussed, and the ability to conduct the required changes of each organisation must be carefully assessed. The changes are furthermore illustrated through the primary usage of ArchiMate. Consequently, the Motivation extension of ArchiMate was used to develop a generic, context-agnostic Motivation viewpoint for adaptability, illustrating its structure and importance (Figure 28).

The next phase, Architecture Vision, generally focusses on the proposition for the to be developed EA. In line with this research's findings, it is recommended that the five previously identified requirements are considered in this phase. The possible outcomes of the incorporation of each requirement have been extensively described in Section 2.5. To illustrate how this phase can be executed when focussing on DBE adaptability, context-agnostic viewpoints have been developed using the Strategy Extension of ArchiMate. Consequently, for each of the proposed requirements, the capabilities and their sub-capabilities have been modelled, including their interrelationships. These models are shown in Figure 29 to 33.

For the architecture development phases of the ADM, nevertheless, no context-agnostic viewpoints could be developed due to their significant dependency on a specific project-context. As a result, the findings of the case studies were utilised for the development of case-specific viewpoints, serving as the application of the previously proposed method extension. The use case viewpoints have been extensively modelled and described in Section 6.4 of this document. In short, the following case-specific viewpoints were developed, serving as a guide for future applications of this research by architects:

- Motivation Viewpoint
- Awareness – Layered Viewpoint
- Continuity – Layered Viewpoint
- Flexibility – Layered Viewpoint
- Scalability – Layered Viewpoint
- Self-Organisation – Layered Viewpoint
- Relation to Strategy Extension Inside Viewpoints

The development of the viewpoints, using the findings of the case studies, led to a final identification of several limitations for the ADM's modelling language ArchiMate. Consequently, to facilitate the incorporation of adaptability constructs in the development of EOAs and to accommodate the proposed changes to the ADM, a final extension is proposed for ArchiMate. Below, the identified limitations are listed. These are discussed in more detail in Section 6.5.1:

1. Modelling 'external' elements
2. Differentiation between ecosystem participant types
3. Modelling ecosystem board
4. Modelling ecosystemic collaboration
5. Participant interest alignment
6. Differentiation between internal and external components

Based on the above limitations, six new ecosystemic concepts for ArchiMate have been proposed and introduced in detail. In a Metamodel Fragment, as illustrated in Figure 48, the relationship between the proposed and existing ArchiMate elements has been shown. In addition, new graphical notations have been introduced and related to the core of ArchiMate in, respectively, Figure 49 and Appendix K: Relationship ArchiMate Extension to Core Layers. Finally, one of the core layer viewpoints developed earlier has been extended with the proposed elements to illustrate their applicability. It should be noted, however, that the ArchiMate extension has not been part of the initial research, nor does it belong to the artefact of this research. As such, it primarily served as a basis for future research and was based on the findings of the case study.

For the answering of the final sub-question, this research proposed and illustrated the extension of the TOGAF ADM. The changes proposed in the previous section were incorporated and processed by the primary utilisation of ArchiMate. Consequently, both context-agnostic and case-specific viewpoints were developed, providing insights into how the development of EOAs can result in more adaptable DBEs. In addition, the development of the viewpoints resulted in the identification of several limitations with regards to ArchiMate. To resolve this issue and accommodate the changes to the TOGAF ADM, a novel extension to ArchiMate was also proposed as part of this research.

8.1.6 Concluding Remarks

Through the research process outlined in the above sections, several points can be concluded. Firstly, it has been shown that the common issue of adaptability in the development of architectures for DBEs can be resolved. By incorporating all or parts of the proposed requirements and through the realisation of their corresponding capabilities, a focus can be placed on enhancing adaptability throughout the design process.

In addition, the continuing applicability of the TOGAF ADM has been confirmed in this research. Consequently, the method has proven to be also utilisable for the development of EOAs, in addition to more traditional EAs. To further improve the applicability of the method, several extensions have been proposed and validated. Through this process, it has been shown that architectures for EOAs can be developed using the ADM's corresponding modelling language ArchiMate.

Lastly, from the research it can be concluded that, although ArchiMate can support the visualisation requirements for DBEs, several deviations from the standard application of ArchiMate could be made to enhance its support. Considering that ArchiMate traditionally focusses on single organisations, the visualisation process of ecosystems has unveiled several limitations. To mitigate these, several extensions and new graphical notations have been proposed.

To conclude, utilising the findings presented in this research can significantly enhance and structure the development of EOAs and moreover increase the success rate of DBEs by resolving the adaptability challenge. It furthermore enables EA practitioners to support a new organisational type and sets the bar for future research on EOAs.

8.2 Contribution

The findings of this research contribute to both communities of academic research on DBE and EA and to communities of practice. The answering of this research's central research question resulted in three distinctive main contributions, as elaborated in the section below.

1. **Ecosystemic Adaptability Constructs Identification**
   Before the adaptability of DBEs can be enhanced, its respective requirements and capabilities must be identified. As such, through an extensive Systematic Literature Review and Semi-Structured Interviews, five generic adaptability requirements and fifteen corresponding capabilities for their realisation have been identified and mapped onto each other. The identification of these challenges resolves a frequently mentioned issue in academic DBE research and furthermore provides insights to, for example, architects who wish to incorporate the notion as the main principle for a DBE-related project.

2. **Architecture Development Method Extension**
   The mere identification of relevant adaptability constructs for DBEs does not address how these can be incorporated explicitly in the development of EOAs. Consequently, this research provides another contribution by extending the TOGAF ADM to accommodate the development of EOAs and, moreover, through the application of the extension for the

incorporation of the identified constructs in the design of EOAs. As a result, it is shown how an existing EA method can be utilised for the development of ecosystem architectures by applying the extension to one of the significant challenges originating from the transition towards EOAs: adaptability.

3. **Modelling Language Extension**
   The extension of the ADM and the application of the adaptability constructs have unveiled several, to the best of our knowledge, previously unknown limitations of ArchiMate as the corresponding modelling language tool for TOGAF. Although not required for the answering of this research's primary research question, the obtained insights from the visualisation of the findings have been used to propose a novel, yet unvalidated, extension of ArchiMate to accommodate the inflicted changes for the development of EOAs. Consequently, a contribution to the ArchiMate community is made. Nevertheless, it leaves ample room for future research, as discussed in Section 7.

In this section, the specific contribution of this research to the academic and practical field of study surrounding EA and DBEs is discussed, focussing on the three main contributions listed above.

8.2.1 Contribution to Academic Research

Several contributions to the academic field of research on both DBEs and EA have resulted from the performed research. Firstly, it has presented an extensive overview of relevant academic literature on DBE research. Consequently, the performed Systematic Literature Review has resulted in two core papers lists, the first containing eighteen papers on DBE research and the latter fifteen papers focussing on the concept of (DBE) adaptability. Through these overviews, researchers are provided insights into the current state of research and the available literature on this topic. These insides can contribute to the DBE area of research as it was shown that, currently, up to 50.5% of DBE research is non-empirical and conceptual (Senyo et al., 2019). This observation highlights the importance of structuring the existing terminology and research on DBEs and analyse the constructs necessary to enhance the adaptability of DBEs.

Furthermore, through this qualitative research, constructs for DBE adaptability have been identified. In total, five generic adaptability requirements and fifteen corresponding capabilities were proposed. In addition, sub-capabilities have been presented to illustrate how the constructs could be realised in practice. These insights are valuable for the current state of academic DBE research, as it resolves the frequently addresses shortcoming and lack of research on adaptability. Furthermore, a contribution of this research originates from the identified relationships between the presented requirements and capabilities, creating some degree of structure in the current set of available adaptability findings.

Although the identification of the constructs provides new academic insights, it does not accommodate the actual incorporation of adaptability constructs in the design of DBEs. As a result, the third contribution of this research lies with the proposed extension of the TOGAF ADM. Being one of the most complete and most used EA frameworks currently available, the TOGAF Standard has been widely adopted for numerous purposes, including its Architectural Development Method (ADM) cycle, forming the core of TOGAF (B. B. H. Cameron & Mcmillan, 2013; The Open Group, 2018). Despite its successfulness, the cycle is most notably applied for the development of EAs, meeting the business and information needs of organisations (The Open Group, 2018). Consequently, the applicability of the TOGAF ADM on Ecosystem-oriented Architectures and their corresponding organisations poses an entirely new challenge. In response, in this research, an extension is addressed, allowing for the development of EOAs. It provides novel insights into how the ADM design phases can be applied to the development of EOAs and discusses how each of the involved phases must adapt. To further clarify how the ADM extension can be utilised for the development of EOAs, it is applied using the identified adaptability constructs, resulting in several architectural viewpoints and guidelines. To the academic field of research, these findings stress the ongoing relevance of the TOGAF ADM and illustrate its applicability for developing ecosystem architecture through the application of the identified constructs onto the design phases of the ADM.

To complement the proposed extension of the ADM, the final contribution of this research is the subsequent extension of the ADM's corresponding modelling language for EA: ArchiMate. Although not immediately involved in the answering of this research's main research question, the extension of ArchiMate has been proposed to mitigate the limitations identified during the viewpoint development, described in Section 6.4. Although the presented viewpoints of this research have been modelled using the available ArchiMate® 3.0.1 Specification elements, an extension of the modelling language was proposed to mitigate the complexity caused by incorporating numerous ecosystem participants and their application and organisational structures into a single ecosystemic viewpoint (The Open Group, 2017). The concepts addressed in the extension have subsequently been derived from the SLR and the conducted case studies. The contribution in terms of new ArchiMate elements allows a first step towards enhanced supported for the modelling of (adaptable) DBEs. Consequently, there exist ample opportunities to further expand, substantiate and describe these extensions in future research.

8.2.2 Contribution to Practice

In addition to the previously described contributions to the DBE area of research, this study has also provided valuable insights to the DBE field of practice. Firstly, the research has shown the importance and benefits of incorporating adaptability as design principle in the development process of DBEs. Ultimately, through the findings of this research, it can be desired that adaptability receives a more prominent position throughout the designs of these ecosystems.

This research has presented extensive insights into the constructs influencing the adaptability characteristics of DBEs. These insights and their application contain several contributions to the field of EA and their practitioners. Firstly, the proposed constructs can be separately utilised throughout future DBE-related projects. In that context, the requirements can support practitioners during the initial design phases, illustrating available approaches for the enhancement of the adaptive abilities of the to-be-developed ecosystem. In addition, the mapped capabilities can be utilised for guidance throughout the development of the ecosystem architectures, providing insights into how the requirements are to be realised.

Moreover, the proposed constructs can be utilised through the extended method they have been applied to. The original method contains clear steps for successfully developing an architecture and is complemented with ecosystem-related steps and insights, to further enhance the applicability of the ADM towards ecosystems. The method contributes to practice by providing guidelines and steps on the development of EOAs.

Another contribution to practice originates from the DBE adaptability viewpoints developed in this research. The utilisation of the context-agnostic viewpoints allows practitioners to structure the modelling of the project's motivation and strategy, using the generic baseline provided in this research. In addition, the case-specific viewpoints guide practitioners through the application of the proposed extension and the incorporation of adaptability constructs and visualise the realisations of each capability. Lastly, the new graphical notations introduced for ArchiMate can be adopted by practitioners to reduce the complexity and enhance the overview of ecosystemic viewpoints.

