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Interorganizational Collaborative Architecture: A Systematic Mapping Study

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Interorganizational Collaborative Architecture: A Systematic Mapping Study

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Abstract

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Titel
Organisationsübergreifende kollaborative Architektur:
Eine Systematic Mapping Study

Stichworte
Organisationsübergreifend, Kollaboration, Architektur, Enterprise Architecture, Systematic Mapping Study

Kurzzusammenfassung
Kontext: Aktuelle Forschung hat Zweifel an der zentralisierten Top-down-Verwaltung von Enterprise Architekturen und deren empirischen Grundlagen geweckt. Diese Probleme könnten sich in komplexen, dynamischen und kollaborativen Umgebungen verschärfen.
Ziele: Diese Arbeit ist darauf fokussiert, einen Überblick über den aktuellen Stand der Forschung zu organisationsübergreifender kollaborativer Architektur zu bieten und Wege für künftige Forschung anhand von Forschungslücken aufzuzeigen.
Methoden: Es wurde eine Systematic Mapping Study auf Basis von 129 Forschungsartikeln durchgeführt.
Ergebnisse: Es wurde eine literaturbasierte Definition von organisationsübergreifender kollaborativer Architektur vorgeschlagen. Außerdem wurden ein Werkzeug zur kollaborativen Prüfung von Forschungsartikeln (*MapMaker*) sowie eine Visualisierung der Ergebnisse von Keyword-Clustering, die *Semantic Map* genannt wird, entwickelt. Es wurde festgestellt, dass die Forschungsaktivität des Felds global verteilt war und kein klarer Trend in der Anzahl der Veröffentlichungen vorlag. Forschungsarbeiten wurden überwiegend auf Konferenzen präsentiert. Die häufigsten Organisationstypen, über die in der Forschung berichtet wurde, waren staatlich betriebene Entitäten. Die häufigsten Motivationen, Herausforderungen und Ergebnisse waren das Reagieren auf externe Einflüsse, soziale Probleme und Software-Artefakte. Forschungsarbeiten schlugen häufig spezifische Lösungen vor, nutzten Frameworks und konzeptionelle Modelle und wurden als Berichte veröffentlicht.
Schlussfolgerungen: Basierend auf diesen Ergebnissen wurden drei Richtungen für künftige Forschung vorgeschlagen: 1) Stärken der empirischen Grundlagen des Felds z.B. durch empirisches Validieren und Evaluieren von Beiträgen. 2) Verbessern des holistischen Blicks der Forschung z.B. indem Wert auf das Angehen sozialer Probleme gelegt wird.
3) Das Erkunden zukünftiger Anwendungen, um Organisationen beim Erreichen von Zielen in größeren Kontexten, wie gemeinwohlorientieren Ansätzen oder globalen Herausforderungen, zu helfen.

Title

Interorganizational Collaborative Architecture: A Systematic Mapping Study

Keywords

Interorganizational, Collaboration, Architecture, Enterprise Architecture, Systematic Mapping Study

Abstract

Context: Recent research raised doubts over centralized top-down management of Enterprise Architecture and its empirical foundations. These issues may be aggravated in complex dynamic collaborative environments.

Objectives: This work focuses on providing an overview of the current state of research on interorganizational collaborative architecture and proposing avenues for future work based on research gaps.

Methods: A systematic mapping study based on 129 papers was conducted.

Results: A literature-based definition of interorganizational collaborative architecture was proposed. Additionally, a tool for collaboratively reviewing articles (*MapMaker*) was developed along with a visualization of results for keyword clustering called *Semantic Map*. The field's research activity was found to be globally distributed without a clear trend in publication numbers. Works were mainly presented on conferences. The most common type of organization reported on in research were state-operated entities. The most common motivations, challenges and outcomes were reacting to external stimuli, social issues and software artifacts. Papers commonly proposed specific solutions, used frameworks and conceptual models, and presented reports.

Conclusions: Based on the findings, three directions for future work were proposed: 1) Strengthening the field's empirical foundation by empirically validating and evaluating contributions. 2) Enhancing the holistic view of research e.g. by placing importance on addressing social issues. 3) Exploring future applications for assisting organizations in achieving goals in larger contexts, such as common-good-oriented approaches or global challenges.

Acknowledgements & Dedication

First and foremost, I would like to thank my mother and my late father – who recently passed way too early and to whom I dedicate this work – for letting me tinker with computers, which set me on this journey. I would also like to thank my family and friends with special thanks to my brother (not only for proofreading).
On a more professional note, I would like to thank my advisor for his, well, advice in hours of discussion and suffering through the review of more than one thousand papers. I would also like to thank my supervisors for making this cooperation possible.
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— Sebastian Wagner, Hamburg 2020

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1 Introduction

This chapter introduces the study's background and purpose. First, it provides an overview over this work's structure. Second, it presents the problem statement. Third, it defines the research questions of this work. The research questions determine the choice of methods in Section 4.

1.1 Outline

This chapter introduces the problem statement as well as the research questions. Chapter 2 summarizes fundamental concepts and definitions, which serve as a common basis for the rest of this work. In Chapter 3 relevant related work is discussed. Chapter 4 details the methods employed for answering the research questions. After this, Chapter 5 presents the results obtained by applying these methods. Chapter 6 discusses the results and the study's limitations. Chapter 7 shows opportunities for future work. Finally, Chapter 8 concludes this work.

1.2 Problem Statement

Recent studies [11], [14], [15], [42] raise doubts over the commonly found approach of centralized top-down Enterprise Architecture Management (EAM) with Horlach et al. even proclaiming that "[e]veryone's [g]oing to be an [a]rchitect" [14] in agile organizations. Hylving and Bygstad follow arguments made more than a decade ago by Kemp and McManus [16] where "the key to successful EAM is not necessarily compliance, but flexibility" [15], suggesting "that EAM, both academically and practically, needs an overhaul." [15] Even maintaining a single organization's architecture model seems to be a challenge as practitioners reportedly struggle to document their distributed systems [22]. Another interview-based study reported: "lack of capacity and the high workload of EAs makes it difficult to deliver their services on time and in appropriate quality"[1] [42]. These problems of maintaining Enterprise Architecture (EA) within an organization may be aggravated in times of "continuous awareness of the entire ecosystem surrounding an organization (including – but not limited to – customer and partner actions, behaviors, and needs), and the resulting identification of all these changing needs as potential drivers for a subsequent rapid internal response" [14] where EA crosses organizational boundaries.

At the same time, from a research perspective, concerns over the empirical foundations of EAM were raised by Gong and Janssen, who found that "[o]nly half of the articles provide empirical evidence supporting the EA value claims" [11]. They subsequently coined the term "EA myths" while calling for "demystification of EA value by analysing the mechanisms behind EA and identifying how these mechanisms result in value creation for organizations" [11]. These findings imply a need for a more evidence-based approach in EA research.

When combined, these examples from research and practice may hint towards a potential for research tackling the problems of an increasingly complex, frequently changing architecture landscape spanning multiple organizations, where decisions are made in a distributed and decentralized manner. In an effort to provide directions for future contributions expanding both a collaborative and empirically-oriented view of EA, this study presents an overview over the current state of research regarding interorganizational collaborative architecture.

1.3 Research Questions

In order to provide an overview and assess the state of research in interorganizational collaborative architecture, the research questions cover motivations, challenges, outcomes, the field's structure and potential research gaps:

Motivations, Challenges and Outcomes

- *RQ 1.1* – What motivations for engaging in interorganizational collaborative architecture were reported in and by research?
- *RQ 1.2* – What challenges were encountered when engaging in interorganizational collaborative architecture in practice?

[1] EA means Enterprise Architect here.

- *RQ 1.3* – What outcomes were documented when engaging in interorganizational collaborative architecture in practice?

Structure of Research

- *RQ 2.1* – Who published research?
- *RQ 2.2* – Where was research published?
- *RQ 2.3* – When was research published?
- *RQ 2.4* – What types of research were published?
- *RQ 2.5* – What methods were employed in research?
- *RQ 2.6* – What types of contributions were made?
- *RQ 2.7* – What types of organization were examined?

Research Gaps

- *RQ 3* – What research gaps can be identified?

Fundamentals

2

The previous chapter introduced the problem statement and research questions. This chapter outlines the relevant fundamentals of the study's subject matter. It also summarizes the definition of the study's key terms from literature. They serve as a common basis for the following chapters.

2.1 Enterprise Architecture

The foundational ideas of Enterprise Architecture can be traced back to the 1960s with the emergence of Enterprise Information Systems (EIS) [38]. According to Romero and Vernadat subsequently "so-called Enterprise Architecture Frameworks (EAFs) [...] have been developed in parallel by two distinct communities: (1) the Enterprise Integration (EI) [...] and (2) the Information Systems (IS) community" [38]. Lapalme et al. found that "[g]iven this history, there are numerous views on what EA is."[25] Yet these frameworks now play a "central role" [40] in the field of Enterprise Architecture. A survey by Winter et al. found "that adapting the EA management approach to company-specific needs is important in practice although EA management literature implies the contrary." [44] This lack of consensus and difficulties in real-world application of EA frameworks imply that defining EA concepts in a generically applicable way is a significant challenge worth its own detailed analysis and thus lies outside the scope of this work. Therefore, like Lapalme et al. in [25], definitions from existing works are chosen as the basis for the purposes of this work. Namely, for this work it was decided to rely on the widely-cited[2] work of Lankhorst [24] for basic definitions.

Lankhorst defines Enterprise Architecture as "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." [24, p. 3] This definition encompasses a technical as well as an organizational perspective by interrelating the design of information systems and business processes

[2] Google Scholar listed 2100 citations on 2020-06-11.

with “a good architecture clearly show[ing] the relation of the architectural decisions to the business objectives of the enterprise.” [24, p. 4] While “[t]he most important characteristic of an enterprise architecture is that it provides a holistic view of the enterprise.” [24, p. 3]
Therefore, when talking about Enterprise Architecture for the purposes of this work the aspects of *guidance* for designing both technical and organizational structures for achieving *business objectives* while taking a *holistic perspective* form the core of reasoning about EA in the further process of this work (e.g. when defining exclusion criteria in 4.2.4). For additional considerations and viewpoints around EA [24] provides a practice-oriented perspective and numerous references to other works.

2.2 Interorganizational Collaboration

This work focuses on collaboration on architecture between multiple *organizations*. One may wonder why this part discusses organizations while the previous part mainly dealt with enterprises. Upon closer inspection an increasingly blurry definition of the term enterprise can be observed in this context: Again, this work relies on Lankhorst [24] to aim for definitions consistent with the previous section who in turn quotes The Open Group Architectural Framework (TOGAF). An enterprise (according to TOGAF 8.1.1) is “any collection of organizations that has a common set of goals and/or a single bottom line.” [12] With the latest standard (TOGAF 9.2 as of this writing) dropping the part regarding the bottom line altogether: “The TOGAF standard considers an "enterprise" to be any collection of organizations that have common goals.” [13] And “[t]he term "Enterprise" in the context of "Enterprise Architecture" can be applied to either an entire enterprise [...] or to one or more specific areas of interest within the enterprise.” [13] This broad definition of the term allows for drawing enterprise boundaries at levels reaching from e.g. interest groups within a company to multiple governments working towards a shared goal as a kind of meta-enterprise.
In a 2014 paper Drews and Schirmer presented a set of stages for attaining so-called “Business Ecosystem Architecture” [8]. While the notion of progression through these stages can be debated (see Section 3), it offers a definition of a boundary line of organizational abstraction titled “Federated or Collaborative Network Architecture (FA/CNA)” [8, Table I.]. It is described as “EEA + several actors in a network are exchanging selected parts of their EA and negotiate about standards, interfaces, inter-organizational processes, etc. due to a common interest or project” [8]. Where “EEA”

refers to the concept of "extended enterprise" as defined by TOGAF: "An extended enterprise nowadays frequently includes partners, suppliers, and customers." [13] This description was chosen for defining the organizational boundary in this work since it includes several aspects of interest.

First, it includes the concept of independent networked actors engaging in exchange and negotiation, which implies distinctive organizations acting collaboratively across organizational boundaries. Second, the "common interest" [8, Table I.] resonates with the "common goals" [13] in the definiton of enterprise in TOGAF. Third, it takes a holistic perspective as described in the previous section by including "standards, interfaces, inter-organizational processes, etc." [8, Table I.] And fourth, it expands the previous stage's concepts with architecture "modeled and managed from a focal actor's perspective" [8, Table I.] however in this stage "[a] central player might take a leading role" [8]. For this work this definition is expanded to explicitly cover decentralized scenarios.

These expanded aspects make up the definition of *interorganizational collaboration* in this work. They play a pronounced role in defining selection criteria later on in 4.2.4. The next chapter discusses related work in more detail.

3 Related Work

This chapter discusses a selection of related work in the field of Enterprise Architecture Management across multiple organizations. The contribution's approaches are contrasted with this work's scope and methods. These methods are described in detail in the next chapter.

In [6] Diirr and Cappelli present a systematic literature review (SLR) on a similar topic. In contrast to this work a SLR is conducted instead of a more broadly-scoped mapping study. Thus, this approach allowed examining the specific sub-field of relationship management between organizations. While the field of Enterprise Architecture is touched upon, it did not fall into the core of the study's scope. In their conclusion they stress the importance of proper scoping when conducting research in this field: "As detailed above, it is possible to focus on different areas to conduct research on cross-organizational relationships. Thus, it is imperative to carefully delimit what is or is not in the research project scope." [6]
In 2019 Diirr and Santos presented a systematic literature mapping [7]. However, here the focus lies more on interorganizational information systems and, like in [6], relationships [7].

In 2014 Banaeianjahromi and Smolander published a systematic mapping study "to survey and analyse the available literature on determining the role of EA in EI and also to identify gaps and state-of-the-art in research" [3]. While the general area, goals and methods are similar, the interrelation of Enterprise Architecture (EA) and Enterprise Integration (EI) was of particular interest [3]. It therefore differs in scope from this work, which is also reflected by the search terms. While this work does not explicitly cover EI aspects like [3] did, there may be implicit overlaps e.g. in ecosystems and federated contexts (see also Section 4.2.3).

Another literature review, which features a different focus, was presented in 2008 by Madlberger and Roztocki [28]. Covering 52 papers, organizations collaborating across borders were also investigated. Among other things, they found that a minority of contributions focused on cross-border aspects. Data was collected mainly by case study or field work followed by surveys as the second most popular method.

The studies selected from four journals were published between 2000 and 2007. [28]

As mentioned in Chapter 2, Drews and Schirmer's 2014 paper [8] is related very closely to the subject matter investigated here. Among other things, they summarize the state of the art in interorganizational EAM and propose a multi-stage model for the extension of EA across multiple organizations. It reaches from EAM focused on a single organization to EA encompassing large parts of the surrounding business ecosystem. [8]
A stage-based model may imply a progression of organizations through the stages in a set order, however it can be argued that the stages could be represented as categories or classes just as well, since an organization moving through the stages in that predefined order was not observed. Nevertheless, this contribution significantly influenced the scoping of this work (see Section 2) and provides references to other relevant works in the field while extending the concepts of interorganizational EAM.

Daclin et al. propose "[...] a methodology to implement and improve interoperability" [5]. The paper includes a case study in which that methodology is applied. With regards to the definitions outlined in the previous chapter interoperability is viewed from different perspectives covering technical as well as organizational aspects. While related works for the purposes of the development of the methodology are analyzed, they do not aim to conduct a review similar in scope and method to this work. [5]

In their 2019 paper "Transforming the Public Sector Into an Arena for Co-Creation: Barriers, Drivers, Benefits, and Ways Forward" Torfing et al. take a perspective similar to this work's research questions [41]. They propose, among other things, several changes and hypotheses around collaboration and innovation in the public sector. However, while there are similarities, the paper focuses on the public sector collaborating with others and does not mainly focus on architectural questions. [41]

In "Towards inter-organizational Enterprise Architecture Management - Applicability of TOGAF 9.1 for Network Organizations" [30] Mueller et al. present, among other things, challenges of applying TOGAF in a networked setting. Based on a literature review of 24 contributions, they found found that TOGAF 9.1 "does not provide solutions regarding the Organization of the Network Organization" [30]. They hypothesize other frameworks would suffer from similar limitations, which could be improved for better supporting business ecosystems. [30] Although similar in method and topic, this contribution focuses mainly on TOGAF.

Another model-based perspective is presented in [23] by Kravets and Zimmermann while highlighting the facet of cooperation between organizations. The viewpoint includes both organizational and technical aspects. However, a major focus lies on informing the design the flow of information between organizations. [23] This sheds light on how the alignment towards goals shared by multiple organizations could be modeled, which touches upon themes from the previous chapter.

It was therefore concluded that this work could make a novel contribution to the field.

Methods

4

This chapter details the choice of methods for answering the research questions from Chapter 1. They are then applied to generate the results presented in Chapter 5.

4.1 Research Approach

4.1.1 Selection

One of this work's primary goals is to explore the field of interorganizational collaborative architecture to reveal opportunities for further investigation. Therefore, existing relevant publications could be examined to assess the current research landscape, thus leading to a meta-analysis approach.

This could be addressed by performing a systematic literature review. However, the research questions are abstract and coarse-grained. Gaining a first overview over the field's current state with a traditional SLR may require disproportionate effort [33] and may pose challenges when including (qualitative) results from a wide variety of studies [9]. Another approach, the systematic mapping study (SMS) as described by Petersen et al. in 2008 [33], may provide better means for achieving these goals. In contrast to an in-depth full text review-based SLR, a SMS mainly relies on keyword-based categorization of scientific contributions found by systematic search guided by research questions [33]. Keywording and data extraction take a central role [33].

Kitchenham et al. note that "[o]ur results indicate that mapping studies can be of significant benefit to researchers in establishing baselines for further research activities" [20], which is exactly what this work is supposed to achieve. Therefore, the SMS approach was chosen for answering the research questions.

4.1.2 Best Practices

When applying the SMS approach, considerable care must be taken to provide a solid foundation for further investigation. For example, Wohlin et al. found after comparing two mapping studies in software engineering that "[s]econdary studies are not reliable per se" [45] and Kitchenham et al. warn "that although mapping studies may claim to follow a rigorous research process, not all follow the process closely enough to ensure that their results are trustworthy." [21] These statements highlight that although systematic mapping studies may provide an alternative to full SLRs (see Section 4.1.1), a balance between scope and resource constraints [21], which does not inhibit the applicability of results for future research, should be strived for. Limitations should be understood and communicated (see Section 6.1).
A wide variety of descriptions of best practices for conducting SLRs and SMSs is available. They are reaching from general guidelines for the social sciences [2], [36], over software engineering specific advice [4], [17], [33], [35], to a template[3] and a proposed quality evaluation "pocket guide" for SMSs [35] for demand identified in [19].
The guidelines published by Petersen at al. in 2015 [35] were found to be fairly comprehensive regarding the process while at least partially addressing the concerns voiced by Wohlin et al. [45] (see also 4.2.5). Hence, they were used extensively during the design of the process outlined in the next section.

4.2 Process

4.2.1 Outline

Figure 4.1 provides an overview over the study's search and data extraction process, which is described in detail in the next few sections. First, search terms for finding relevant publications for answering the research questions were defined. Then, a set of literature databases was queried using search queries including these terms. Next, the metadata retrieved from the databases was cleaned and duplicate entries were filtered in a partially automated manner. The prepared metadata was imported into a custom web application where titles, abstracts and if necessary further portions of the publication were vetted for relevance by the application of previously defined

[3]http://community.dur.ac.uk/ebse/resources/templates/MappingStudyTemplate.pdf

exclusion criteria. Then, data attributes for answering the research questions were extracted from the filtered publications. When papers were added after the initial search, e.g. due to updated search terms (see Section 5.1), these papers were then vetted again and their data extracted. In the final step the data was then processed to generate the study's results.

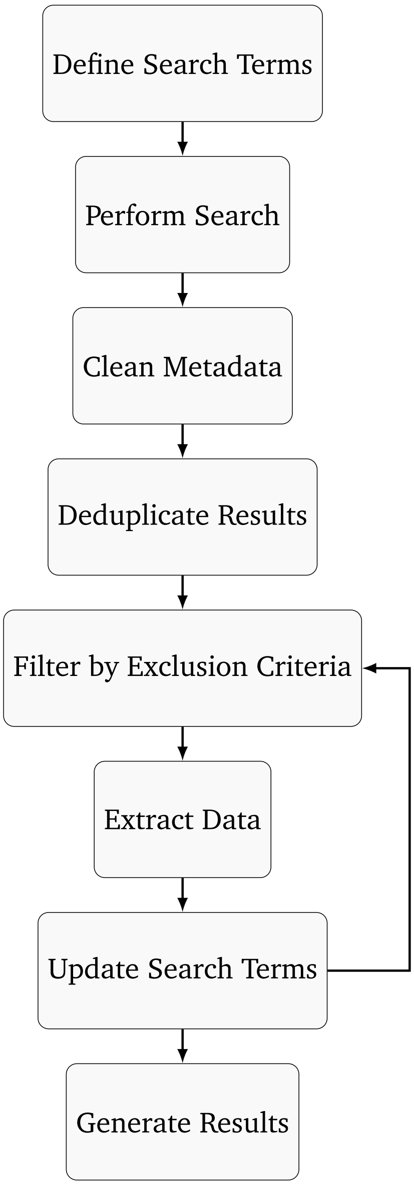

Figure 4.1: The Study's Search and Data Extraction Process as Outlined in this Chapter

4.2.2 Custom Supporting Software

Even though there are existing software solutions for supporting SLRs (e.g. [29] lists some), in order to facilitate collaboration during the filtering part of the study, a web-based prototype called "MapMaker" was developed by the author as a spreadsheet-based workflow was expected to be error-prone and not well-suited for reviewing segments of prose, such as abstracts. MapMaker could be extended in future work to support the creation of SLRs in novel ways as an alternative free and open source solution for other researchers. The following paragraphs provide an overview over the tool's capabilities. Screenshots can be found in this work's appendix.

MapMaker is a web-based tool implemented in the Phoenix[4] web application framework. It is hosted as a central server instance and can be accessed with a web browser. Users can register for an account and create projects. Projects support two access roles: project member and project owner. Users can create a new project by uploading their bibliography and adding other members to the project as needed. Project owners can then create new review stages for their project. Stages can be arranged linearly one after another and are one of two types: filter stages and tagging stages. Filter stages are used to reduce the corpus of papers moving on to the next stage via rejection criteria. Tagging stages allow for assigning tags from a predefined list to an entry in the publication list, e.g. during data extraction. Reviews can be assigned to project members during stage creation as needed. Some members may only review a subset of papers or papers assigned to another reviewer to reduce bias. The review is based on a publication's title and abstract with customizable keywords (wildcards are supported) being highlighted. The review supports keyboard controls to facilitate working with large amounts of papers. Authors and publications are hidden during review to reduce bias. However, a link to the paper's full text is provided on the review screen if available in the metadata, e.g. for looking up the abstract when it is missing from the metadata.

MapMaker features interactive conflict resolution. Once all assigned reviews in a stage have been completed, any conflicting tags or exclusions must be resolved before the stage can be closed. Project members then open the conflict resolution screen (which is similar to the review screen) at the same time and need to assign the same tags or arrive at the same inclusion/exclusion decision in order to move on to the next conflict. This design is supposed to encourage discussion between reviewers during conflict resolution. After all conflicts have been resolved, the stage can be closed. Results from closed stages can be exported in CSV format.

However, in its current state the tool suffers from several limitations. For example,

[4] `https://phoenixframework.org/`

there is no support for retroactively modifying the literature corpus after project creation. Also, the dynamic creation of tags during review is not supported. Therefore, MapMaker was only used for the initial filtering of the deduplicated search results (application of the exclusion criteria), as it was deemed too time-consuming to support more use cases within the constraints of this work. Data extraction was performed using a spreadsheet-based workflow supported by scripts (see Section 6.1). Nevertheless, especially the interactive collaborative parts were deemed promising and could be extended in future work. Hence, its use was briefly covered here.

4.2.3 Search Strategy

Overview

The aim of the study is, among other things, to provide a comprehensive overview over the field's research landscape. Therefore, this study employed a combined search strategy of manual and automatic search with an initial manual search providing the starting point for automated search: First, a manual search for literature was performed by the advisor to identify papers deemed relevant in the field. Then, search queries for the field's most important literature databases were designed collaboratively. After this, the author and the advisor vetted the papers returned by the search according to the selection process described below. The search queries were validated by checking whether they returned a relevant subset of papers from the initial manual search process. Regarding manually-found papers not returned by automated search, investigation revealed that not all papers returned by manual search were relevant for this work or available on the databases selected. Therefore, all results described in later chapters stem from automated search as outlined in this chapter.

Selection of Databases

The following databases were selected for search based on the author's and the advisor's personal experience (see also Section 6.1):

- ACM Digital Library

- Association for Information Systems eLibrary (AISeL)
- IEEE Xplore
- Scopus

Definition of Search Terms

Best practice papers [17], [36] recommend constructing a search string split into components of population, intervention, comparison and outcome (PICO) when conducting a systematic mapping study. However, the proposed categories did not fit this study's research questions. Another contribution by Petersen et al. [35] recommends using only the population and intervention part of the method. It can be argued that this approach would not constitute the application of the PICO-method anymore and that it needs to be adapted. Therefore, the idea of a "componentized" search query was taken up and tailored to the work's requirements.
The author and advisor identified two core semantic components of this work:

1. Collaboration across organizations
2. The Enterprise Architecture context

Therefore, search terms fitting each of these two components were devised collaboratively to reduce bias (see Section 6.1) and combined with logical `AND` operators. Within a component, terms were combined with an `OR` expression. To further broaden the scope of search results, wildcard expressions indicated by an "*" character were used when deemed appropriate. For the first component (collaboration) the following terms were chosen:

> *ecosystem OR inter-* OR interorganizational OR interorganisational OR cross* OR collaborat* OR coop* OR feder**

The second component, Enterprise Architecture, is closely related to the field of IT architecture in general. Also, a publication may cover the activities of the respective architects. These considerations resulted in the second component:

"enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures"

The raw query was then prepared for the varying capabilities of the individual search engines. When in doubt, the more generic variant of a search string was chosen to not exclude relevant literature by accident. As the results were vetted by title and abstract, the search was limited to these fields (including keywords) when possible. This process resulted in the following engine-specific search strings.