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10 APPENDIX

Appendix A: Literature Review Protocol

This Appendix covers the methodology of the literature review that was conducted as part of this research. Considering that the (academic) field of Digital Business Ecosystems (DBE) is still in its infancy, the availability of academic papers is limited. Therefore, it is necessary to obtain a solid theoretical background and a comprehensive overview of all the available academic literature. To ensure the comprehensiveness of the literature review, a scientifically rigorous and structured approach could prove to be highly valuable. Accordingly, the review document in this section draws major concept from existing guidelines for Systematic Literature Reviews (SLR). In the next sections, the protocol prescribing the undertaken steps of the review is addressed. Furthermore, applied strategies and search criteria are covered.

A.1. Literature Review Structure

To ensure a scientifically rigorous and structured approach, for this literature review, existing approaches for an SLR have been adopted. Subsequently, major concepts have been drawn from existing guidelines for SLRs, most notably from the guide proposed by Okoli (2015a). The author points out that during the past years, numerous research papers in the field of Information Systems (IS) have been dedicated to improving the quality of literature reviews within the field. Nevertheless, considering that the majority of the proposed guides lack the employment of standardised methodologies for SLRs, Okoli (2015a) proposed a new, improved guide. In preparation of his novel guide, Okoli (2015a) has studied a large number of academic studies. Consequently, for the development of the SLR guidelines, major points were drawn from a set of six, commonly applied, guides for SLRs, of which several originate from different fields of study. The list below shows the academic studies that have been included in the SLR guidelines developed by Okoli (2015a).

1. Kitchenham & Charters (2007)
2. Petticrew & Roberts (2008)
3. Fink (2014)
4. Rousseau, Manning, & Denyer (2008)
5. Levy & Ellis (2006)
6. Webster & Watson (2002)

The developed guide has been visualised in Figure 52. Its contents have been used as a point of reference throughout this research' literature review. Nonetheless, there exist some discrepancies between the proposed roadmap of Okoli (2015a) and the applied structure of this review. Several deviations from the proposed steps have been made since, for his guide, Okoli (2015a) presumes that the SLR is part of a standalone literature study conducted by a group of researcher. However, the literature review documented in this section served as a basis for follow-up research and was conducted by merely one researcher. Therefore, several proposed steps were adapted to better suit the available resources.

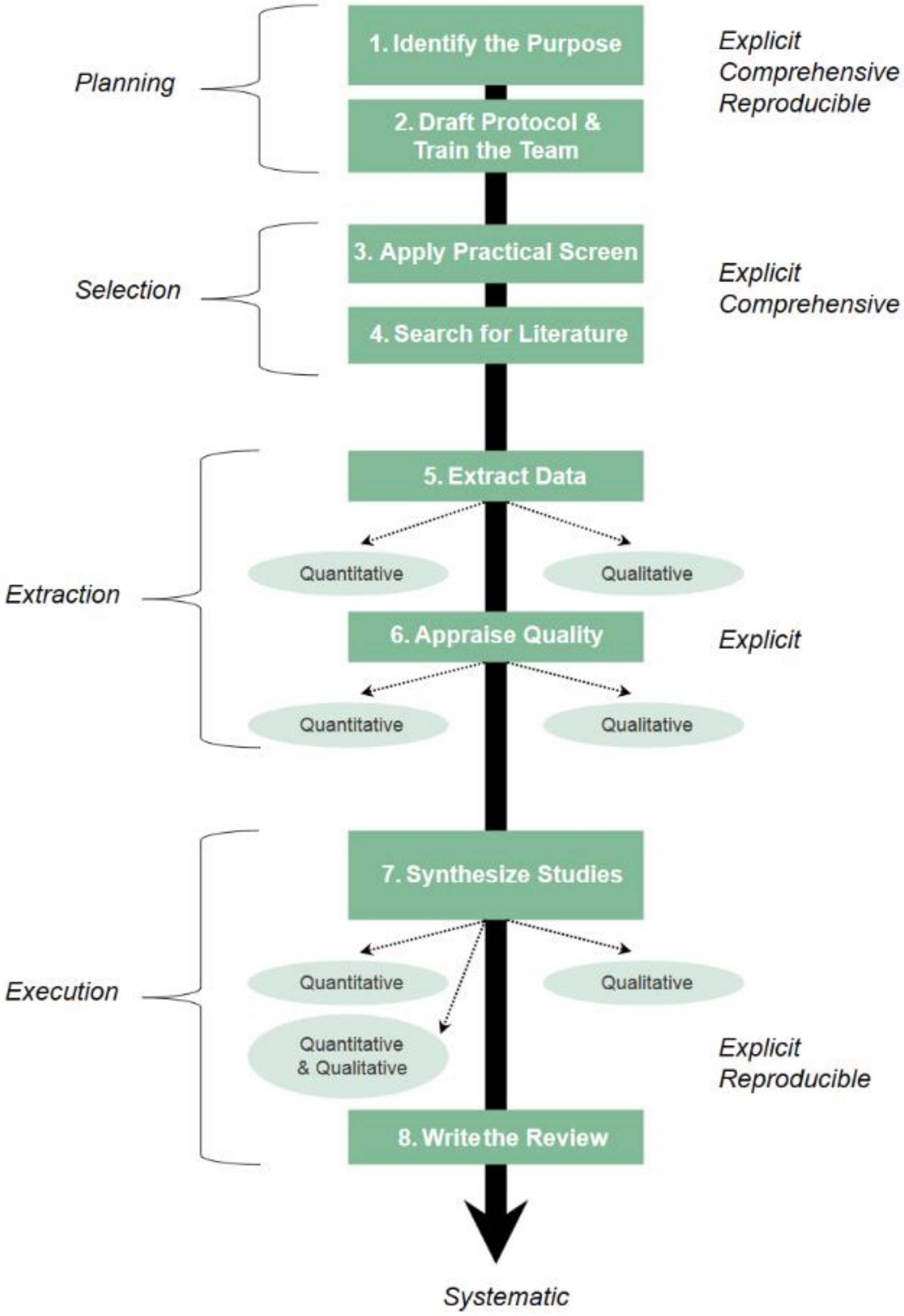


Figure 54: A Systematic Guide to Literature Review Development (Okoli, 2015a)

A.3. Literature Review Protocol

To ensure clarity and agree about the literature review procedure that is followed, in this section, the Literature Review Protocol (LRP) is addressed. In their guide, Kitchenham & Charters (2007) stress the importance of developing an LRP in advance of the actual literature review. Moreover, the authors recommend the external validation of the protocol to verify its rigorousness. In line with the guide proposed by Okoli (2015a), the following LRP is used as a roadmap throughout this research. In the next sections, the protocol for the literature review is discussed. The protocol was drafted based upon the guide provided by Okoli (2015a), including additional concepts adopted from the guide by Kitchenham & Charters (2007). Moreover, several points are drawn from the studies by Webster & Watson (2002), Bandara et al. (2015) and Wolfswinkel et al. (2013).

Scoping Search

Table 10: Principle Scoping Search Functions
(Adapted from Booth et al. (2016))

Principal Function	Brief Description
Methodological	Determination of appropriate review methods
Logistical	Estimation of required time and effort for review
Conceptual	Identification of topics that should be included or excluded
Practical	Identification of terms and synonyms to be used in search phase

From a systematic perspective, it must be noted that this step is not an official component of an SLR. Nevertheless, for the attainment of an enhanced research direction before initiating the systematic search and to familiarise with the Digital Business Ecosystems (DBE) area of research an exploratory, unstructured Scoping Search (SS) has been conducted. The SS moreover served to identify usable research directions, search terms and search criteria for the SLR. The SS served four core principle functions: methodologically, logistically, conceptually and practically, as mentioned by Booth et al. (2016). These functions are briefly described and listed in Table 10. By initiating the literature review with the SS, various requirements for the SLR were identified beforehand, as is visualised in Figure 53. Furthermore, the search allowed for a mitigation of the impact of newly obtained insights and knowledge during the subsequent systematic stages, as these had already been explored previously through the SS.

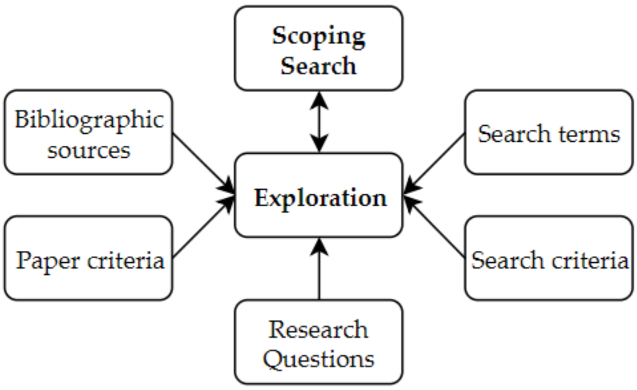


Figure 55: Exploratory Literature Search Objectives

Research Questions

To carefully study the field of DBEs, analyse the role that Enterprise Architecture (EA) poses in that context and identify requirements of DBE adaptability, the following research questions have been defined and included in the literature review:

1. What types of DBEs are discussed in relevant academic literature?

2. What is the role of EA when architecting within DBEs?

- Do existing EA capabilities sufficiently support the transition towards Ecosystem-oriented Architectures (EOA)?

3. What architectural requirements influence digital business ecosystem adaptability?

Research question one and two are analysed first and serve to develop a theoretical basis on DBEs and the applicability of EA on these types of collaborative networks. Subsequently, important adaptability requirements are analysed and selected, as part of research question 3.

Practical Screen

In line with the proposed guide by Fink (2014), Okoli (2015a) recommends using a practical screen for the SLR. According to the researcher, a practical screen must be the first step to follow after the planning phase of the review and should focus on the question: "What studies should be considered in the review?". Okoli (2015a) stresses the importance of being explicit about the criteria used to determine whether the identified studies can be considered for further analysis or not. Moreover, in this section, the exclusion terms are described. These terms discuss when and how studies can be excluded from follow-up analysis in the literature review. By incorporating a practical screen in the SLR, the total number of studies that must be considered can be reduced so that the analysis phase can be realistically conducted by one researcher. In addition, the development of selection criteria during the protocol definition phase can reduce the likelihood of bias throughout the SLR (Kitchenham & Charters, 2007).

Selection Criteria

The selection criteria can be used to determine whether the identified studies should be included in the list of core literature or not. The developed inclusion- and exclusion criteria have been listed and briefly described in Table 11. Before the criteria were applied to the chronological steps of the selection procedure, they have been piloted on a small subset of the initial literature set (Kitchenham & Charters, 2007). The pilot showed the applicability of the criteria and did not produce any changes to the developed listed.

Table 11: Inclusion & Exclusion Criteria

Inclusion Criteria	
1.	The architectural aspect of ecosystems is considered
2.	Digital business ecosystems or digital ecosystems are addressed by the paper
3.	The paper was published in English
Exclusion Criteria	
1.	The paper does not originate from an academic journal
2.	The paper does not originate from the selected fields of study
3.	The paper was published before 2000

It must be acknowledged that the criteria incorporated in the practical screen are debatable in terms of subjectivity. Consequently, there exists no 'hard' border between what papers are included or not. Nevertheless, the criteria are used in support of the decision whether a paper is sufficiently comprehensive and trustworthy, or unsatisfactory and unsuitable for the follow-up review (Okoli, 2015a).

Literature Search Strategy

In this section, the process for searching relevant literature is described. The chronological order of the search strategy has been primarily based on the eight literature review steps defined by Okoli (2015a) but incorporates several adaptations as proposed by Kitchenham & Charters (2007) in their LRP.

Initial Search (Search 1)
For the initial search phase, several bibliographic databases and websites have been used. These digital libraries were pre-selected to ensure, at least a certain level of, academic quality of the selected literature for this research. To reduce search bias, the decision was made to initially include Google Scholar in the selection, which inevitability could lead to a reduction of the academic level of the selected studies. Nevertheless, by filtering the studies using the defined inclusion- and exclusion criteria, these risks can be mitigated. The selected sources have been listed below in Table 12.

Table 12: Selected Bibliographic Databases and Websites

• Scopus
• Web of Science
• IEEE Xplore
• Google Scholar
• ResearchGate
• ACM Digital Library

Moreover, in line with the defined inclusion- and exclusion criteria, the selection of papers must be restricted to publications in academic journals, conferences and proceedings from the field of Information Systems (IS) and Computer Science (CS). The selected academic sources are listed in Table 13. It must be noted that this table comprises the primary set of academic sources, and could be extended with similar or related sources, if applicable.

Table 13: Criteria for Academic Sources

• Business, Management and Accounting
o Management Information Systems
• Computer Science
o Information Systems
• Decision Sciences
o Information Systems and Management

For the identification of relevant literature, the following search terms were applied:

- “*Ecosystem Architecture”
- “*Ecosystem Architecture” AND (Challenge* OR Risk*)
- Ecosystem AND Architecture
- “Enterprise Architecture”
- (Ecosystem OR “Ecosystem-oriented”) AND Architecture
- “Enterprise Architecture” AND “Ecosystem Architecture”
- Ecosystem AND “Collaborative Network”

It should be noted that the list above comprises the main search terms used to select the literature. The development of relevant search terms was an iterative process where terms were combined using Boolean operators such as “AND” and “OR”. Moreover, proximity operators “Pre/n” and “W/n” and wildcards ? and * were applied to further refine the search results. Although these operators differ slightly depending on the type of bibliographic source used, they contain equivalent meanings. Lastly, the terms were used to query on title, abstract, keyword and topic. Once more, this prerequisite depended on the type of source that was used.

Follow-Up Search (Search 2)

The SS and initial search described above have answered listed research questions of this literature review. From the obtained insights, it became apparent that in light of the novelty of this area of research, knowledge with regards to capabilities or approaches supporting the adaptability requirements was limited. Furthermore, the majority of the discussed capabilities was highly subjective or based on personal experiences, lacking extensive validation (Senyo et al., 2019). Therefore, an SLR was deemed too structured and extensive for this research’ third sub-question.

Instead, a Semi-Systematic Literature Review (SSLR) was conducted to gain better insights and explore the suggested approaches. With this review method, the intention shifted from answering research question three to providing a basis for follow-up qualitative research. The approach for the selection of relevant literature was highly similar to the approach described above for the initial search. Consequently, bibliographic sources and academic source criteria were used for the review. However, the analysis of the selected literature was performed less strictly and different search terms, as listed below, were used.

- Ecosystem AND Architecture AND Adapt*
- Ecosystem AND Adaptability
- “Enterprise Architecture” AND Adapt*
- “Adapt* Capabilit*” AND Architecture
- Changeability AND Ecosystem

Again, the above list comprises the primary search terms used for the identification of core literature. Nevertheless, to arrive at this list has been part of an iterative process involving several other combinations of operators as described for the first search.

Selection Procedure

For both search iterations (Initial Search and Follow-Up Search), a set of papers was identified using the previously described method. The identified papers were subsequently mapped on the inclusion- and exclusion criteria. The mapping process was conducted by screening the title, abstract, keywords and conclusion of each paper on both of the criteria (Brereton, Kitchenham, Budgen, Turner, & Khalil, 2007; Kitchenham & Charters, 2007). Papers that do not meet the defined criteria are excluded from the final set of literature, combined with a reason for their exclusion. It is highly important to ensure that a reason for exclusion is given so that when re-evaluating a sample of studies, the results can be checked in terms of consistency in applying inclusion and/or exclusion (Kitchenham & Charters, 2007). Using the screened and cleaned set of literature, a second eligibility assessment can be conducted. For this assessment, however, the full text of the papers is considered and mapped on the criteria.

The literature that results from the two criteria assessments should lastly be checked on their references, as was suggested by Webster & Watson (2002) and Levy & Ellis (2006). Firstly, the citations of the articles are reviewed to determine prior articles that could be of interest to the research topic. Having finished the 'backward search', a 'forward search' is initiated by identifying the articles that have cited the literature that was identified so far. Before being included in the core list of literature, the selected references studies have to pass the selection procedure described previously.

The systematic approach described throughout the previous sections ensures the accumulation of a relatively complete census of relevant literature on this research' topic (Webster & Watson, 2002). Once no new concepts are found in the selected set of literature, or once the searches resulted in the same references with no new results, the literature search can be concluded (Levy & Ellis, 2006). However, before finalisation, the core papers must be assessed by experts to determine their completeness (Fink, 2014; Petticrew & Roberts, 2008). This step is highly essential since the review was performed by merely one researcher, instead of a larger group of researchers.

Data Extraction

The obtained list of core papers for this research has been collected systematically. At this stage, relevant information can be extracted from these papers by means of a systematic approach. For that purpose, a data extraction form can be used. The form, as shown below, has been developed by Okoli (2015a), who adapted the original form proposed by Bandara et al. (2015). Due to resource constraints, the forms were not separately filled in for each of the selected papers. Instead, the relevant sections with regards to the data extraction form were carefully quoted and, when needed, combined with a comment. As such, the data was still identified by means of a systematic approach.

Table 14: Data Extraction Form
(Adapted from Bandara et al. (2015) & Okoli (2015b))

Details	Source
	Year
	Author & Affiliation
General Information	Study Objectives
	Research Question(s)
	Historical Analysis of the Phenomenon
Research Design	Employed Research Methods
	Empirical Data Characteristics
Theory Elements	Concept Definitions
	Characteristics, Dimensions and Level of Analysis of the Concepts
	Relationships Between Concepts
	Theoretical Explanations for Relationships
	Boundary Conditions
Practical Issues	Success Factors
	Issues or Failure Factors
Future Work	Suggested Work

Quality Appraisal

Throughout the data extraction phase, the process of extracting data goes hand in hand with the appraisal of their quality. Therefore, in this section, the quality appraisal process is addressed. Okoli (2015a) recommends using the quality assessment form developed by Fink (2014) as an example when assessing the quality of the papers from the core list. However, as a large part of this review serve to set a solid theoretical background for further research, the quality assessment process proposed by Fink (2014) is considered too broad as it would risk the loss of several papers that, although they are of a slightly lower quality, can still contain highly relevant information for this research. Moreover, in light of the novelty of this area of research, the requirements proposed by Fink (2014) would have a counterproductive result.

Therefore, the checklist provided by Kitchenham & Charters (2007) for a quantitative and qualitative quality appraisal is using for this literature review instead. The developed checklists can be consulted throughout the extraction phase, when papers have been fully read, to prevent literature with lower quality standards to 'corrupt' the results of the literature review.

Literature Synthetisation

The final section of the LRP describes the synthetisation process applied to combine the results obtained through the data extraction and appraisal phases. Depending on the nature of the literature (qualitative, quantitative or both), different procedures must be applied. However, the following procedure already incorporates general guidelines for this process and, as recommended by Okoli (2015a), the guidelines developed by Bandara et al. (2015) should be used for the synthetisation. Bandara et al. (2015) differentiate between two forms of data extractions, or, coding: inductive and deductive. Considering that the main goal of the review is mostly interpretative of nature, the inductive approach can be best applied. This approach allows for the enhancement of our understanding of the meaning of research concepts (Bandara et al., 2015). Moreover, as the authors propose the Grounded Theory literature review methodology by Wolfswinkel et al. (2013), it has been considered in this review. Using this synthesis technique, both quantitative and qualitative studies can be processed (Okoli, 2015b).

Open Coding

The first step in the process is to analyse a random subset of the selected literature and highlight the findings and insights that are considered relevant to the scope of the review and its corresponding research questions (Wolfswinkel et al., 2013). It must be noted that later in the review process, all of the selected studies will be covered. The highlighted sections should be read once more, so that general concepts can be defined. These concepts can subsequently be visualised in a matrix, as recommended by Webster & Watson (2002). A visualisation of this matrix can be seen below, in Table 15. Subsequently, the concepts can be mapped onto higher-order categories to refine the results. For this purpose, a second matrix can be introduced.

Table 15: Concept Matrix Example

Articles		**Concept**		
		Concept 1	Concept 2	Concept 3
1.	Example et al. (Year)	X		X
2.	Example & Example (Year)	X	X	

Axial Coding

The second phase of the research involved the remainder of the papers. Having fully read these papers as well, new insights could lead to a revisitation of the defined concepts and categories. The higher-level categories should represent the main themes of the review. Through axial coding, interrelations between categories, sub-categories and concept can be identified (Wolfswinkel et al., 2013). Moreover, the axial coding process could lead to the development of an additional matrix, mapping the concepts, sub-categories and categories onto each other.

Selective Coding

Lastly, the categories can be further integrated and refined through the selective coding phase. This phase could lead to several final improvements in the matrices made before, by once more going backwards and forward through the excerpts highlighted in the previous stages.

Appendix B: Literature Review Overview

B.1. Literature Selection Details

In this section, an overview is provided of the conducted selection process of the literature review. First, the performed procedure is described, and an overview of the refinement process is presented. Secondly, the process of appraising the quality of the literature is described. Lastly, the process of extracting and synthesising relevant data from the literature has been described.

Selection Procedure

The prescribed search terms and constraints have contributed to the identification of 223 papers for Search 1 and 116 papers for Search 2. The initial set of papers has been further refined based on their title and using the selection criteria. As a result, respectively 168 and 73 studies were excluded primarily since they contained an insufficient focus on Enterprise Architecture (EA) and ecosystems. The subsequent stage focussed on the abstracts, which led to the exclusion of 13 and 16 papers, respectively. Thereafter, respectively 21 and 7 papers were excluded based on their introduction and conclusion. The majority of the exclusions was made based on an insufficient focus on the architectural aspect of ecosystems. Furthermore, several papers focussed to specifically on a non-related subtype of ecosystems or a specific ecosystem integration technique.

Lastly, having read the full texts of the remaining papers in both literature sets, an additional 10 and 13 papers were excluded. The first five steps described above have been illustrated in Figure 54.