ACM Digital Library

Title:(ecosystem OR inter- OR interorganizational OR interorganisational OR cross OR collaborat* OR coop* OR feder*) AND (Abstract:("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures") OR Keyword:("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures") OR Title:("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures"))*

The search was conducted on the ACM's whole corpus ("Guide to Computing Literature"). The search string was pasted into the "Anywhere" field in the "Search Within" section. The publication date was set to include results up to January 2020.

Association for Information Systems eLibrary (AISeL)

(ecosystem OR inter- OR interorganizational OR interorganisational OR cross OR collaborat* OR coop* OR feder*) AND (abstract:("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures") OR subject:("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures") OR title:("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures"))*

The search included publications not marked as peer-reviewed (such as certain conference papers) and was conducted on the AISeL corpus, as the "All Repositories" setting did not allow for a machine-readable bibliography export. The date range was set to end on "01/01/2020". Due to limitations of the input form provided on the website, the search string was passed to the search by directly modifying the URL parameter.

IEEE Xplore

("All Metadata":ecosystem OR inter- OR interorganizational OR interorganisational OR cross OR collaborat* OR coop* OR feder*) AND ("All Metadata":"enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures")*

The search string was pasted into the command search. Then, the publication type filter was set to include conferences and journals. The publication year filter was set to include results from 1991 (earliest year selectable) to 2019.

Scopus

(TITLE-ABS-KEY (ecosystem OR inter- OR interorganizational OR interorganisational OR cross* OR collaborat* OR coop* OR feder*) AND TITLE-ABS-KEY ("enterprise architect" OR "enterprise architects" OR "enterprise architecture" OR "enterprise architectures" OR "it architect" OR "it architects" OR "it architecture" OR "it architectures")) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re")) AND (EXCLUDE (PUBYEAR , 2020))*

The publication type filter was set to include conference papers, articles and reviews. Then, the documents indexed by Scopus were exported.

Metadata Import and Deduplication

First, metadata downloaded from AISeL was augmented based on heuristics implemented in a Python[5] script (see Appendix A.3.1) so it could be imported into literature management software together with the other results. The results were then exported from that software and duplicates were identified using another script (see Appendix A.3.2). Then, a second deduplication pass using the literature management software's (Zotero[6]) deduplication function was undertaken. When removing duplicate entries, the entry with less complete metadata was removed. When there was both a conference paper and a journal paper on the same topic by the same authors available, the conference paper was removed. When a publication was published multiple times, only the earliest recorded publication was kept.

4.2.4 Selection Criteria

The author proposed an initial set of selection criteria for selecting relevant publications from the search results. A trial run with a subset of publications was conducted by the author and advisor. Any differences in the application of criteria were resolved by discussion to ensure a shared understanding of the criteria. Then, the criteria were revised to reflect the insights from the trial run.

[5] https://www.python.org/
[6] https://www.zotero.org/

After the trial run all publications were reviewed by both the author and the advisor. This was done in multiple sessions involving breaks to limit potential negative effects of mental exhaustion on review quality [10]. Conflicts in the application of the criteria were resolved by discussion on a case-by-case basis.
The selection criteria were formulated as exclusion criteria. Therefore, when a publication matched any of the exclusion criteria, it was excluded from the study. To reduce bias, titles and abstracts were used for the review by default. Other metadata was hidden, such as publication year, venue, names and affiliations of the authors if they were not included in the abstract. The full text was only accessed in case of faulty metadata (e.g. a missing abstract) or edge cases where a decision was not possible based on title and abstract alone (e.g. an inconclusive abstract). The exclusion criteria were applied sequentially as shown below. The criteria expected to exclude most publications were checked first to increase the review's efficiency.

Exclusion Criteria

***EC1* – Not about collaboration across organizations**
As reflected in the research questions, collaboration is one of the core aspects of this work. When the search result did not present work related to the collaboration across organizations as described in Chapter 2, it was discarded.

***EC2* – Not about collaboration on a holistic architecture level**
Enterprise Architecture includes multiple organizational and technical views on an organization (see Chapter 2). The goal of this study was, among other things, to assess the state of research in collaboration while taking that holistic view. When the perspective presented in the search result lacked these viewpoints and was for example focused solely on technical implementation details or the outline of a single business process, it was excluded.xw

***EC3* – Wrong publication type**
As this work assesses the state of research, only journal papers and conference papers (including workshops) were included. This excludes e.g. introductory papers of a journal's issue providing an overview over this issue's contents, as the main contribution lies in the published papers following the intro.

***EC4* – Not in English**
Only English language results were included. This was done to facilitate the reproducibility of the results by a wide audience.

***EC5* – Duplicate**
Any remaining duplicate publications were excluded to prevent skewed results. When a publication displayed significant overlaps in structure and content when compared to other publications by the same author, they were classified as duplicates. Only one of the overlapping publications was kept in these cases. Preference was given either to journal papers or the earliest publication available. In these cases journal papers were prioritized, as they were assumed to be subject to a more thorough review than e.g. conference papers.

***EC6* – No full text-access**
When the author did not have full text access to the publication, data extraction was impossible and the search result was thus excluded.

***EC7* – Published after 2019**
This work was conducted in 2020. To aid reproducibility, search results published after 2019 were excluded.

When data extraction revealed the applicability of an exclusion criterion, the search result was excluded retroactively if author and advisor agreed on this. This way, even though data extraction was done by the author, the removal of a result followed the same standards as the initial review.

4.2.5 Data Extraction

In this stage, publications were classified by reviewing their metadata and text. Therefore, classes needed to be derived from the research questions (see Section 1.3). A list of the attributes extracted from publications is shown in Table 4.1. Petersen et al. differentiate between topic-independent classification and topic-specific classification in systematic mapping studies [35]. For *topic-specific* classification schemes "the majority of studies built new classifications"[35]. They note however, that "it is useful to take an existing classification as the baseline as this supports the comparability between mapping studies." [35] *Topic-independent* classification "should be generally applicable" [35] and "using the same or similar classification

Attribute	Research Question	Comments
A1 - Motivations	*RQ1.1*	Keywording
A2 - Challenges	*RQ1.2*	Keywording
A3 - Outcomes	*RQ1.3*	Keywording
A4 - First Author	*RQ2.1*	
A5 - Organization	*RQ2.1*	Based on first author
A6 - Country or Region	*RQ2.1*	Based on organization
A7 - Publication Venue	*RQ2.2*	
A8 - Publication Venue Type	*RQ2.2*	Simplified classes
A9 - Publication Year	*RQ2.3*	
A10 - Paper Type	*RQ2.4*	Extended classes from [43] and guide from [35]
A11 - Research Method	*RQ2.5*	Classes from [31]
A12 - Contribution Type	*RQ2.6*	Classes from [39]
A13 - Organization Type	*RQ2.7*	Keywording

Table 4.1: Attributes Extracted from the Set of Accepted Publications

schemes consistently enables comparisons.” [35]

In the context of this work a topic-specific classification scheme was used for the research questions *RQ 1.1*, *RQ 1.2* and *RQ 1.3*. As they are highly specific to the subject matter, a custom classification scheme was developed by following a process based on the keywording method outlined in [35] by reviewing a publication’s abstract and summary/conclusion (*A1-3*), if available. When in doubt, a cursory review of a paper’s other sections was conducted, which is similar to the dynamic adaptive reading depth approach outlined in [33]. See Section 6.1 for more on this. The results are presented in Section 5. *A2* and *A3* focus mainly on challenges and outcomes encountered during the implementation of collaborative architecture in practice, as it was regarded more appropriate for guiding future research into these challenges compared to e.g. anticipated or speculative challenges or both. Since *RQ 2.1* to *RQ 2.6* are not as specific to the subject matter, data extraction relied on topic-independent classifications in their case. *RQ 2.7* is a special case, as it turned out literature covered organizations ranging from companies to supranational organization forms. Therefore a keywording strategy was also chosen here.

For *RQ 2.1* the first author, the organization they were associated with and the organization’s country or region were extracted from the paper (*A4-6*) to allow for views including a personal, institutional and geographic perspective on available research. For *RQ 2.2* the name of the conference or journal was extracted (*A7*), which could help identify important publications and conferences for future research. Also, based on *EC3*, each publication venue was classified as conference, journal or workshop (*A8*, see Table 4.2). As this classification was supposed to only take an auxiliary role during analysis, with *A7* taking the main role, this classification was chosen using a simplified process when compared to the other classification schemes outlined below. Nevertheless, this attribute was included here for the sake of completeness. To identify potential trends in publication count (*RQ 2.3*), the publication year was also extracted (*A9*).

A10 required a classification scheme for research methods to answer *RQ 2.4*. While

Publication Venue Types
P1 - Journal
P2 - Conference
P3 - Workshop

Table 4.2: Publication Venue Types Based on *EC3*

Wohlin et al. [45] have shown weaknesses in the application of the categories proposed by Wieringa et al. [43], Petersen et al. [35] propose a decision table to facilitate the classification of papers. As one of the potential advantages of using a shared classification scheme is enabling comparisons between studies, it was decided to not develop a custom scheme and use the scheme proposed by Wieringa et al. [43] (see Table 4.3) instead while taking into account the proposals made by Petersen et al. [35]

Paper Classes
C1 - Evaluation Research
C2 - Proposal of Solution
C3 - Validation Research
C4 - Philosophical Paper
C5 - Opinion Paper
C6 - Personal Experience Paper
C7 - Review Paper

Table 4.3: Extended Paper Classes Based on [43]

This may enable future comparisons between this work and other works. The classes proposed by Wieringa et al. [43] are based on the engineering cycle. During data extraction it became apparent that some papers did not fit these classes. For example, the classification of some papers covering problem investigation proved to be challenging when they neither fit the philosophical, opinion nor experience paper classes. For example, this could have been papers presenting a literature review or a qualitative analysis of concepts. They would not propose (*C2*), evaluate (*C1*) or validate (*C3*) a specific solution, provide a new framework (*C4*), depict the author's opinion (*C5*) or relate to (personal) experience (*C6*). Nevertheless, they made a contribution by providing insights for future research. Therefore, class 7 "Review

Paper" (*C7*) was added to the list. For the purposes of this work experience papers (*C6*) also include non-personal reports. For example, when a case from practice was presented and the review of the abstract and conclusion did not reveal a focus on evaluation (*C1*), the paper was classified as an experience paper (*C6*).
Applying the other classification schemes proved less challenging. To enable cross-study comparison, existing schemas were also used for *RQ2.5* and *RQ2.6*. Inspired by Banaeianjahromi and Smolander[7] [3], work of Palvia was taken as a basis [31] for classifying research methods (*A11 RQ2.5*). The classes are listed in Table 4.4. To enable an overview over existing contributions in the field by contribution type

Method
M1 - Speculation/commentary
M2 - Frameworks and Conceptual Model
M3 - Library Research
M4 - Literature Analysis
M5 - Case Study
M6 - Survey
M7 - Field Study
M8 - Field Experiment
M9 - Laboratory Experiment
M10 - Mathematical Model
M11 - Qualitative Research
M12 - Interview
M13 - Secondary Data
M14 - Content Analysis

Table 4.4: Research Methodologies from [31]

(*RQ2.6*, *A12*), inspired by Rodriguez et al. [37], who refer to Paternoster et al. [32], who in turn refer to Shaw [39] for a list of contribution types, which can be found in Table 4.5. When a paper matched multiple classes (e.g. by employing a mixed-methods approach), the primary contribution or method was extracted.

Type
T1 - Procedure or technique
T2 - Qualitative or descriptive model
T3 - Empirical model
T4 - Analytic model
T5 - Tool or notation
T6 - Specific solution, prototype, answer, or judgment
T7 - Report

Table 4.5: Contribution Types from [39]

[7] They also refer to work by Wieringa et al. [43] and Petersen et al. [33]

To provide directions for future research, the type of organizations covered (industrial / public sector etc.) was also extracted in *A13* for *RQ2.7* using a keywording process.
The answer to *RQ 3* was synthesized from the answers of the other research questions. Therefore it did not require a separate classification scheme during data extraction.
Initially, it was considered to also include a measure of evidence presented in the papers. This was inspired by work of Li et al. [26], who were using the adaptation by Alves et al. [1] of Kitchenham's evidence hierarchy in software engineering [18]. However, it proved unfeasible to assess the level of evidence by merely reviewing the abstract and conclusion. Therefore, this aspect was dropped from the analysis. Yet *A10-12* still provide insight into evidence-related matters without giving the impression of assessing scientific rigor for which a full SLR may be a more appropriate method.

4.2.6 Analysis and Automation

The analysis and discussion of the mapping study's results relies on visualizations. These are based on the data extracted in the previous step. In their 2015 guidelines Petersen et al. conclude that "[a]ll visualizations are useful in the context of mapping studies" [35], with the most common being "bubble plots, bar plots, and pie diagrams" [35]. The bubble plot seemed to be characteristic for this type of study, e.g. when comparing multiple class mappings (for example which class coincided with a mapping in another set of classes) [35].
Taking these findings into account, various types of visualization deemed appropriate for the task were chosen for enabling analysis of the collected data and answering the research questions. After filtering, data was extracted in a spreadsheet-based workflow (see Section 4.2.2), where the spreadsheet served as the single source of truth for the generation of diagrams and tables based on that data. This was done to reduce errors and the amount of effort required when adding or removing papers from the selection, e.g. when it was discovered during data extraction that a paper was irrelevant. The data analysis pipeline took the spreadsheet's values as its input. The different stages would then be executed in individual Docker[8] containers with each container able to use artifacts generated by the preceding stage. The first stage consisted of a series of Python scripts, which performed plausibility checks on the data, generated tables, performed graph analysis and saved an enriched version

[8]https://www.docker.com/

of the spreadsheet data to disk. A second container running an R[9] script would then take that data and generate graphs, which would be read together with the first container's artifacts by the third container which typeset this document using pdfTeX[10]. Because data visualization and documentation was automated using this approach it was then integrated into the version control system Git[11] and GitLab[12] to log changes to the dataset and typeset the document every time the author uploaded an updated version of the document to the GitLab instance.

[9]https://www.r-project.org/
[10]https://www.tug.org/applications/pdftex/
[11]https://git-scm.com/
[12]https://about.gitlab.com/

5 Results

This chapter presents the results obtained by applying the methods outlined in the previous chapter. These findings are then discussed in Chapter 6.

5.1 Database Search

Table 5.1 lists the number of results returned by applying the method outlined in Section 4.2.3.

The ACM Digital Library turned out to be a special case, as it returned 72 results. Of these, 65 manually filtered conference papers and journal papers were kept, as filtering using the site's filter functions returned less papers than indicated on the results page. In order to include as many relevant papers as possible, they were filtered manually during the initial search run.

In total, the search returned 1 482 results. The deduplication and data cleaning process (see Section 4.2.3) was applied. An additional manual review also led to the removal of three publications consisting of title pages only and three entries containing only tables of content. This led to the removal of 290 metadata entries in total, thus 1 192 entries moved on to the next stage.

Database	Number of raw results
ACM Digital Library	65 (see Section 5.1)
Association for Information Systems eLibrary (AISeL)	340
IEEE Xplore	275
Scopus	802
Total	**1 482**

Table 5.1: Number of Results Returned by Literature Databases

Search Query Update

After the initial search in the databases the search string was revised to include more relevant literature. Additional terms ("interorganisational" and "interorganizational") were introduced. Also, the search was set to select results published before 2020 for each database. The results were merged using a Python 3 script (see Appendix A.3.3) and new entries not included in the original search were added (in total 24 results were added) if they were not already present. When a result which was part of the original search was not returned by the updated search[13], it was not considered in the review. Three of the four papers were published or went into print in 2020, as the original search was not consistently limited by publication date. One paper was removed from the Scopus index and was thus removed in the interest of reproducibility. The numbers above (see also Table 5.1) reflect the number of results after the introduction of the updated search string.

5.2 Selection Criteria

Following the database search, the results were vetted according to the process outlined in Section 4.2.4 using MapMaker (see Section 4.2.2). Table 5.2 lists the number of matches for each criterion. Note that criteria were applied sequentially and only the first matching criterion was selected. For example, a result covering an unrelated topic in an industry magazine may be excluded for not being about collaboration (*EC1*) and only show up as unrelated while it also has the wrong publication type (*EC3*). This was done to increase the efficiency of the review. When e.g. data extraction revealed that a full text was not available to the author, the result was retroactively excluded. The process resulted in 129 accepted papers out of 1 192.

[13]This applied to three results out of the original 795 in the Scopus search and one out of 272 in the original IEEE search.

Exclusion Criterion	Number Tagged
EC1 – Not about collaboration across organizations	934
EC2 – Not about collaboration on a holistic architecture level	84
EC3 – Wrong publication type	20
EC4 – Not in English	3
EC5 – Duplicate	7
EC6 – No full text access	15
EC7 – Published after 2019	0
Accepted	129
Total	1 192

Table 5.2: Number of Results Excluded by Criterion

5.3 Data Extraction

5.3.1 Overview

The following sections present the results generated during data extraction. They also highlight and contrast different aspects of the visualizations. Their order is similar to the order of the research questions. The first part presents isolated aspects of the data. The last section takes a broader view. It combines various viewpoints to explore the research landscape in a multi-faceted manner and provides foundations for proposals for directions of future research made during the in-depth analysis in Chapter 6.

Forms of Presentation

The findings' presentation relies on different forms of visualization. They were chosen depending on the specific question or data examined and they range from tables to graph visualizations. The simplest kind is the presentation of raw data in tables, such as Table 5.6. They list an attribute and the count of matching papers. When a research question required identifying proportions between classes observed, presentation could rely on tables or diagrams or both. When a large number of classes was identified (such as a paper's first author in Table 5.8), tables omit classes observed a single time for readability. Another distinction was made between observations analyzed for frequency (analysis leaning towards deductive reasoning) and observations analyzed for existence (analysis leaning towards exploration).

For example, in the case of challenges observed in practice, this work focused on identifying possible challenges and preserving detail in an attempt to aid future research in e.g. developing a classification scheme or focusing on detailed facets of challenges uncovered.

In other cases where an exhaustive classification scheme was available (e.g. research method) the ratio between methods was used to attempt to uncover gaps in literature, where a different angle may yield novel results. Some papers may follow a mixed-methods approach or make multiple types of contributions. It was decided to extract the contribution or method regarded as primary in these cases. Extracting all methods employed would have required a thorough full text review, which is outside the scope of this work. Additionally, objective definitions of e.g. what constitutes a substantial contribution would have to be developed. Tree maps (such as Figure 5.8) primarily visualize the ratio between observations with exhaustive classification schemes (except Figure 5.10). Consequently, classes in predetermined classification schemes which were not observed are missing from these maps. Therefore, they are accompanied by tables.

The keywording process was inspired by [35] and yielded a wide variety of keywords and phrases relating to diverse semantic concepts. To aid analysis, these keywords were clustered using cluster keywords. At first, the creation of a taxonomy was considered. However, due to their diversity and semantic ambiguity, keywords lack a "natural order" like taxonomies in fields, such as evolutionary genetics. Therefore, cluster keywords were derived in a bottom-up manner from the base keywords until a satisfactory level of abstraction was reached which struck a balance between condensation of meaning and loss of detail due to abstraction. Each keyword was assigned to only one abstract category or base keyword. One could work with multiple connections. However, the resulting semantic graph may lead to undesired complexity when attempting to structure a field.

From this effort emerged a directed acyclic graph (DAG, directed from base keywords towards abstract terms) divided into components with each component having a root node. These nodes formed the basis for further analysis. It should be noted that the cluster keywords merely represent *a* way rather than *the* way to categorize this data.[14] Individual components may resemble a tree with inverted edges, yet the inversion may imply an order which contradicts the bottom-up nature of its construction. Therefore, keywords and their abstractions are presented as graphs called "Semantic Map" (for example Figure 5.2). At the time of this writing the author was not aware of any other systematic mapping studies taking this approach towards clustering and visualization. The semantic map presents the structure of the semantic graph as well as two methods of counting a keyword's occurrences. Each

[14] The raw data from which other categorizations could be developed can be found in the appendix.

keyword is represented by a node. The color of the node's border shows whether a node represents a base keyword found in literature or an abstract keyword used for clustering. The node's fill color signifies whether a node is a component's root node. The number at the center of each node shows the number of times the node's keyword was found in literature plus the sum of the node's ancestors' numbers. However, one paper may report multiple similar observations related to the same cluster root. Therefore, the nodes are not only labeled with the keyword they represent, but also the count of distinct papers related to that (cluster) node. This way the graph shows all base keywords, the way they are clustered, possible semantic components or "islands" as well as keyword and publication-based counts. This could for example support discussion around the proposed structure and prevalence of keywords.

The cluster roots of keyword observations were used in conjunction with other attributes to produce bubble plots depicting the field's structure aiming at aiding in identifying research gaps similar to [33]. Other analyses rely on visualizations specific to their attribute's nature, such as geographic maps (see Figure 5.4) for geographically distributed observations or column graphs (see Figure 5.6) for time series data. The raw mappings of attributes which can not be easily extracted objectively (such as primary contribution type versus publication year) are listed in the appendix for transparency.

5.3.2 Motivations

Figure 5.1 depicts the clusters derived from motivations for engaging in interorganizational collaborative architecture as reported in literature. Table 5.3 lists the collection of cluster root categories and their associated numbers (see Section 5.3.1). A majority of papers listed motivations. In total, six clusters were identified. The main motivations revolved around interorganizational architecture as a means for "Reacting to External Stimuli", "Working Across Organizations" and supposed "Financial Benefits". "Reacting to External Stimuli" for example included motivations of "Following Trends", "Improving Reaction Speed" as an organization (including motivations around agility) and "Compliance" reasons. "Working Across Organizations" was for example driven by collaboration and interoperation concerns, while the supposed "Financial Benefits" were rooted in "Business Development", "Reducing Cost" and "Increasing Technological Efficiency". The cluster around "Internal Reform" also listed motivations, such as "Achieving Transparency" and "Achieving

Accountability”. Other motivation clusters included “Improving Product / Service Quality” as well as “Managing Complexity”.

Root	Papers	Reported Instances
Reacting to External Stimuli	69	99
Working Across Organizations	49	73
Financial Benefits	42	56
Internal Reform	21	25
Improving Product / Service Quality	15	17
Managing Complexity	7	7

Table 5.3: Root Keywords of Semantic Map for Motivations

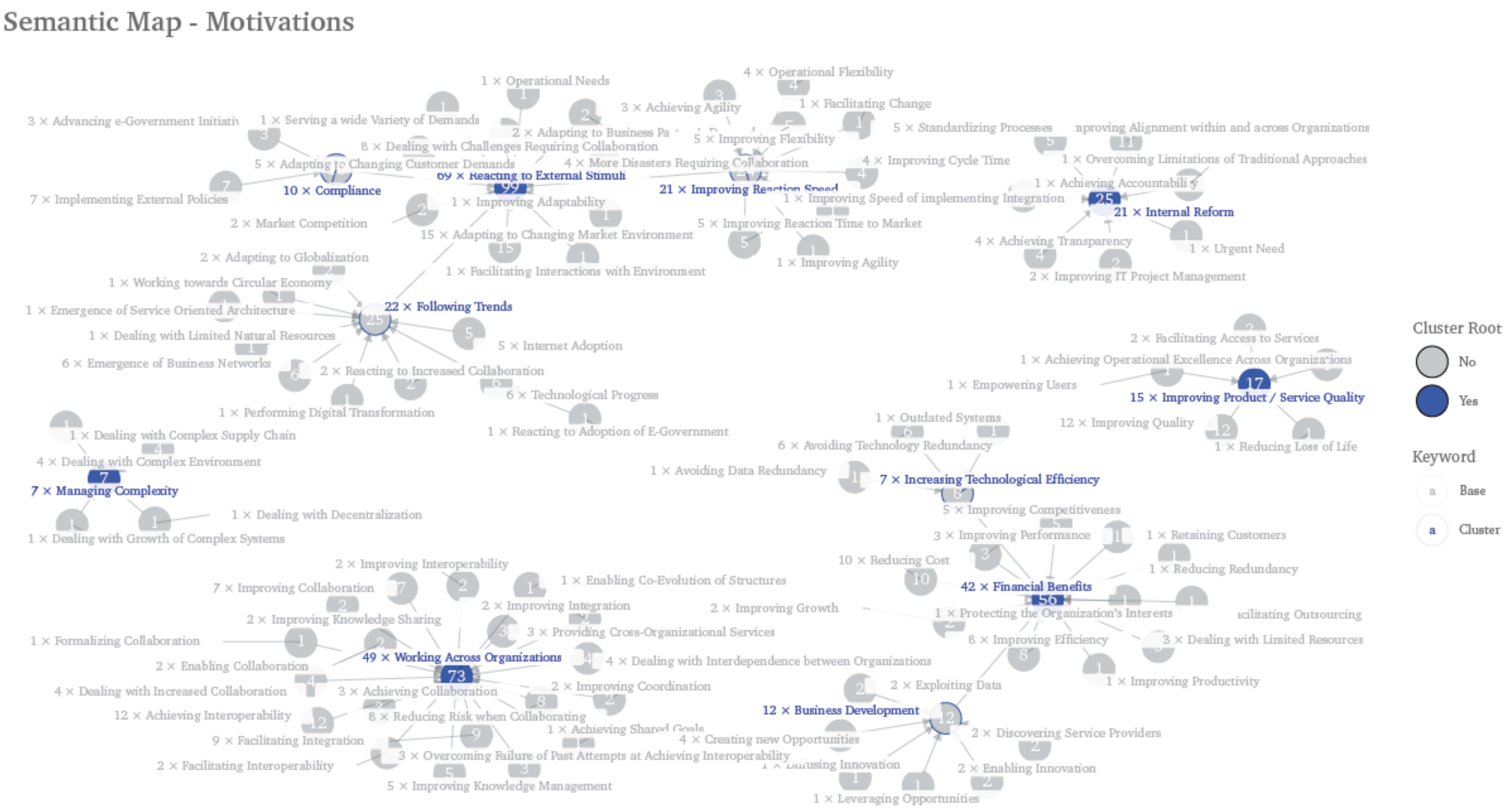

Figure 5.1: Semantic Map of Motivations

5.3.3 Challenges

The clusters of challenges encountered while implementing interorganizational collaborative architecture in practice are presented in Figure 5.2. The root cluster's numbers are presented in Table 5.4. Only a minority of papers reported challenges in practice. The top clusters were "Social Issues" and "Technical Issues". "Legal Issues", "Changing Requirements", "Complexity" and "Challenges (Generic Term)" were not reported as often.
While the "Technical Issues" cluster had no sub-clusters at all, the "Social Issues" cluster was comprised of several thematic sub-clusters. For example, a majority of social issues reported traced back to "Power Dynamics", which in turn related to issues around "Ownership, Governance and Roles", "Backing and Commitment" and "Rigid Structures". Another sub-cluster encompassed various types of "Ignorance", such as insufficiently trained staff or lack of knowledge about the organization's operation. The remaining two sub-clusters were centered around "Trust" issues and "Resistance to Change".