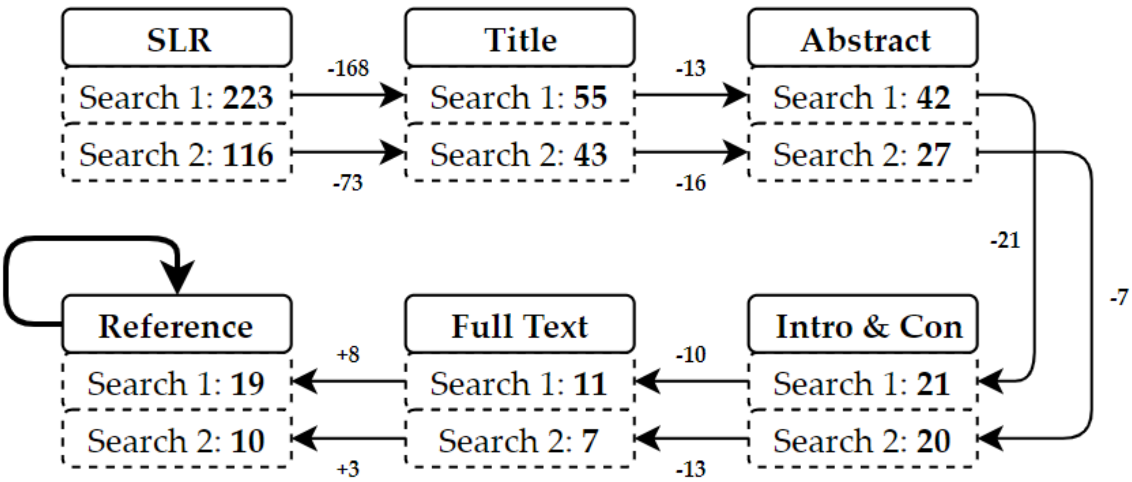


Figure 56: Literature Refinement Procedure Overview

Quality Appraisal

As a result of the checklists, part of the quality appraisal phase, one paper was considered insufficient for inclusion in this research. However, as a measure to resolve this issue, another study by the same author, published shortly before the initial paper, was selected. In contrast to the initial paper, the alternative contained similar results and was published in scientific proceedings (A. R. Bakhtiyari, Barros, & Russell, 2015).

Data Extraction & Synthesis

For the answering of the first research question of the literature review, a concept-centric approach, proposed by Webster & Watson (2002) was applied to extract the existing variety of terms used to describe DBEs and similar concepts. The concepts were extracted from the papers and mapped onto a matrix, containing the respective papers. This resulted in a matrix with rows representing each term and columns representing the analysed papers as Table 20:

For the answering of the second review research question, a less rigorous approach was necessary as it served to identify conceptual findings and opinions from the academic literature. As a result, the same method was applied to extract relevant information from the literature. However, the results were not processed into a matrix with the same level of detail.

The third research question of the literature review focussed on the identification of adaptability requirements. Once more, the concept-centric approach was applied to develop a matrix mapping the identified requirements onto their respective academic papers.

B.2. Selected Core Papers

In this section, the three sets of selected core papers, utilised for the answering of this research's research questions, are listed. The first set of core papers was identified through the conducted Systematic Literature Review (SLR) and focussed primarily on existing research with regards to Digital Business Ecosystems and challenges that come with them. The second set of core papers was established through the Semi-Systematic Literature Review and, each of the papers in the set focussed on the shortcoming of adaptability. The final set of core papers comprised a merge between the initial sets and served as a base for the answering of the adaptability-related research questions.

Systematic Literature Review (Search 1) – Core Papers

In Table 16, the papers that were selected through Search 1 (Systematic Literature Review) as 'core papers' for the data collection phase of the SLR are listed. The applied process, which has led to this selection, is addressed in detail in Appendix A.3. Literature Review Protocol.

Table 16: SLR Core Paper Selection

No.	Authors	Paper
1.	(A. R. Bakhtiyari et al., 2015)	Enterprise Architecture for Business Network Planning: A Capability-Based Approach
2.	(Aldea et al., 2018)	Modeling and Analyzing Digital Business Ecosystems: An Approach and Evaluation
3.	(Briscoe et al., 2011)	Digital Ecosystems: Ecosystem-Oriented Architectures
4.	(Camarinha-Matos & Afsarmanesh, 2012)	Taxonomy of collaborative networks forms: FInES Task Force on Collaborative Networks and SOCOLNET - Society of Collaborative Networks
5.	(Drews & Schirmer, 2014)	From Enterprise Architecture to Business Ecosystem Architecture
6.	(Fayoumi, 2018)	Toward an Adaptive Enterprise Modelling Platform
7.	(Korhonen & Halén, 2017)	Enterprise Architecture for Digital Transformation
8.	(Korhonen et al., 2016)	Adaptive Enterprise Architecture for the Future
9.	(Korpela, Kuusiholma, Taipale, & Hallikas, 2013)	A Framework for Exploring Digital Business Ecosystems
10.	(Krogstie, 2012)	Modeling of Digital Ecosystems: Challenges and Opportunities
11.	(Mäkinen & Dedehayir, 2012)	Business Ecosystem Evolution and Strategic Considerations: A Literature Review
12.	(Moore, 1993)	Predators and prey: A new ecology of competition
13.	(Nachira, 2002)	Towards a Network of Digital Business Ecosystems Fostering the Local Development
14.	(Peltoniemi & Vuori, 2004)	Business ecosystem as the new approach to complex adaptive business environments
15.	(Ramljak, 2017)	Business Models and Value Oriented Service Design Elements in Ecosystem Architecture
16.	(Senyo et al., 2019)	Digital business ecosystem: Literature review and a framework for future research

17.	(Valtonen et al., 2018)	Envisioning Information Systems Support for Business Ecosystem Architecture Management in Public Sector
18.	(Vargas et al., 2016)	Towards the development of the framework for inter sensing enterprise architecture
19.	(Zimmermann et al., 2018)	Evolution of Enterprise Architecture for Digital Transformation

Semi-Systematic Literature Review (Search 2) – Core Papers

The table below lists the papers that were selected through the second literature review search (Semi-Systematic Literature Review) as 'core papers' for the data collection phase of the SSLR. The applied process, which has led to this selection is addressed in detail in Appendix A.3. Literature Review Protocol.

Table 17: Adaptability SSLR Paper Addition

No.	Authors	Paper
1.	(Andresen & Gronau, 2006)	Managing Change – Determining the Adaptability of Information Systems
2.	(Averian, 2018a)	A Conceptual Framework for Adaptability in Digital Ecosystems
3.	(Dantas & Borba, 2003)	Adaptability Aspects: An Architectural Pattern for Structuring Adaptive Applications with Aspects
4.	(Fricke & Schulz, 2005)	Design for Changeability (DfC): Principles to Enable Changes in Systems Throughout Their Entire Lifecycle
5.	(Goel, Schmidt, & Gilbert, 2009)	Towards Formalizing Virtual Enterprise Architecture
6.	(Lapalme et al., 2016)	Exploring the Future of Enterprise Architecture: A Zachman Perspective
7.	(Li et al., 2012)	Digital Ecosystems: Challenges and Prospects
8.	(Masuda et al., 2017)	An Adaptive Enterprise Architecture Framework and Implementation: Towards Global Enterprises in the Era of Cloud/Mobile IT/Digital IT
9.	(van de Wetering & Bos, 2017)	A Meta-Framework for Efficacious Adaptive Enterprise Architectures
10.	(Yu et al., 2012)	Enterprise Architecture for the Adaptive Enterprise – A Vision Paper

Merged Core Papers - Adaptability

In both sets of core literature, as presented above, papers focussing on the challenge of adaptability are present. Consequently, the table below presents a combination of both sets and serve as a basis for the research on the adaptability constructs.

Table 18: Adaptability Requirements Core Papers

No.	Authors	Paper
1.	(Andresen & Gronau, 2006)	Managing Change – Determining the Adaptability of Information Systems
2.	(Averian, 2018a)	A Conceptual Framework for Adaptability in Digital Ecosystems
3.	(Dantas & Borba, 2003)	Adaptability Aspects: An Architectural Pattern for Structuring Adaptive Applications with Aspects
4.	(Fricke & Schulz, 2005)	Design for Changeability (DfC): Principles to Enable Changes in Systems Throughout Their Entire Lifecycle
5.	(Li et al., 2012)	Digital Ecosystems: Challenges and Prospects
6.	(Masuda et al., 2017)	An Adaptive Enterprise Architecture Framework and Implementation: Towards Global Enterprises in the Era of Cloud/Mobile IT/Digital IT
7.	(van de Wetering & Bos, 2017)	A Meta-Framework for Efficacious Adaptive Enterprise Architectures
8.	(Yu et al., 2012)	Enterprise Architecture for the Adaptive Enterprise – A Vision Paper
9.	(Goel et al., 2009)	Towards Formalizing Virtual Enterprise Architecture
10.	(Korhonen et al., 2016)	Adaptive Enterprise Architecture for the Future
11.	(Korhonen & Halén, 2017)	Enterprise Architecture for Digital Transformation
12.	(Lapalme et al., 2016)	Exploring the Future of Enterprise Architecture: A Zachman Perspective
13.	(Peltoniemi & Vuori, 2004)	Business ecosystem as the new approach to complex adaptive business environments
14.	(Valtonen et al., 2018)	Envisioning Information Systems Support for Business Ecosystem Architecture Management in Public Sector
15.	(Zimmermann et al., 2018)	Evolution of Enterprise Architecture for Digital Transformation

B.3. Ecosystem Types

The matrix below illustrates the occurrence of each ecosystem type discussed in the covered literature. It must be noted that the complete set of literature included in this matrix deviates slightly from the core papers selected previously as part of the SLR. This deviation can be explained by the fact that several papers did contain relevant information on types of ecosystems but failed to meet each of the selection criteria. As such, the papers were not included in the core list of literature but were incorporated in the matrix to ensure completeness. The exact details of the matrix are part of previously conducted research, by the same author**.

Table 19: Overview of Addressed Ecosystem Types

Concept	(Abdul et al., 2011)	(A. R. Bakhtiyari et al., 2015)	(Briscoe et al., 2011)	(Drews & Schirmer, 2014)	(Esper, Sliman, Badr, & Biennier, 2008)	(Fayoumi, 2018)	(Goel et al., 2009)	(Korhonen & Halén, 2017)	(Korhonen et al., 2016)	(Korpela et al., 2013)	(Krogstie, 2012)	(Lapalme et al., 2016)	(Peltoniemi & Vuori, 2004)	(Rabelo, Noran, & Bernus, 2015)	(Ramljak, 2017)	(Reimer & Tan, 2014)	(Senyo et al., 2019)	(Sun et al., 2016)	(Tanriverdi & Lim, 2017)	(Valtonen et al., 2018)	(Vargas et al., 2013)	(Vargas et al., 2016)	(Zimmermann et al., 2018)	**Frequency**
Adaptable Ecosystem																							X	**4%**
Biological Ecosystem	X		X								X		X											**17%**
Business Ecosystem	X		X	X		X		X		X			X		X				X	X				**43%**
Business Network		X																						**4%**
Collaborative Network											X				X						X	X		**17%**
Digital Business Ecosystem										X			X	X			X	X	X		X	X		**35%**

** Research previously issued in Research Topics by the same author (Verhoeven, 2019).

Digital Ecosystem	X		X					X			X			X						X				**26%**
Digital Platform Ecosystem								X																**4%**
Ecosystem	X		X										X		X	X			X					**26%**
Government Ecosystem																				X				**4%**
Innovation Ecosystem																		X						**4%**
Service Ecosystem					X																			**4%**
Virtual Business Ecosystem							X																	**4%**

B.4. Adaptability Requirements

The third research question of the literature review focussed on the identification of relevant requirements for adaptability that must be included when incorporating 'adaptability' in the design of digital business ecosystems. As such, Table 20 lists the merged core papers and maps these on each of the requirements that have been discussed in the analysed literature. Please note that the 'greyed out' rows contain no relevant adaptability requirements for further research.