Root	Papers	Reported Instances
Social Issues	27	79
Technical Issues	21	29
Legal Issues	9	11
Changing Requirements	3	3
Complexity	2	3
Challenges (Generic Term)	1	1

Table 5.4: Root Keywords of Semantic Map for Challenges

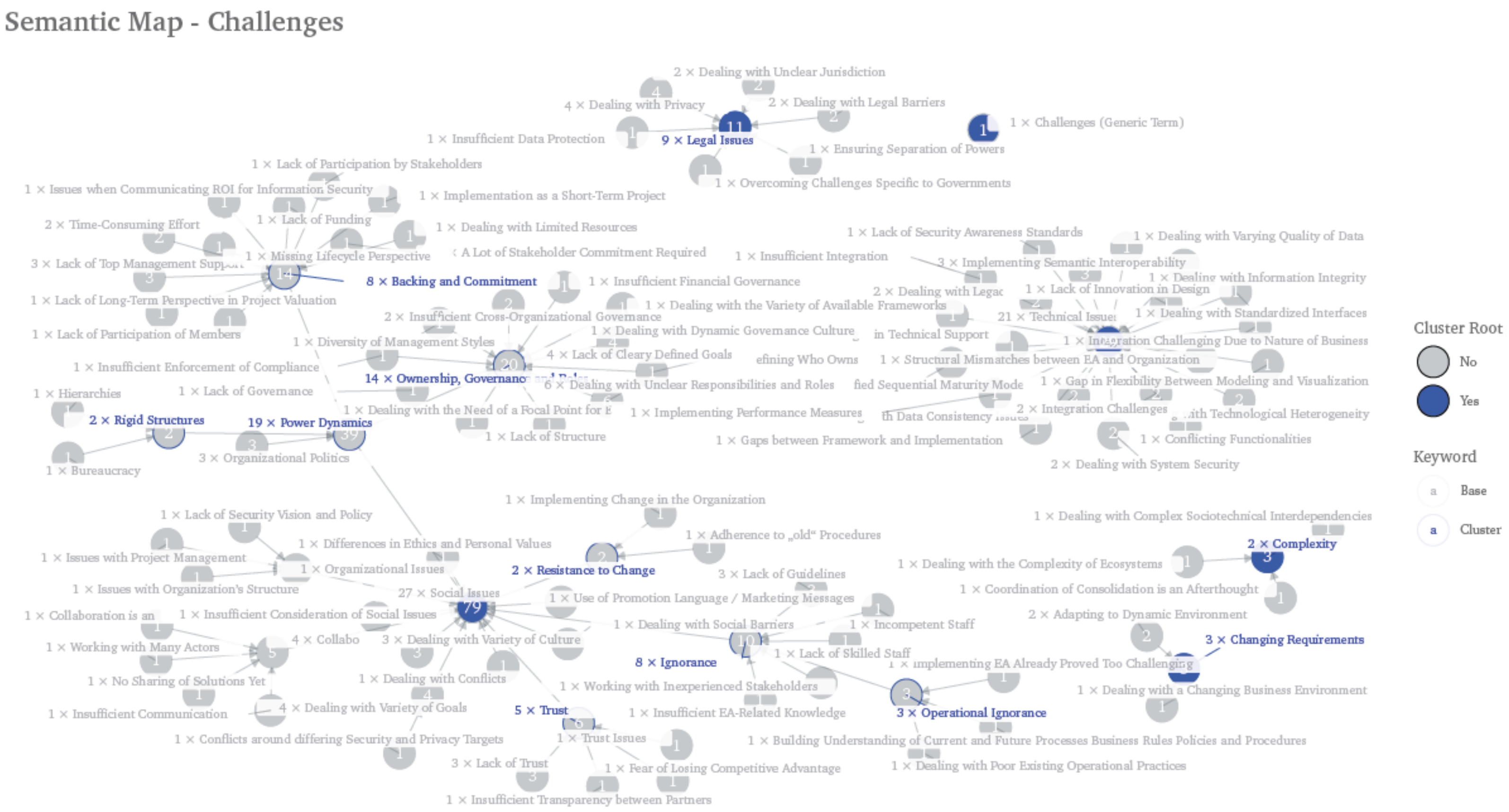

Figure 5.2: Semantic Map of Challenges

5.3.4 Outcomes

Compared to motivations and challenges, even less papers reported on the outcomes of the application of interorganizational collaborative architecture. A wide variety of outcomes ranging from technical solutions to transparency improvements was reported. This led to a comparatively large number of clusters presented in Figure 5.3 and Table 5.5. The most reported outcome was the creation of "Software Artifact[s]", followed by efforts around "Standardization" and "Collaboration". Yet not only positive outcomes were reported. For example, one paper reported "Decreased Financial Performance" and another one reported "Increased Complexity" as outcome.

Root	Papers	Reported Instances
Software Artifact	18	18
Standardization	11	13
Collaboration	10	11
Financial Benefits	7	7
Improved Operational Transparency	5	5
Improved Governance / Compliance	4	4
Actions	2	2
Processes	2	2
Decreased Financial Performance	1	2
Improved Project Management	2	2
Change	2	2
Technical Benefits	1	1
Complexity	1	1

Table 5.5: Root Keywords of Semantic Map for Outcomes

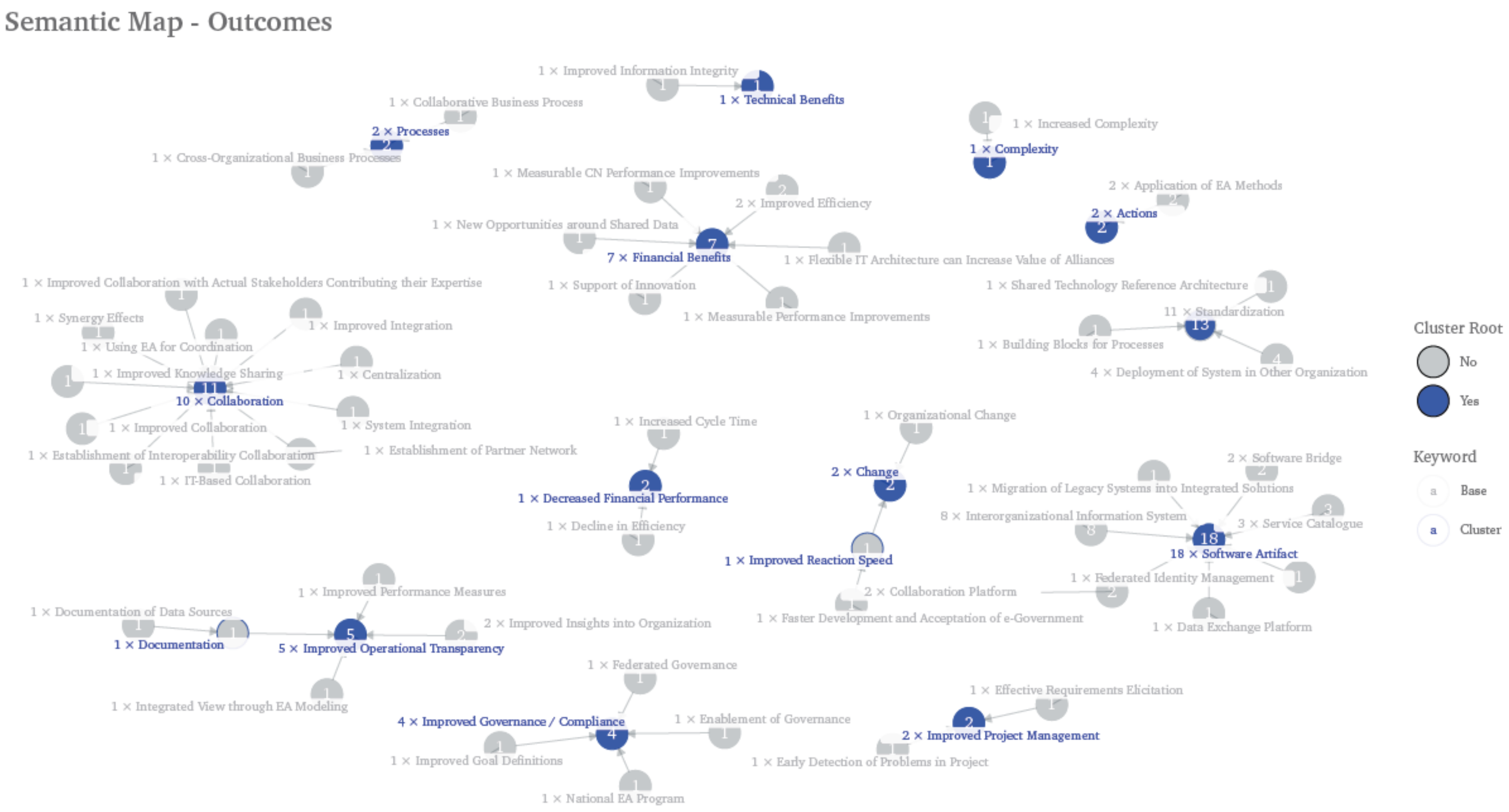

Figure 5.3: Semantic Map of Outcomes

5.3.5 Publication Origins

For identifying regional research clusters, the first author's name was extracted from the papers. Then, the name of the organization associated with the author was extracted and assigned to a country or region's name. The results are visualized in Figure 5.4, with an alternative list including country or region names in Table 5.6. Figure 5.4 shows the number of papers by country or region both as a label and as the color of the country or region's silhouette. While contributions were made from every continent except Antarctica (which was also excluded in Figure 5.4 for readability), three regional clusters emerged from this depiction. Europe appeared to be the world's largest cluster of origin for papers in this work. The second cluster appeared be the United States of America followed by Australia.

When considering individual countries and regions in Table 5.6, authors associated with organizations in the United States of America published most contributions, followed by Germany and Australia. The top three organizations by paper count (see Table 5.7) were located in Spain (Universitat Politècnica de València) with seven papers, Estonia (Tallinn University of Technology) with six papers and Australia (Griffith University) and Germany (University of Hamburg) with five papers each. These corresponded with the authors listed in Table 5.8, with "Vargas, Alix"[15] (Universitat Politècnica de València) having published six papers deemed relevant for this work, "Kangilaski, Taivo" (Tallinn University of Technology) with four papers and "Noran, Ovidiu" (Griffith University) with three papers.

[15] Even though care was taken when extracting author's family and given names from papers, any combination of reversals or omissions or spelling mistakes might have occurred for which the author would like to apologize in advance.