Table 20: Adaptability Requirements Literature Overview

Author(s)	Adaptability Requirement Research Topic	Agility	Awareness (+ Responsiveness)	Co-evolution	Continuity (/ Sustainability)	Emergence	Flexibility	Heterogeneity	Interoperability	Modularity	Reusability	Scalability	Security	Self-Organisation	Self-Similarity	Speed
(Andresen & Gronau, 2006)	Information Systems	X					X		X	X		X		X	X	
(Averian, 2018a)	Digital Ecosystems		X				X	X				X	X			
(Dantas & Borba, 2003)	(Adaptive) Applications									X	X	X				
(Fricke & Schulz, 2005)	Changeability						X			X		X				

(Goel et al., 2009)	Virtual Enterprises															
(Korhonen & Halén, 2017)	Enterprise Architecture															
(Korhonen et al., 2016)	Enterprise Architecture	X	X		X		X							X		X
(Lapalme et al., 2016)	Enterprise Architecture						X									
(Li et al., 2012)	Digital Ecosystems				X							X		X		
(Masuda et al., 2017)	Enterprise Architecture		X				X									X
(Peltoniemi & Vuori, 2004)	Business Ecosystems			X		X								X		
(Valtonen et al., 2018)	Business Ecosystems															
(van de Wetering & Bos, 2017)	Enterprise Architecture		X		X		X					X				
(Yu et al., 2012)	(Adaptive) Enterprises		X				X									
(Zimmermann et al., 2018)	Enterprise Architecture				X											
Relevance (%)		**17**	**42**	**8**	**33**	**8**	**67**	**8**	**8**	**25**	**8**	**50**	**8**	**33**	**8**	**17**

B.5. SSLR - Adaptability Capabilities

Although the performed literature review illustrated that insufficient capabilities were proposed throughout the selected list of core papers. In this section, an overview of the small number of capabilities that have been mentioned in existing literature is given.

Table 21: Semi-Systematic Literature Review - Adaptability Capabilities

Adaptability Capability	Author(s)	NO.
(Platform) Independence	(Andresen & Gronau, 2006; Dantas & Borba, 2003; Fricke & Schulz, 2005)	3x
Agility	(Andresen & Gronau, 2006; Korhonen et al., 2016)	2x
Analytics	(Korhonen et al., 2016; Yu et al., 2012)	2x
APIs	(van de Wetering & Bos, 2017)	
Autonomy	(Fricke & Schulz, 2005; Korhonen et al., 2016)	2x
Availability	(Andresen & Gronau, 2006)	
Business Intelligence	(Yu et al., 2012)	
Cloud Architecture	(Masuda et al., 2017)	
Co-evolution	(Peltoniemi & Vuori, 2004)	
Collaborative Design	(Korhonen et al., 2016)	
Decentralisation	(Fricke & Schulz, 2005)	
Design Thinking	(Korhonen et al., 2016)	
Ecosystem Management	(van de Wetering & Bos, 2017)	
Enterprise-Wide Service Levels	(van de Wetering & Bos, 2017)	
Heterogeneity	(Averian, 2018a)	
High Distribution	(Zimmermann et al., 2018)	
Holism	(Korhonen et al., 2016)	
Integrability	(Fricke & Schulz, 2005)	
Interdependence	(Korhonen et al., 2016)	
Interoperability	(Andresen & Gronau, 2006)	
Knowledge	(Andresen & Gronau, 2006)	
Leanness	(Korhonen et al., 2016; Masuda et al., 2017)	2x
Loose Coupling	(Averian, 2018a; van de Wetering & Bos, 2017)	2x
Microservices	(Masuda et al., 2017)	
Modularity	(Andresen & Gronau, 2006; Dantas & Borba, 2003; Fricke & Schulz, 2005)	3x
Non-Hierarchical	(Fricke & Schulz, 2005)	
On- and Offboarding Support	(Goel et al., 2009)	
Open Standards	(van de Wetering & Bos, 2017)	
Resiliency	(Korhonen et al., 2016)	
Reusability	(Dantas & Borba, 2003)	
Security	(Averian, 2018a; Korhonen et al., 2016; van de Wetering & Bos, 2017)	3x
Self-Similarity	(Andresen & Gronau, 2006)	
Sensing and Seizing	(Yu et al., 2012)	
Service Science	(Korhonen et al., 2016)	

Service-Oriented Architecture	(Masuda et al., 2017)	
Simplicity	(Fricke & Schulz, 2005)	
Standardized Interfaces	(van de Wetering & Bos, 2017)	
Sustainment	(Korhonen et al., 2016)	2x
Systems Thinking	(Korhonen et al., 2016)	
Virtualisation	(van de Wetering & Bos, 2017)	

Appendix C: Interview Results

Throughout this section, the structured results of the conduct interviews are presented. The first sub-section contains an overview of the axial coding of each identified capability. These values are extracted from Atlas.ti and illustrate the number of interviews that referred to the respective capability. The following sub-section presents the mapping of the identified adaptability requirements and capabilities, as obtained from the conducted literature review and interviews.

C.1. Axial Codes Overview

In the table below, the axial codes for each of the proposed capabilities, mapped onto the previously identified adaptability requirements, are listed. The values illustrate the total number of papers that have referred to each of the capabilities and are used to calculate their 'groundedness'.

Table 22: Axial Codes Overview

Adaptability Requirement	Adaptability Capability	Codes
Awareness	Agility	3
	Environmental Openness	5
	Insights	12
	Maturity	8
	Scenario Planning	9
Continuity	Agility	4
	Alignment	9
	Contingency Management	12
	Integration Strategy	4
	Version Support	7
Flexibility	Agility	5
	Integration Configuration	10
	Modularity	4
	Partner Selection	9
	White Label	1
Scalability	Boarding Support	4
	Cloud Technology	2
	Ecosystem Loading	3
	Elasticity	7
Self-Organisation	Agility	2
	Decentralisation	4
	End-to-End Responsibilities	5
	Governance	9
	Interests Balancing	8
	Maturity	1
	Relationship Management	4

C.2. Adaptability Requirements & Capability Mapping

Utilising the conducted literature reviews and interviews, as described in this research, the adaptability requirements and capabilities listed below have been obtained. The overview presented in Table 23 has not yet been validated by means of the case studies.

Table 23: Adaptability Requirements and Capability Mapping

Adaptability Requirements	Adaptability Capabilities	Adaptability Sub-Capabilities
Awareness	Agility	Agile Frameworks
		Short Cycles
	Environmental Openness	Insights
		Open Mindset
		Open Working Environment
		Team Support
	Insights	Analysis
		Analytics
		Customer Feedback
		Market Scans
		Sensing
	Maturity	Experience
		Industry Knowledge
		Vendor Selection
		Vendor Specialisation
Continuity	Agility	Agile Frameworks
		Short Cycles
	Alignment	Ecosystem Thinking
		Holistic Ecosystem Interpretation
		Participant Framework Alignment
		Prerequisite Checks
		Requirement Alignment
		Requirement Management
		Task Separation
	Contingency Management	ESCROW Agreements
		Lifecycle Management
		Process Monitoring
		Service-Level Agreements
		TOGAF Checklists
		Vendor Autonomous
		Vendor Selection
	Integration Strategy	Generic Integrations
		Intelligent Integrations
	Version Support	Rate of Change Support
		Technology Renewal
		Uptime Management
Flexibility	Agility	Agile Frameworks
		Short Cycles

	Integration Configuration	APIs
		Configurable Code
		Connectable Layers
		Generic Connections
		Loosely Coupled Architecture
	Modularity	Componentisation
		Overhead Reduction
	Partner Selection	Advanced Partners
		Experience
		Modern Technological Offering
		On- and Offboarding Support
		Sourcing Strategy
Scalability	Boarding Support	Partner & Vendor Support
		Personnel Management
		Service Management
	Cloud Technology	Hybrid Cloud Infrastructure
	Ecosystem Loading	Event-Driven Architecture
		Power Balancing
	Elasticity	Elastic Infrastructure
		Open Source Tools
		Participant Size Management
		Scalable Frameworks
Self-Organisation	Agility	Agile Frameworks
		Minimum Viable Ecosystem (MVE)
		Short Cycles
	Decentralisation	Autonomy
	End-to-End Responsibilities	End-User Thinking
		High Performing Teams
	Governance	Decision Maker(s)
		Governance Thresholds
		Service Assurance
	Interests Balancing	Interests Alignment
		Partner Involvement
		Partner Management
	Relationship Management	Communication Management
		Continuously Redefining Relationships
		Interdependence Management

Appendix D: Interview Guide

In this section, the full interview guide used for the conducting of the interviews is described. The first section described the background analysed through the literature review and used as a basis for the interview. Thereafter, the goals of the interviews are listed and the intended respondent 'types' are introduced. The following sections are meant for utilisation throughout the interviews themselves and comprise the full Interview Protocol and an Interview Shortlist. The final sections of this chapter address the definitions of notions used in the interviews and briefly discuss the intended results processing method.

D.1. Background

Scientific research has shown that Enterprise Architecture can play a pivotal role in designing digital ecosystems. However, since these ecosystems are often located in highly turbulent environments and due to the many changes, that occur in its business, information, social and technological landscape, adaptability is essential to allow for fast and efficient responses to these changes. Unfortunately, it appears that existing EA frameworks and methods are insufficient for achieving that.

This research aims to develop a new method for designing adaptable digital ecosystems. By means of this method, adaptability of ecosystems should be improved so that the mentioned problem can be tackled, and digital ecosystems can be made more relevant and competitive.

D.2. Goals

To achieve the above goal, I would like to conduct an interview with you as enterprise architect or expert involved with designing a digital ecosystem. The following are the goals of this interview:

1. Identify and evaluate factors of digital ecosystem adaptability
2. Identify methods for enhancing digital ecosystem adaptability
3. Identify the role of Enterprise Architecture for the design and implementation of adaptable ecosystems

D.3. Respondents

For the interviews, several different types of respondents can be interviewed. In this section, these respondent types are listed and briefly discussed. However, even though their tasks and roles can differ, each of the respondents must be (or have been) active within an ecosystem design-related project. This is necessary to exclude potential respondents that were not involved in the design process and therefore, cannot answer the approach or process-related questions.

- Consultant

The first respondent group consists of consultants. These experts are valuable to the research due to the fact that they have been involved in ecosystem-related projects and hold a broad set of knowledge on the topic.

- Enterprise Architects / Solution Architects

This second group of experts holds knowledge over the design and architecture of ecosystems. Therefore, they are valuable to the research as they could share their experiences over applied approaches for improving adaptability.

- Developers

The last group of experts is composed of the developers involved in implementing digital ecosystems. With their technical and hands-on knowledge, they can provide highly valuable information regarding the available technologies for enhancing adaptability.

Naturally, experts involved with digital ecosystems from other backgrounds are not excluded purely based on the list above. Instead, when not part of one of the groups above, an individual assessment should highlight their relevance to the research.

D.4. Interview Protocol

In this section, the protocol for the Semi-Structured Interviews is described. The protocol serves as primary guideline during the interviews, to ensure that all necessary questions are appropriately addressed and answered.

<table>
<tr><th>Semi-Structured Interview Protocol</th></tr>
<tr><th>Introduction</th></tr>
<tr><td>[Introduce the purpose of interview]

---- Permission ----
• Before we continue, I would like to ask for your permission to have this interview recorded. The recording serves to provide a detailed transcription for future analysis.

---- Background information ----
For your information, the results of this interview will be solely used as a source of data for my Thesis. If desired, your personal information or any other sensitive information can be fully anonymised before it is analyses and processed. The transcript of this interview will be sent to you for your acknowledgement. Only with your permission, it will be used in my thesis. This interview will take up around one hour of your time.

---- Introducing questions ----
• Could you please introduce yourself to me?
• Can you tell me something about your professional background?
    • How long have you been active in your current role?
    • What are your tasks at your current role?
• Could you elaborate upon your current background with working on [ecosystem]?
    • What is/was your role regarding [ecosystem]?
• Can you provide some information about [ecosystem]?
    • Who designed it?
    • What was its goal?</td></tr>
<tr><th>Digital Business Ecosystems</th></tr>
<tr><td>During the upcoming questions, I will often be referring to Digital Business Ecosystems. To be clear on what Digital Business Ecosystems are, throughout my Thesis, the following definition is used:

“A socio-technical environment of individuals, organisations and digital technologies with collaborative and competitive relationships to co-create value through shared digital platforms.”</td></tr>
</table>

- Would you say that [ecosystem] is a type of Digital Business Ecosystem, given the definition I just shared with you?
- In the environment of [ecosystem], how prone to change is it in your opinion? Do the most changes occur in its business, information, social or technological landscape?

Adaptability Definition (+ Requirements)

---- Background information ----

The scientific literature on ecosystem adaptability highlights the following:

"EA methods and tools do not provide support for adaptability in reacting to internal and external change demands and therefor are not adaptive enough in the face of today's complex environment. There is a lack of modelling and analysis support for adapting to fast-moving environments."

In the following section, I will be asking several questions about adaptability. To be clear, throughout my research I have defined adaptability as:

"The ability of an ecosystem to internally adapt itself towards its changing environment."

---- Questions ----

- The following framework for adaptability has been made as a basis for the above definition. What factors do you believe are most relevant to [ecosystem], and why?
  - Are there, in your opinion, factors missing?
  - (Regarding factors that have not been mentioned) Are they not applicable?
  - Could these factors be seen as requirements for adaptability?
- Has adaptability been considered throughout the design of [ecosystem]?
  - When is it most frequently considered? As guiding principles driving the design process of an architecture.

Adaptability Capabilities

---- Considered adaptability (if "yes" to above question) ----

- What adaptability approaches have been applied throughout the development of your ecosystem in line with the defined requirements? What capabilities have these resulted in?
  - On what layer of the four-layered EA model (business, data, application and technology) would you classify this approach?
  - Reflecting on the approach mentioned previously, how successful were they in your opinion?
    - In what sense did the ecosystem become more adaptable?
  - If unsuccessful, what is in your opinion the cause of that?
    - What could have been done to avoid that in the future?
    - Do you think that this made the ecosystem less adaptable?

-- Did not consider adaptability (if "no" to above question) --

- Why do you think that no efforts were made regarding the adaptability of [ecosystem]?
- Looking back, do you believe that this would have been valuable?
  - What approaches would have been valuable?

• [If no approaches are mentioned] Do you think [approach found in literature] would have been useful?
Role of Enterprise Architecture for Digital Business Ecosystems

• Was Enterprise Architecture involved during the design phase of [ecosystem]?
  • Do you believe that Enterprise Architecture is valuable for creating well-functioning and effective ecosystems?
 	
• If so, were any EA frameworks used to structure the process?
• Did they sufficiently support the creation of adaptable digital ecosystems?
  • If not, what were the shortcomings?
 	
• To ensure adaptability for future (digital business) ecosystems, would you prefer a specific type of solution? (as in, new method, best practices, extension of framework, etc.)

D.5. Interview Shortlist

Whereas the Interview Protocol described in the previous section was extensively used during the first set of interviews, most of the interviews was performed using a simplified document containing a summarised overview of each of the to-be asked questions. The decision to make use of the Interview Shortlist instead was made to enhance the natural flow of the interviews and allow for more freedom in follow-up questions.

Introduction	
Introduction	
Permission	
Background	
Introducing questions	
• Professional background	
• Ecosystem	
Digital Business Ecosystems	
Definition	
• Relevant to ecosystem?	
Changes in ecosystem environment?	
Adaptability Requirements	
Background + Definition	
Framework	
• Relevant factors	

• Missing factors	
Adaptability considered?	
Adaptability Capabilities	
Applied approaches	
(Un)successful	
Improvements	
If not considered, why not? • Valuable approaches?	
Role of EA	
Involvement of EA	
EA Frameworks • Sufficient support?	
Solution preference	

D.6. Interview Definitions

Throughout the interviews, the following two definitions have been presented to the respondents. To ensure that each respondent answer the questions with the exact same definitions in mind, these have been prepared beforehand and were handed to the respondents. This section contains the definitions for the digital business ecosystem and adaptability.

Digital Business Ecosystem
"A socio-technical environment of individuals, organisations and digital technologies with collaborative and competitive relationships to co-create value through shared digital platforms."

Adaptability
"The ability of an ecosystem to internally adapt itself towards its changing environment."

D.7. Results Processing

The processing of the interview results will contain several steps. Firstly, the audio recordings are to be transcribed. These transcriptions will be fully anonymised. Thereafter, the transcriptions will be analyses using open and axial coding. The relevant parts of the transcriptions should be categorised over the defined research questions so that the coding process can be split up into sections. This is necessary as the first part of the interviews intends to validate existing results, whereas the second part intends to explore entirely new approaches.

Appendix G: Case Study Guide

To ensure that the same questions are answered throughout each of the conducted case studies, a case study guide was developed, containing each of the necessary questions and a questionnaire part on the grading of the presented adaptability constructs.

(0) Record + Anonymization
(3) What is your current function within [company]?
(3) How many years of experience do you have with Enterprise Architecture?
(3) How many years of experience do you have with working with Digital (Business) Ecosystems?
(3) Could you describe the [DBE Mobility Platform] project to me?
(3) Could you describe to me your involvement with [DBE Mobility Platform]?
(4) With respect to [DBE Mobility Platform], do you recognize any of the mentioned shortcomings?
(4) In your opinion, would it have been valuable to incorporate 'adaptability' as design principle/requirement in the design of [DBE Mobility Platform]?
(6) Do you have any experience working with TOGAF? **Could you describe that?**
(6) Could you describe the design phase of [DBE Mobility Platform]? **Have methodologies/frameworks been used?** **Were specific steps/guidelines followed?** **(Has TOGAF been (in)directly used throughout the design of [DBE Mobility Platform]?)**

Awareness		
Has 'awareness' been considered throughout the design of [DBE Mobility Platform]?	**Yes ( )**	**No ( )**

In your opinion, how relevant would 'awareness' be for [DBE Mobility Platform]?	1 ( )	2 ( )	3 ( )	4 ( )	5 ( )
If yes, could you describe how?					
If not, would it, given the definition, have been valuable?					
Continuity					
Has 'continuity' been considered throughout the design of [DBE Mobility Platform]?	Yes ( )		No ( )		
In your opinion, how relevant would 'continuity' be for [DBE Mobility Platform]?	1 ( )	2 ( )	3 ( )	4 ( )	5 ( )
If yes, could you describe how?					
If not, would it, given the definition, have been valuable?					
Flexibility					
Has 'flexibility' been considered throughout the design of [DBE Mobility Platform]?	Yes ( )		No ( )		
In your opinion, how relevant would 'flexibility' be for [DBE Mobility Platform]?	1 ( )	2 ( )	3 ( )	4 ( )	5 ( )
If yes, could you describe how?					
If not, would it, given the definition, have been valuable?					
Scalability					
Has 'Scalability' been considered throughout the design of [DBE Mobility Platform]?	Yes ( )		No ( )		
In your opinion, how relevant would 'scalability' be for [DBE Mobility Platform]?	1 ( )	2 ( )	3 ( )	4 ( )	5 ( )
If yes, could you describe how?					
If not, would it, given the definition, have been valuable?					
Self-Organisation					
Has 'self-organisation' been considered throughout the design of [DBE Mobility Platform]?	Yes ( )		No ( )		

<table>
<tr><td>In your opinion, how relevant would ‘self-organisation’ be for [DBE Mobility Platform]?</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
<tr><td colspan="11">If yes, could you describe how?</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td colspan="11">If not, would it, given the definition, have been valuable?</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td colspan="11">(15) In your opinion, what requirements do you consider to be most important?</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td colspan="11">(15) Do you believe that, with regards to [DBE Mobility Platform], any requirements are missing?</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td colspan="11">Awareness</td></tr>
<tr><td>‘Agility’ Relevant</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
<tr><td>‘Agility’ considered in [DBE Mobility Platform]?</td><td colspan="5">Yes ( )</td><td colspan="5">No ( )</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td>‘Environmental Openness’ Relevant</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
<tr><td>‘Environmental Openness’ considered in [DBE Mobility Platform]?</td><td colspan="5">Yes ( )</td><td colspan="5">No ( )</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td>‘Insights’ Relevant</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
<tr><td>‘Insights’ considered in [DBE Mobility Platform]?</td><td colspan="5">Yes ( )</td><td colspan="5">No ( )</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td>‘Maturity’ Relevant</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
<tr><td>‘Maturity’ considered in [DBE Mobility Platform]?</td><td colspan="5">Yes ( )</td><td colspan="5">No ( )</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td colspan="11">Do you agree with the mapping of the capabilities on the requirements?</td></tr>
<tr><td colspan="11"></td></tr>
<tr><td colspan="11">Continuity</td></tr>
<tr><td>‘Agility’ Relevant</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
<tr><td>‘Agility’ considered in [DBE Mobility Platform]?</td><td colspan="5">Yes ( )</td><td colspan="5">No ( )</td></tr>
<tr><td></td><td colspan="5"></td><td colspan="5"></td></tr>
<tr><td>‘Alignment’ Relevant</td><td colspan="2">1 ( )</td><td colspan="2">2 ( )</td><td colspan="2">3 ( )</td><td colspan="2">4 ( )</td><td colspan="2">5 ( )</td></tr>
</table>

<table>
<tr><td>‘Alignment’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td>‘Contingency Management’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Contingency Management’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td>‘Integration Strategy’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Integration Strategy’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td>‘Version Support’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Version Support’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td colspan="6">Do you agree with the mapping of the capabilities on the requirements?</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Flexibility</td></tr>
<tr><td>‘Agility’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Integration Configuration’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td>‘Modularity’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Modularity’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td>‘Partner Selection’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Partner Selection’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
<tr><td colspan="6">Do you agree with the mapping of the capabilities on the requirements?</td></tr>
<tr><td colspan="6"></td></tr>
<tr><td colspan="6">Scalability</td></tr>
<tr><td>‘Boarding Support’ Relevant</td><td>1 ( )</td><td>2 ( )</td><td>3 ( )</td><td>4 ( )</td><td>5 ( )</td></tr>
<tr><td>‘Boarding Support’ considered in [DBE Mobility Platform]?</td><td colspan="2">Yes ( )</td><td colspan="3">No ( )</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="3"></td></tr>
</table>

‘Cloud Technology’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Cloud Technology’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘Ecosystem Loading’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Ecosystem Loading’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘Elasticity’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Elasticity’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
Do you agree with the mapping of the capabilities on the requirements?					
Self-Organisation					
‘Agility’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Agility’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘Decentralisation’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Decentralisation’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘End-to-End Responsibilities’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘End-to-End Responsibilities’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘Governance’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Governance’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘Interests Balancing’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Interests Balancing’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	
‘Relationship Management’ Relevant	**1 ( )**	**2 ( )**	**3 ( )**	**4 ( )**	**5 ( )**
‘Relationship Management’ considered in [DBE Mobility Platform]?	**Yes ( )**			**No ( )**	

Do you agree with the mapping of the capabilities on the requirements?		
(24) Having observed the proposed adaptability constructs, would they have had a positive impact on [DBE Mobility Platform]?		
(24) Would you consider incorporating adaptability as design principle in future projects?		
(24) In your opinion, how relevant is the proposed extension of the ADM?		