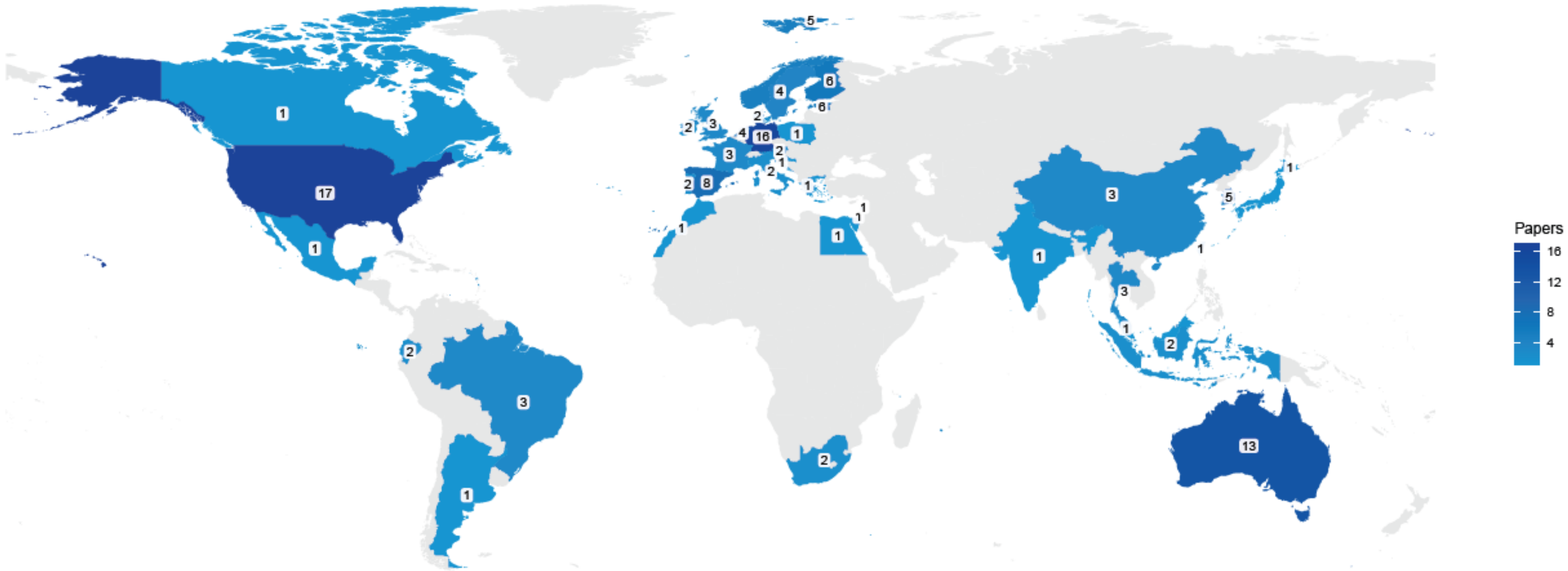

Figure 5.4: Publications by Region (Map Excludes Antarctica)

First Author's Organization's Country or Region	Papers
Argentina	1
Australia	13
Austria	2
Brazil	3
Canada	1
China	3
Croatia	1
Denmark	2
Ecuador	2
Egypt	1
Estonia	6
Finland	6
France	3
Germany	16
Greece	1
India	1
Indonesia	2
Ireland	2
Israel	1
Italy	2
Japan	1
Korea	5
Lebanon	1
Malaysia	1
Mexico	1
Morocco	1
Netherlands	4
Norway	5
Poland	1
Portugal	2
South Africa	2
Spain	8
Sweden	4
Taiwan	1
Thailand	3
United Kingdom	3
United States	17

Table 5.6: Paper Count by First Author's Organization's Country or Region

First Author's Organization	Count
Universitat Politècnica de València	7
Tallinn University of Technology	6
Griffith University	5
University of Hamburg	5
University of Jyväskylä	4
Pohang University of Science and Technology	3
RMIT University	3
Norwegian University of Science and Technology	2
Deakin University	2
Carnegie Mellon University	2
Brunel University	2
University of Oslo	2
Delft University of Technology	2
Kasetsart University	2
Claremont Graduate University	2
Technical University of Lisbon	2
Fraunhofer IOSB Institute of Optronics, System Technologies and Image Processing	2
Georgia State University	2

Table 5.7: Number of Papers by First Author's Organization Occurring More than Once

First Author	Count
Vargas, Alix	6
Kangilaski, Taivo	4
Noran, Ovidiu	3
Andriyanto, Agustinus	2
Choi, Younghwan	2
Gebre-Mariam, Mikael	2
Goel, Amit	2
Janssen, Marijn	2
Marich, Michael	2
Müller, Wilmuth	2
Peristeras, Vassilios	2
Rai, Arun	2
Tesse, Jöran	2

Table 5.8: Number of Papers by First Author Occurring More than Once

5.3.6 Publication Venues

In order to identify the field's relevant publication venues, the venue type ("Conference", "Journal" or "Workshop") of the paper was extracted and the respective ratios

Figure 5.5: Ratio between Venue Types

Venue Type	Papers
Conference	84
Journal	32
Workshop	13

Table 5.9: Paper Count by Venue Type

visualized in Figure 5.5 while Table 5.9 lists the specific numbers. The majority of papers deemed relevant were published on conferences with the second class, journal papers, not even making up half as many papers numbers-wise and roughly half that number in the form of workshop papers. Table 5.10 lists the top publication venues, with the top three (shared between four venues) being the “Americas Conference on Information Systems (AMCIS)” with eight papers, the “IEEE International Enterprise Distributed Object Computing Conference Workshops” and “International Conference on Enterprise Information Systems” with six papers each and the “Annual Hawaii International Conference on System Sciences (HICSS)” ranking third with five papers.

Publication Venue	Count
Americas Conference on Information Systems (AMCIS)	8
International Conference on Enterprise Information Systems	6
IEEE International Enterprise Distributed Object Computing Conference Workshops	6
Annual Hawaii International Conference on System Sciences (HICSS)	5
European Conference on Information Systems (ECIS)	4
The International Journal of Advanced Manufacturing Technology	3
Computers in Industry	3
IFIP Working Conference on Virtual Enterprises	3
IEEE Conference on Business Informatics (CBI)	2
Pacific Asia Conference on Information Systems	2
IFAC Symposium on Information Control Problems in Manufacturing	2
International Conference on Digital Information Management (ICDIM)	2
Sustainability	2
SPIE Defense + Security	2
MIS Quarterly Executive	2

Table 5.10: Number of Papers by Publication Venue Occurring More than Once

5.3.7 Trends over Time

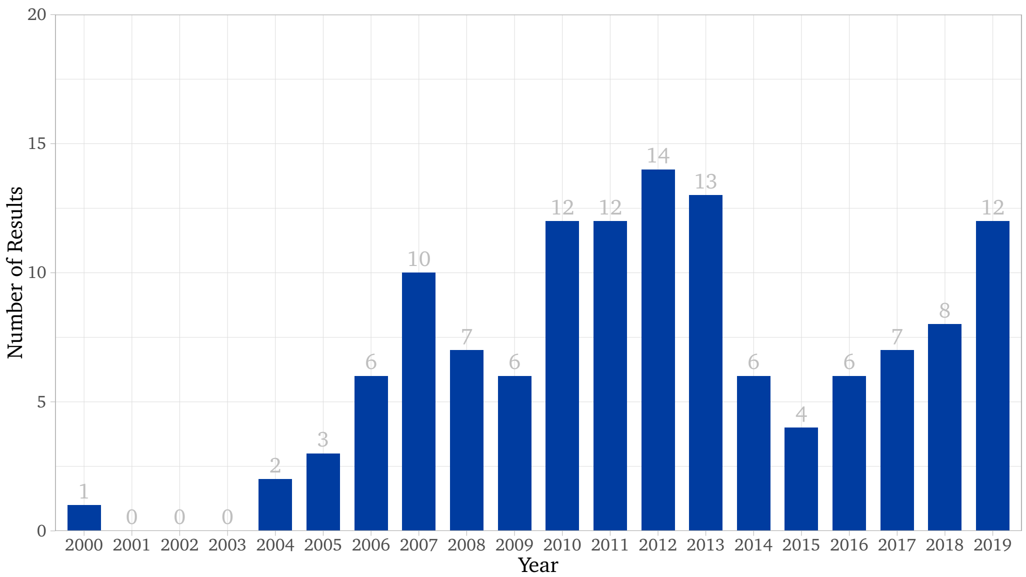

Figure 5.6: Papers per Year

Figure 5.6 shows the number of papers deemed relevant for this work per year. The oldest paper included was from the year 2000, with publications picking up from 2004. Publications peaked in 2012 with fourteen papers. Following a sharp decrease in 2014, from thirteen papers in the previous year down to six papers, publication volume has picked up in recent years.

5.3.8 Classes of Research

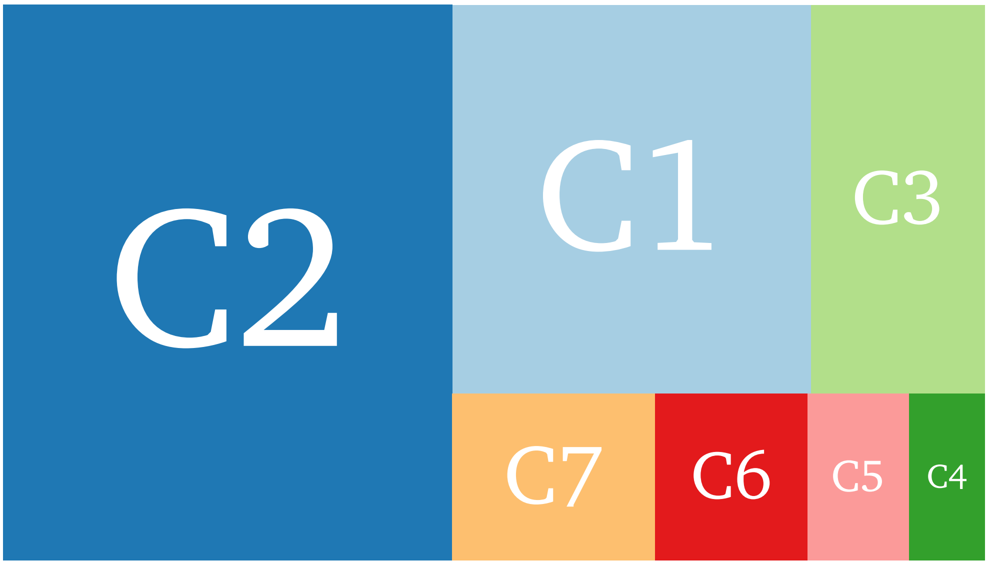

Figure 5.7: Ratio between Primary Paper Types

Paper Class	Papers
C1 – Evaluation Research	33
C2 – Proposal of Solution	59
C3 – Validation Research	16
C4 – Philosophical Paper	3
C5 – Opinion Paper	4
C6 – Personal Experience Paper	6
C7 – Review Paper	8

Table 5.11: Paper Count for Paper Class

When examining the ratio between primary paper classes the visualization in Figure 5.7 showed solution proposals (see Table 5.11 for descriptions and numbers) as the dominant class of paper (59 papers). The second most common class with little more than half as many papers (33 papers) was evaluation research and about half of that validation papers (16 papers). Even though the majority of papers fell into one of the top three classes, papers covering all types were found which included e.g. eight instances of the custom class “Review Paper”.

5.3.9 Methods

Figure 5.8: Ratio between Primary Methods

Primary Method	**Papers**
M1 – Speculation/commentary	1
M2 – Frameworks and Conceptual Model	63
M3 – Library Research	11
M4 – Literature Analysis	5
M5 – Case Study	19
M6 – Survey	1
M7 – Field Study	17
M8 – Field Experiment	4
M9 – Laboratory Experiment	1
M10 – Mathematical Model	1
M11 – Qualitative Research	3
M12 – Interview	1
M13 – Secondary Data	2
M14 – Content Analysis	0

Table 5.12: Paper Count for Primary Method

Figure 5.8 depicts the ratios between primary methods employed in papers. When combined with Table 5.12 it shows that frameworks and conceptual models were by far the most popular primary method chosen by the paper's authors. They were applied as a primary method in 63 publications compared to 19 for the second most common method. Except for content analysis, which no paper used as primary method, each class was observed at least once.

5.3.10 Type of Contributions

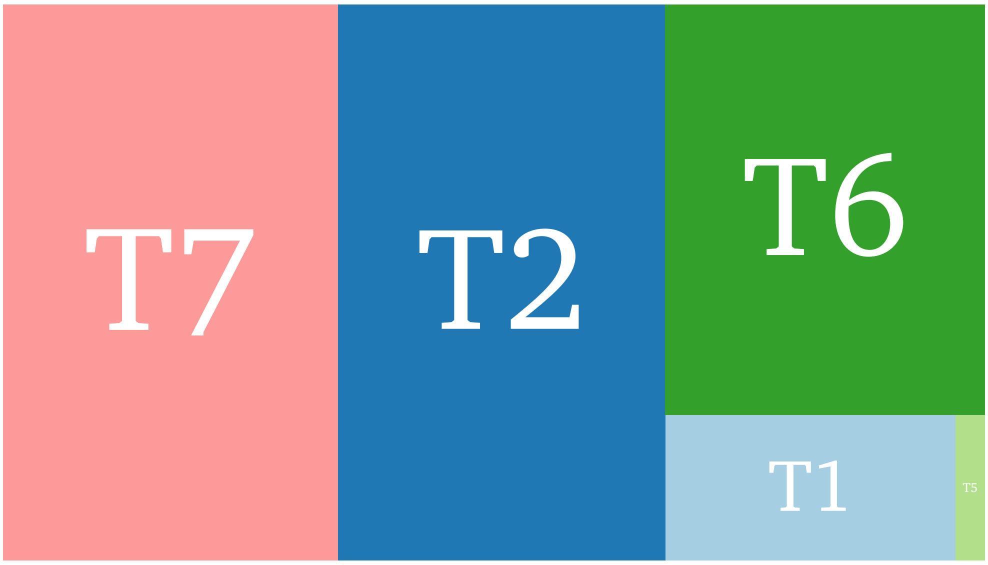

Figure 5.9: Ratio between Primary Contribution Types

Primary Contribution Type	Papers
T1 – Procedure or technique	10
T2 – Qualitative or descriptive model	43
T3 – Empirical model	0
T4 – Analytic model	0
T5 – Tool or notation	1
T6 – Specific solution, prototype, answer, or judgment	31
T7 – Report	44

Table 5.13: Paper Count for Primary Contribution Type

Like other classifications, contribution types feature three classes with high prevalence, which are depicted in Figure 5.9 and Table 5.13. Reports and qualitative or descriptive models were found to be almost equally prevalent (43 papers compared to 44 papers), with slightly fewer (31) papers contributing a specific solution, prototype, answer or judgment. Notably, there were no papers where the primary contribution was an empirical model or analytic model.