Appendix H: Adaptability Constructs Grading

A large part of the case studies focussed on the validation of the identified adaptability constructs. For this assessment, respondents were requested to score each of the explained constructs on their relevance and applicability, using a five-point scale. The individual and average results of this scoring process have been listed in Table 24, as visible below.

Table 24: Adaptability Constructs Grading

Adaptability Construct	SME 1	SME 2	SME 3	SME 4	AVG
Awareness	3	3	3	3	3,00
Agility	-	-	-	-	-
Environmental Openness	2	3	5	3	3,25
Insights	5	4	2	4	3,75
Maturity	4	4	4	5	4,25
Continuity	4	5	3	4	4,00
Agility	-	-	-	-	-
Alignment	3	3	4	4	3,50
Contingency Management	4	4	5	5	4,50
Integration Strategy	4	3	5	4	4,00
Version Support	3	4	4	2	3,25
Flexibility	5	3	4	5	4,25
Agility	-	-	-	-	-
Integration Configuration	4	3	5	4	4,00
Modularity	4	5	4	4	4,25
Partner Selection	5	4	4	4	4,25
Scalability	3	3	4	3	3,25
Boarding Support	2	3	4	3	3,00
Cloud Technology	3	3	3	2	2,75
Ecosystem Loading	2	2	5	2	2,75
Elasticity	4	4	3	4	3,75
Self-Organisation	4	4	5	4	4,25
Agility	2	3	3	2	2,50
Decentralisation	4	4	3	3	3,50
End-to-End Responsibilities	5	4	4	4	4,25
Governance	5	5	5	4	4,75
Interests Balancing	4	5	4	5	4,50
Relationship Management	3	4	4	3	3,50

Appendix I: Final Adaptability Constructs Mapping

The identified adaptability constructs and their mapping, as listed in Appendix C.2. Adaptability Requirements & Capability Mapping, have been presented to each of the case study participants to validate their applicability and relevance with regards to the selected DBE case. Consequently, through the collected feedback, several refinements have been made with regards to the initial mapping of the constructs. Below, the refined and final overview of the adaptability requirements, capabilities, sub-capabilities and their mapping is presented.

Table 25: Final Adaptability Constructs Mapping

Adaptability Requirements	Adaptability Capabilities	Adaptability Sub-Capabilities
Awareness	Environmental Transparency	Insights
		Open Mindset
		Open Working Environment
		Team Support
	Analytics & Insights	Analyses
		Analytics
		Customer Feedback
		Market Scans
		Sensing
	Participant Maturity	Experience
		Industry Knowledge
		Vendor Selection
		Vendor Specialisation
Continuity	Prerequisite Alignment	Ecosystem Thinking
		Holistic Ecosystem Interpretation
		Participant Framework Alignment
		Prerequisite Checks
		Requirement Alignment
		Requirement Management
		Task Separation
	Contingency Management	ESCROW Agreements
		Lifecycle Management
		Process Monitoring
		Service-Level Agreements
		TOGAF Checklists
		Vendor Autonomous
		Vendor Selection
	Integration Strategy	Generic Integrations
		Intelligent Integrations
		Rate of Change Support
		Technology Renewal
		Uptime Management
		Version Support
Flexibility	Integration Configuration	APIs
		Componentisation
		Configurable Code

		Connectable Layers
		Generic Connections
		Loosely Coupled Architecture
		Modularity
		Overhead Reduction
	Participant Selection	Advanced Partners
		Experience
		Modern Technological Offering
		On- and Offboarding Support
		Sourcing Strategy
Scalability	Boarding Support	Partner & Vendor Support
		Personnel Management
		Service Management
	Ecosystem Balancing	Event-Driven Architecture
		Power Balancing
	Elasticity	Cloud Technology
		Elastic Infrastructure
		Open Source Tools
		Participant Size Management
		Scalable Frameworks
Self-Organisation	Agility	Agile Frameworks
		Minimum Viable Ecosystem (MVE)
		Short Cycles
	Decentralisation	Autonomy
		End-to-End Responsibilities
		End User Thinking
		High Performing Teams
	Governance	Decision Maker(s)
		Governance Thresholds
		Service Assurance
	Participant Management	Communication Management
		Continuously Redefining Relationships
		Interdependence Management
		Interests Alignment
		Partner Involvement
		Partner Management

Appendix J: Architecture Development Method Phases

In this section, concise descriptions for each of the phases included in the TOGAF ADM cycle are presented. These descriptions address the primary objectives of each of the phases and, subsequently, cover some essential inputs and outputs. The presented descriptions are based on the specification provided by The Open Group (2018).

J.1. Preliminary Phase

The Preliminary Phase serves to prepare and initiate the necessary activities for the creation of an architecture capability for an organisation. In this phase, it is permitted to tailor TOGAF to accommodate the needs of the involved organisation and define the architectural principles. Summarising, through this phase, architectural principles are defined, a framework definition is provided, and the project's goals and drivers are demonstrated.

J.2. Phase A: Architecture Vision

The second phase of the ADM is Architecture Vision. In this phase, the scope of the architecture development initiative should be defined. In addition, it is vital to identify the architecture's stakeholders and develop a vision. To proceed to the following phases for the architecture development, approval should be obtained. Lastly, the architectural principles defined in the previous phase can be further refined, as basis for the architecture vision.

J.3. Phase B: Business Architecture

In this phase, the Business Architecture is developed in support of the approved Architecture Vision developed in the previous phases. Subsequently, the baseline and target architecture descriptions should be developed, and a gap analysis must be performed.

J.4. Phase C: Information Systems Architectures

Similar to description provided in Phase B yet focussed on the development of the Information Systems Architecture.

J.5. Phase D: Technology Architecture

Similar to description provided in Phase B yet focussed on the development of the Information Systems Architecture.

J.6. Phase E: Opportunities & Solutions

In this phase, the initial implementation planning is conducted through the determination of crucial change attributes and implementational constraints. Furthermore, the 'delivery vehicles' for the defined architecture are identified, and the gap analysis conducted in the architectural phases is reviewed. Concluding, an architecture roadmap and implementation migration plan should be developed to guide the remaining phases of the architecture development process.

J.7. Phase F: Migration Planning

In this phase, the necessary process for the shift from the Baseline to the Target Architecture is addressed. Primarily, this is achieved by the finalisation of a detailed implementation and migration plan, introduced in the previous phase. This plan furthermore (i.e.) includes resource requirements, availability details and benefit assessments.

J.8. Phase G: Implementation Governance

In short, this phase is conducted for the provision of an architectural oversight of the implementation process. As such, the development and solution deployment work is guided and EA compliance reviews are performed.

J.9. Phase H: Architecture Change Management

In the Architecture Change Management phase, procedures for managing the changes to the new architecture requirements management are established. Furthermore, value realisation processes are established, and the development process' risks are managed. Through this phase, the process of implementing change should be activated.

J.10. ADM Architecture Requirements Management

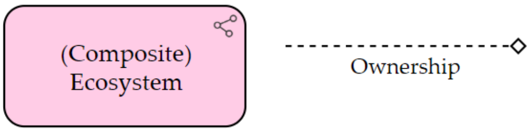
Being not an immediate part of the architecture development cycle, it is stressed that every stage of the project is based on and validate the defined business requirements. In addition, changed requirements should be identified and processed, and the requirements repository must be kept up to date at all times.

Appendix K: Relationship ArchiMate Extension to Core Layers

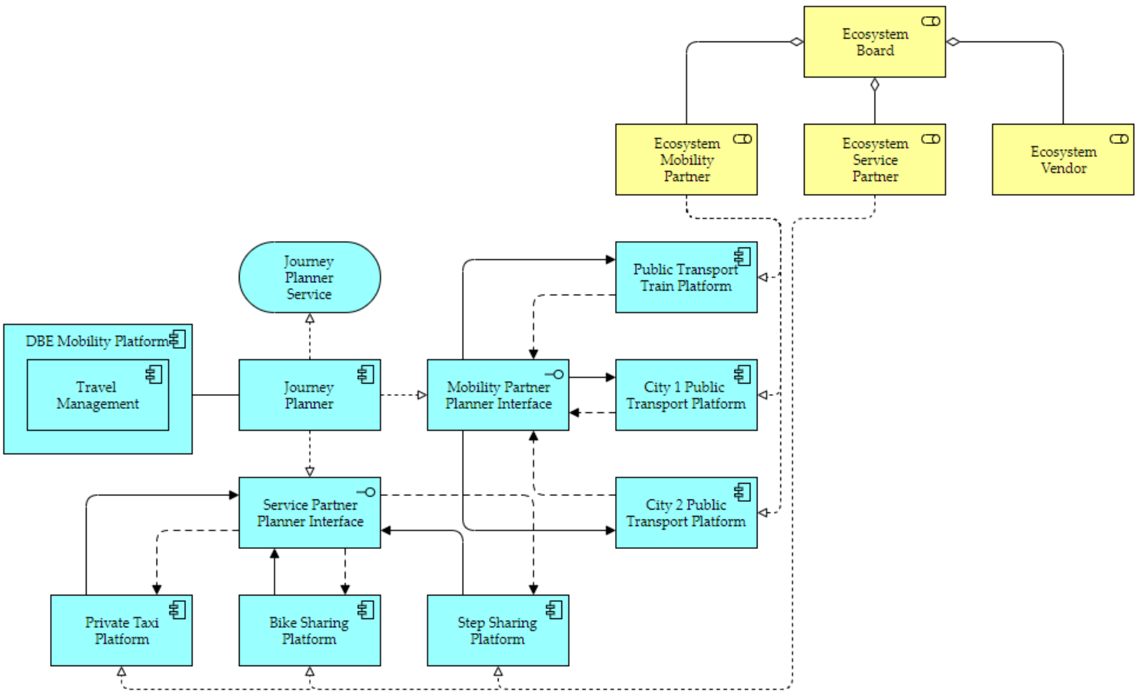
In this Section, the proposed graphical notations, and their relationships with elements originating from the ArchiMate® 3.0.1 Specification are visualised and addressed. A viewpoint, illustrating the combined usage of the novel extension is illustrated in Section 6.5.4.