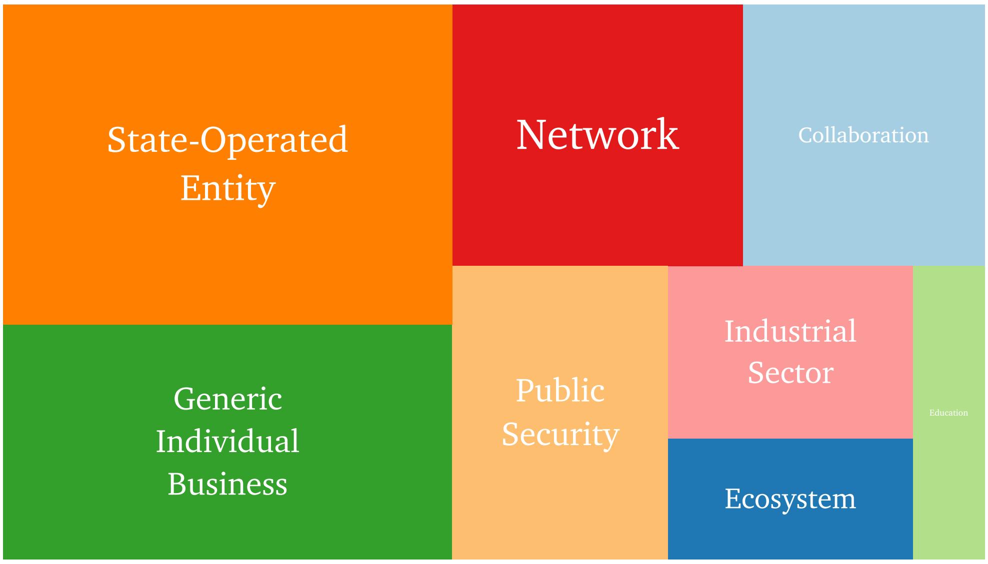

Figure 5.10: Ratio between Organization Types

5.3.11 Organization Types

A hybrid-style was used for visualizing organization types. Even though it was keyword-based, every paper related its work to some kind of organization, while for example not all papers reported challenges. Furthermore, the keywords describing organization types were semantically more homogenous than the concepts of the other keyword attributes. Therefore a tree map (Figure 5.10) depicting the ratios between organization types was created. The types are based on the root node of the first organization type reported by the paper. It shows state-operated entities, generic businesses, networks and collaborations as the main clusters. It should be noted that one paper may reference multiple organization types when reviewing the numbers in this section.
Like the other keyword attributes, the organization type relied on clustering, which is shown in the semantic map in Figure 5.11 and Table 5.14. The biggest cluster was called "State-Operated Entity" and consisted of nodes, such as "Government" or "Nation State". The second largest cluster was "Generic Individual Business", which consisted of papers, which referenced classes like "SME" or simply "Enterprise". The third largest cluster was "Network", which included nodes such as "Collaborative Network". However, distinctions between classes were not clear-cut due to regional differences. For example, one may count "Public Security", which also includes "Healthcare", which in turn included "EMS" (Emergency Medical Services), towards "State-Operated Entity". Yet healthcare organizations may be operated by private

entities in some regions and by the government in others. Given the fact that research contributions originated from diverse regions, classes were kept separate in these cases, leading to the layout shown in Figure 5.11. With regards to the more "generic" cluster roots, papers mentioning ecosystems were put into the "Ecosystem" cluster. The "Generic Individual Business" cluster was explained above. "Network" describes networks between organizations ranging from "Value Network[s]" to arrangements like "Multi-Partner Network[s]". For example, "Collaboration" includes "Virtual Enterprise[s]" or "Strategic Alliance[s]", which may imply a direct collaboration between organizations.

Root	Papers	Reported Instances
State-Operated Entity	34	34
Generic Individual Business	25	25
Network	20	20
Collaboration	16	17
Public Security	15	15
Industrial Sector	10	10
Ecosystem	7	7
Education	6	6

Table 5.14: Root Keywords of Semantic Map for Organization Type

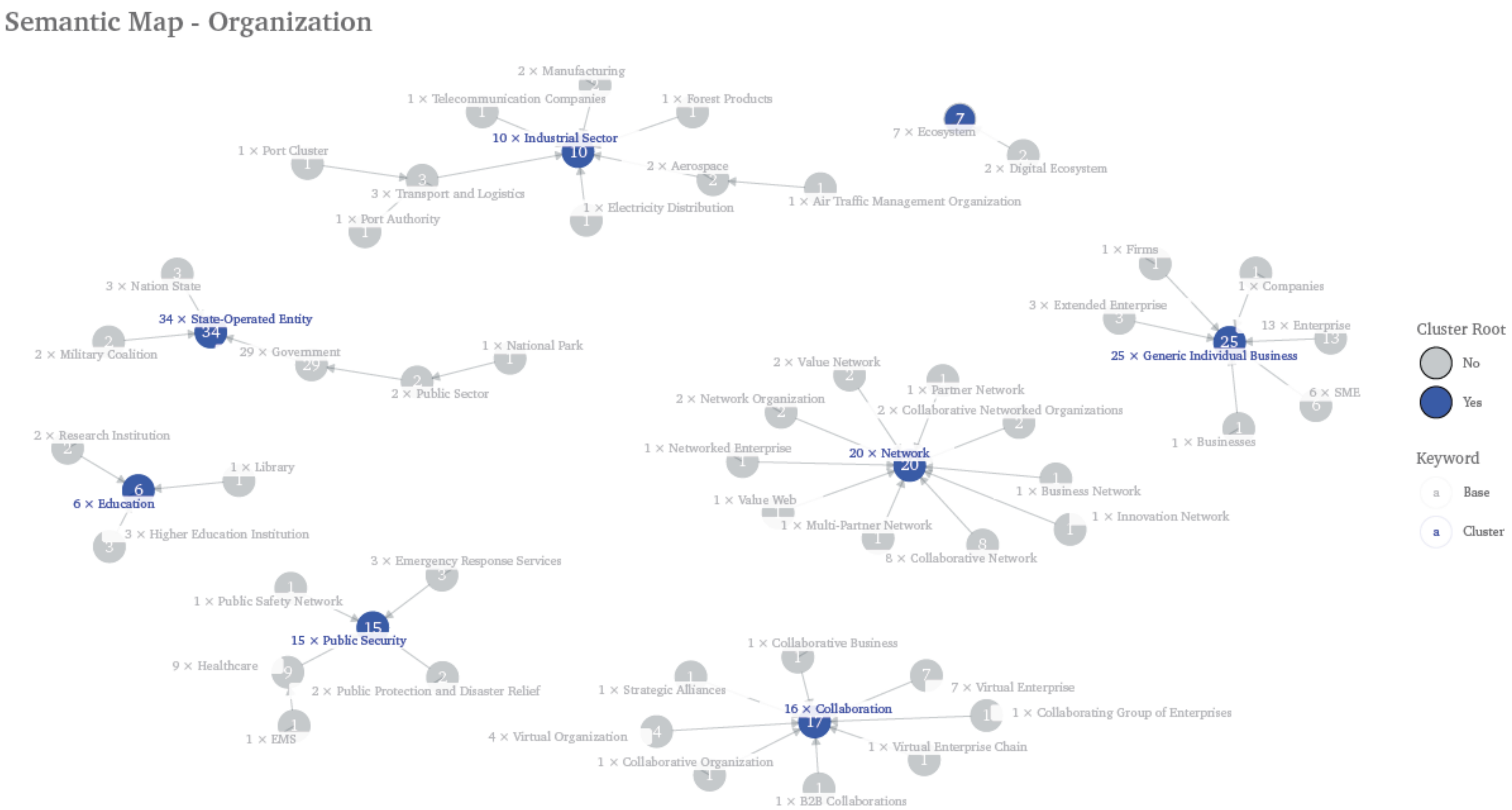

Figure 5.11: Semantic Map of Organization Types

5.3.12 Structure of Research

While the previous sections examined individual attributes, this section combines them for investigating the structure of research in the field of interorganizational collaborative architecture. Visualizations rely on bubble plots where each axis is associated with a categorical variable or attribute. Counts for co-occurrences of two classes are displayed at the intersections of lines originating from the axis tick marks of the respective classes. To enable quick visual analysis, the numbers are displayed inside circles, which are scaled relative to the number.
This section is split into two parts. First, a methods-driven perspective is taken. Combinations of research methods, contribution types and paper classes are explored. Then, methods and keyword attributes are related to certain root contribution types.

Methods

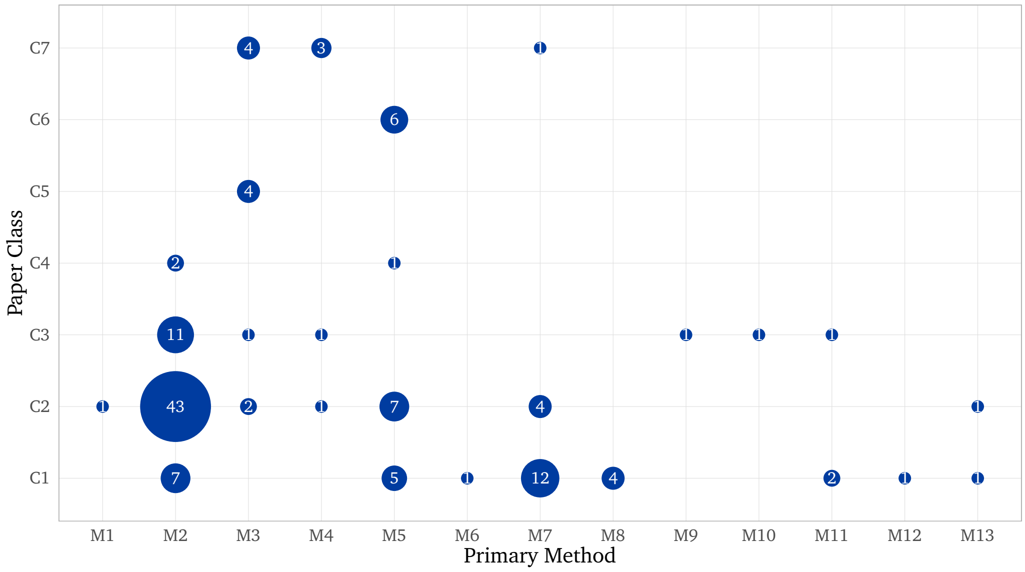

Figure 5.12: Paper Classes and Methods

Figure 5.12 shows observations by primary methods and paper classes. Papers commonly used "Frameworks and Conceptual Model[s]" (*M2*) for "Proposal[s] of Solution[s]" (*C2*). This combination makes up one third of all papers (43 out of 129 papers). The second most common combination included 12 papers featuring a combination of "Field Experiment" (*M7*) and "Evaluation Research" (*C1*). The combination of "Frameworks and Conceptual Model" (*M2*) and "Validation Research" (*C3*) was observed 11 times. Papers did not cover every possible combination. Also, there were no observations involving the primary method of "Content Analysis" (*M14*). Therefore, it is not displayed on the X-axis.

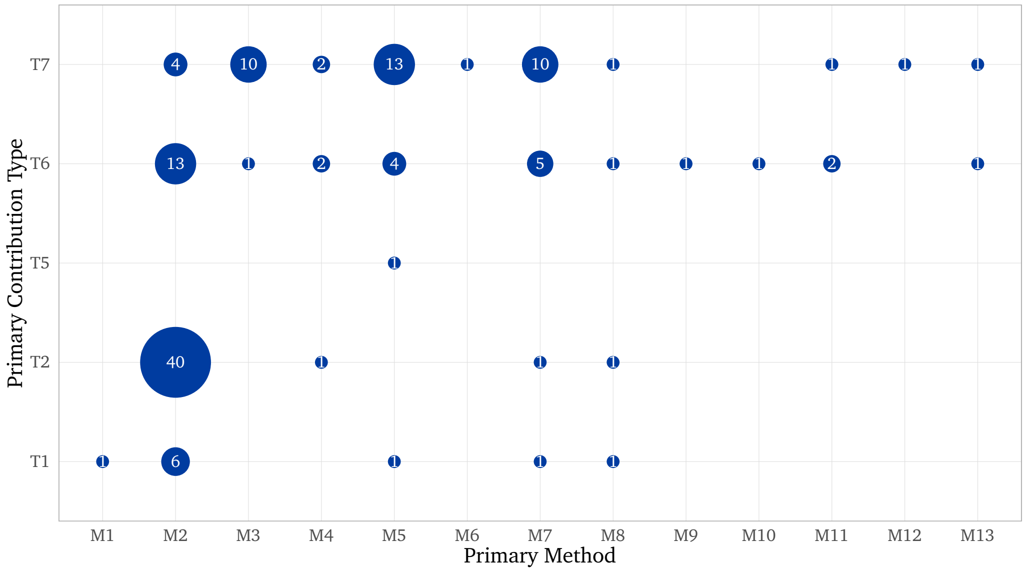

Figure 5.13: Methods and Contribution Types

Figure 5.13 shows how primary contribution types are related to primary methods. The combination of "Frameworks and Conceptual Model" (*M2*) and "Qualitative or descriptive model" (*T2*) was most common (40 matching papers). The second most common combinations (13 matching papers) were "Frameworks and Conceptual Model" (*M2*) and "Specific solution, prototype, answer, or judgment" (*T6*) as well as "Case Study" (*M5*) and "Report" (*T7*). As noted in previous sections, some methods and contribution types did not have any associated papers (*T3, T4* and *M14*). Also, combinations with observations in other categories were only observed once or not at all. Notably, primary contributions of the types "Specific solution, prototype, answer, or judgment" (*T6*) and "Report" (*T7*) rely on a comparatively broad variety of primary methods.