K.1. (Composite) Ecosystem

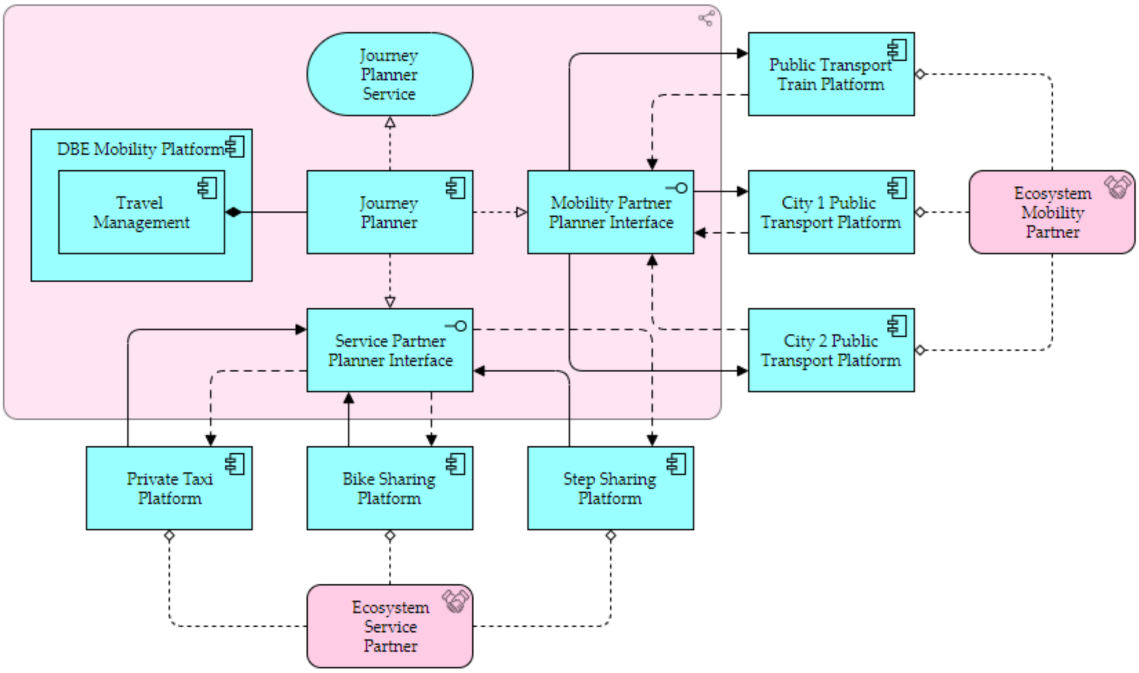
The proposed element for the (Composite) Ecosystem and a corresponding Ownership relationship can be seen below. These elements can be ideally utilised when numerous similar elements, such as application elements, are visualised next to each other, yet their 'ownership' originates both from within the ecosystem and from outside.

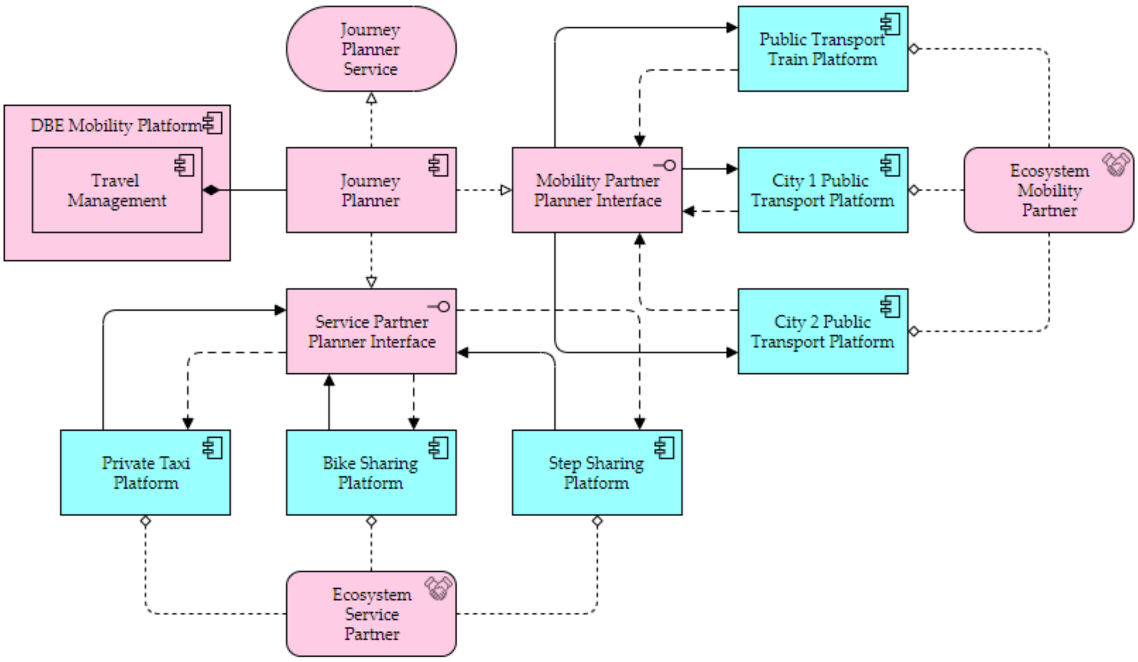


Below, the original situation, as modelled in Figure 43, can be seen. In this viewpoint, the usage of a core application component developed in the ecosystem by ecosystem participants is visualised. The figure contains numerous relationships used to visualise through what interfaces each of the applications collects their information and what component is owned by what participant. Nevertheless, using the proposed elements described above, it is believed that this model can be made simpler and less complex.



As visible below, two viewpoints containing the proposed elements have been developed. The first viewpoint illustrates the exact usage of the notation illustrated above and clearly separates the ecosystem 'internal' parts from the application components that are active and owned by several participants in their application layers. This is further substantiated by the ownership relationships that connect the participant types to their applications that use the ecosystem core data through interfaces.



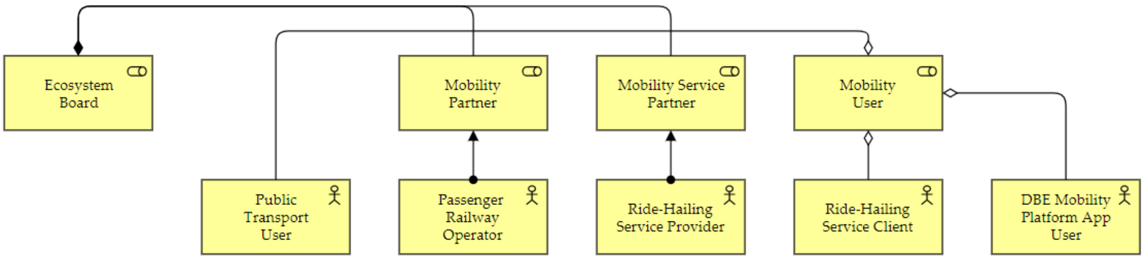


The first usage of the proposed extension is most useful in case the internal and external components are grouped. Only in that scenario, a 'box' or 'group' can be made from the components. Above, a second utilisation of the extension is illustrated, although identical in its meaning. In this viewpoint, instead of grouping the components by means of their colour, the difference in internal and external component is expressed.

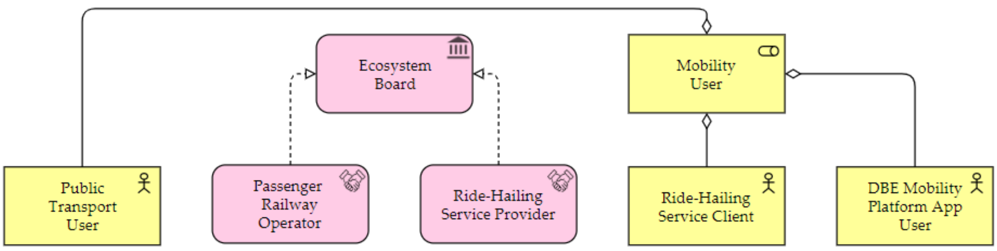
K.2. Ecosystemic Organisation

Another extension that was proposed comprises the taxonomy surrounding the different types of ecosystem participants that were identified. Below, the graphical notation of these elements is illustrated.

A part of the Flexibility viewpoint illustrated in Figure 44 is shown below. It contains several roles involved in the viewpoint and shows the composition of the board of the ecosystem. Nevertheless, from this business layer, it remains challenging to identify which actors and roles are actual clients or external organisations and which of those is, in fact, a participant of the ecosystem. As such, the layers show several customer and platform users alongside some partners of the ecosystem. However, both types of 'actors' are visualised through the same element.



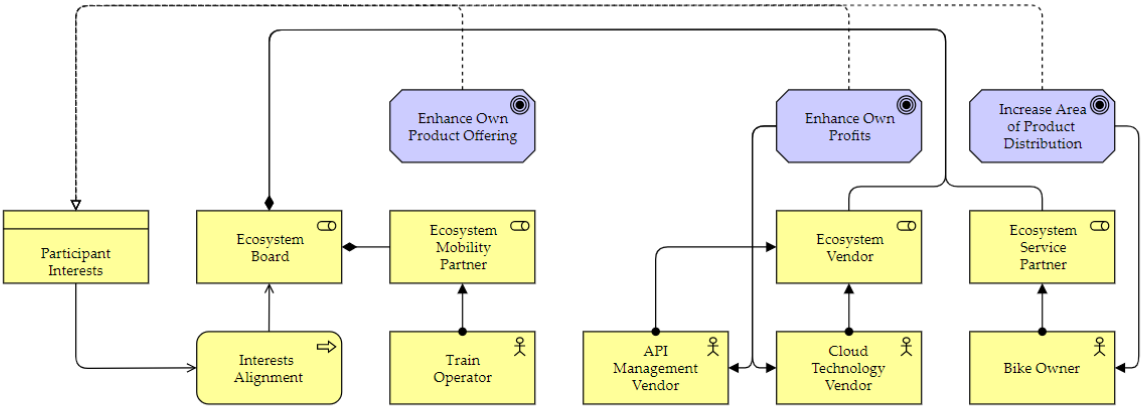
Consequently, several graphical notations have been proposed to mitigate this degree of ambiguity and complexity and clearly differentiate internal from external actors. In the viewpoint below, this is illustrated. From the figure, it becomes immediately visible what the participants of the ecosystem are and how the respective board is formed, in addition to the clients and users of the platform.



K.3. Ecosystem Participants Interests

The final graphical notation that was proposed after the modelling of the DBE adaptability constructs is Participant Interest. From the research, the importance of carefully balancing each of the interests of the ecosystem participants to join and collaborate in an ecosystem became apparent. Consequently, due to a lack of clear modelling support on this matter, a final element was proposed in this research, as illustrated below.

When utilising the core elements currently provided by ArchiMate, it becomes apparent that the modelling of ecosystem participants must go through the usage of the Motivation extension of ArchiMate, as illustrated below. Nevertheless, this leads to increased complexity when using the Motivation extension for its original purposes as well. Also, as visible in this figure, for the roles and actors, the proposed extension has not been used.



In the figure below, the proposed extension is used for modelling the same components. As visible, the complexity of the overall model can be reduced and, in this case, a direct element exists for the modelling of the interests of each participant.