When analyzing the combinations of paper classes and primary contribution types in Figure 5.14 "Qualitative or descriptive model[s]" (*T2*) were most often reported in "Proposal of Solution" (*C2*) papers (29 times). Next were "Proposal of Solution" (*C2*) papers presenting a "Specific solution, prototype, answer, or judgment" (*T6*) and "Evaluation Research" (*C2*) presenting a "Report" (*T7*) (16 times each). Again, the "Report" (*T7*) contributions featured diversity in their associations with other

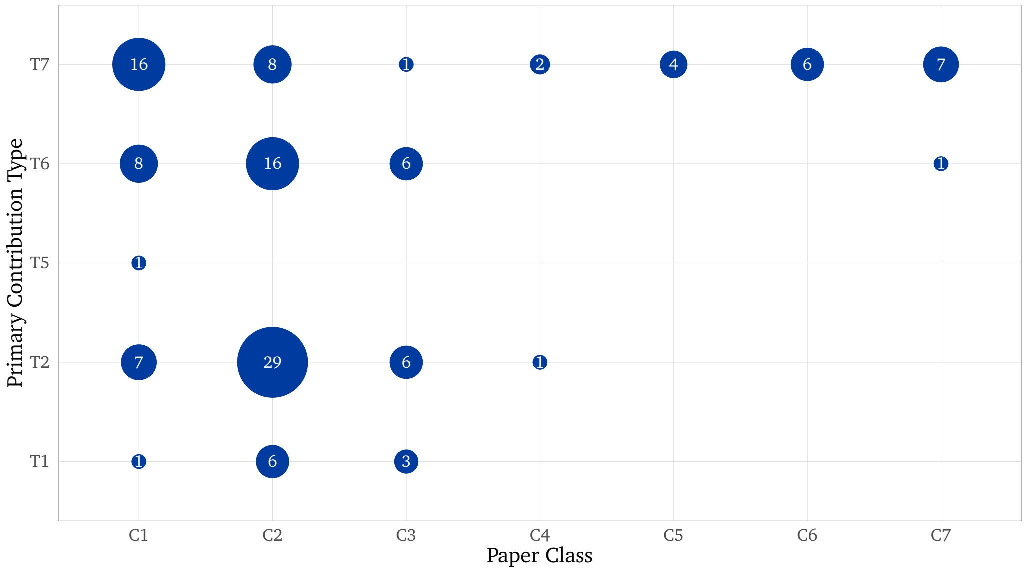

Figure 5.14: Paper Classes and Contribution Types

classes. Also, when compared to the "Report" (*T7*, 16 papers) contribution type, less "Evaluation Research" (*C1*) papers evaluated a "Qualitative or descriptive model" (*T2*, 7 papers) or "Specific solution, prototype, answer, or judgment" (*T6*, 8 papers). As in the previous section, some primary contribution types were not observed (*T3* and *T4*) and not all possible combinations were observed.

Organizations

In an effort to provide insights for conducting future research, this section features a primary organization-type-centric perspective[16] on paper's attributes. For Figure 5.15 and Figure 5.16 primary classes were analyzed with the primary organization type on the Y-axis, like in the previous section. For the keyword-based Figure 5.17, Figure 5.18 and Figure 5.19, the metrics were generated using a different method. While the primary organization type stayed on the Y-axis, the X-axis shows the keyword's cluster roots. As a paper may report findings related to multiple keywords, which in turn may relate to multiple different root nodes, all keywords were considered in this case instead of dropping "non-primary" classes. However, each paper was only counted once towards a given root node in these diagrams.

[16] Only a paper's first organization type was kept to enable this analysis. Any additional organization types were dropped. Only a minority of papers reported more than one organization type. Therefore, it was decided that the loss of precision was acceptable in this case.

This enables the diagrams to be read in the manner of e.g. “X number of papers with the primary organization type of ’Network’ reported ’Social Issues’ when engaging in interorganizational collaborative architecture”.

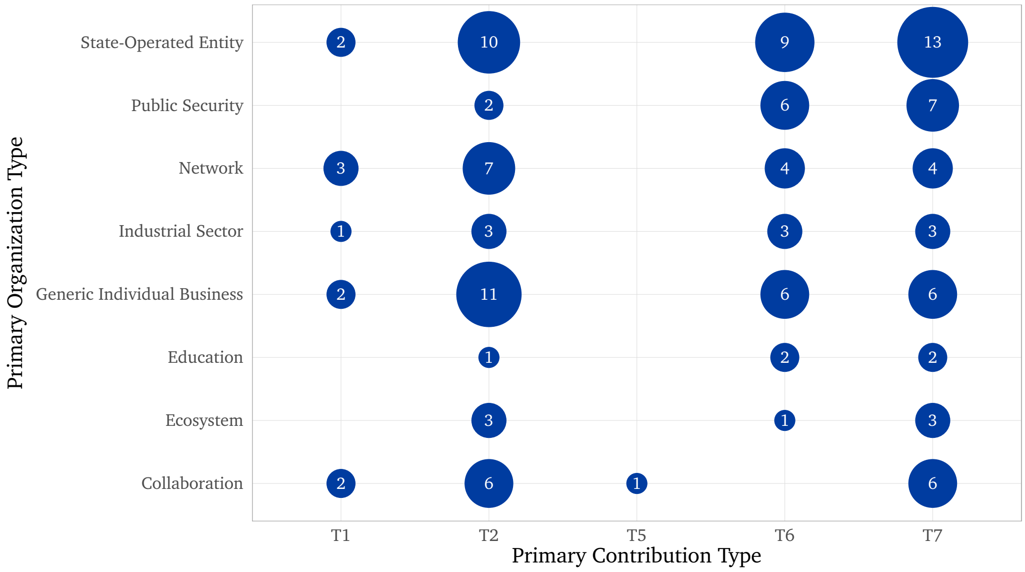

Figure 5.15: Primary Contribution Types by Organization Type

Similar to the findings of the previous section, Figure 5.15 shows that “Report[s]” (*T7*) were available for every primary organization type. “Qualitative or descriptive model[s]” (*T2*) were also contributed for every primary organization type and “Specific solution, prototype, answer, or judgment” (*T6*) were only missing the “Collaboration” type, yet it was the only class with a paper primarily presenting a “Tool or notation” (*T5*). The most common combinations were “State-Operated Entity” and “Report” (*T7*, 13 papers), followed by “Generic Individual Business” combined with “Qualitative or descriptive model” (*T2*, 11 papers) and “State-Operated Entity” combined with “Qualitative or descriptive model” (*T2*, 10 papers). Again, some primary contribution types are missing, as they were not observed (*T3* and *T4*).

“Frameworks and Conceptual Model” (*M2*) was the most observed primary method as shown in Figure 5.16, with most observations relating to “State-Operated Entity” (17 papers) and “Generic Individual Business” featuring almost as many observations (16 papers). “State-Operated Entity” was also examined using the “Case Study” (*M5*, 9 papers) and “Field Study” (*M7*, 7 papers) methods. The “Content Analysis” (*M14*) was not observed and is thus missing from the X-axis.

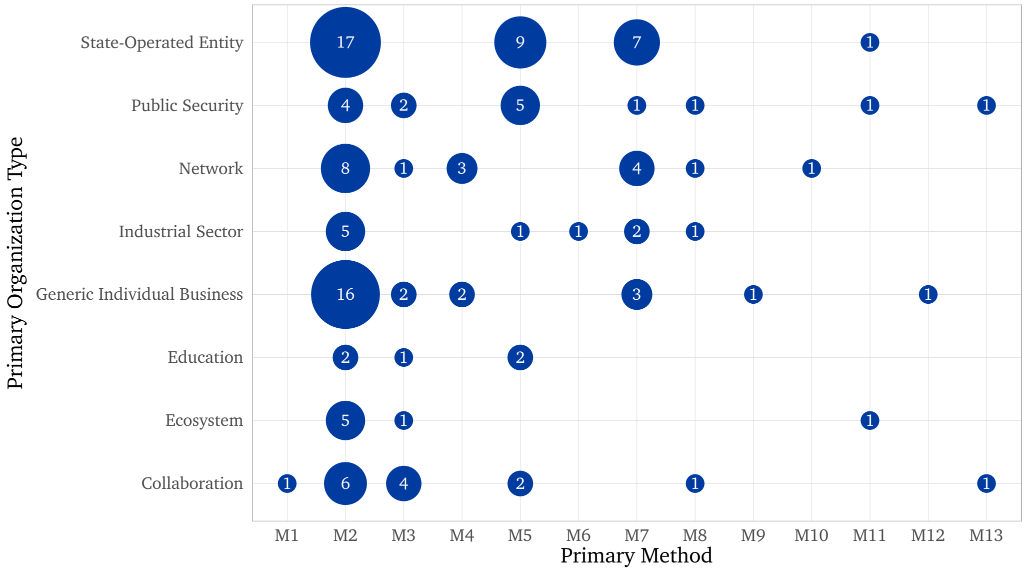

Figure 5.16: Primary Method by Organization Type

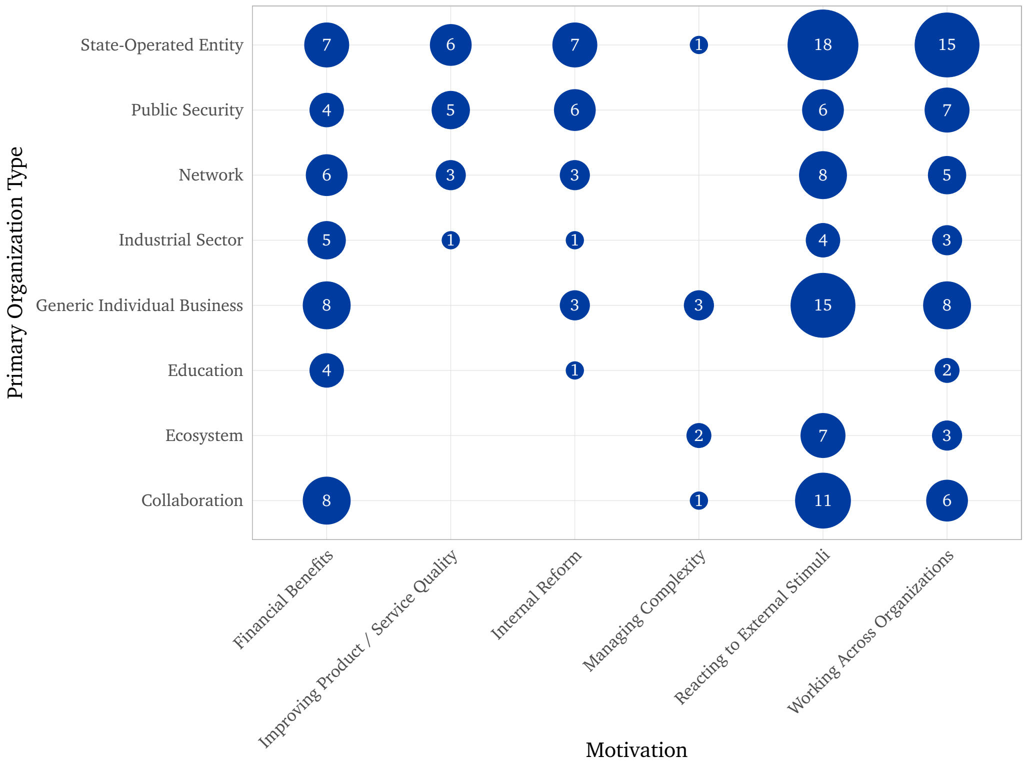

Figure 5.17: Motivations by Organization Type

Figure 5.17 lists primary organization types and motivations, enabling the identification of organization's focal points for motivations. For "State-Operated Entity"

"Reacting to External Stimuli" (18 papers) and "Working Across Organizations" (15 papers) were reported more often than other motivation types. "Reacting to External Stimuli" was also observed comparatively often (15 papers, next most common are 8 papers) from "Generic Individual Business" and "Collaboration" (11 papers versus 8 on next palace). Other classes do not show a similar distribution of reports or feature less observations overall.

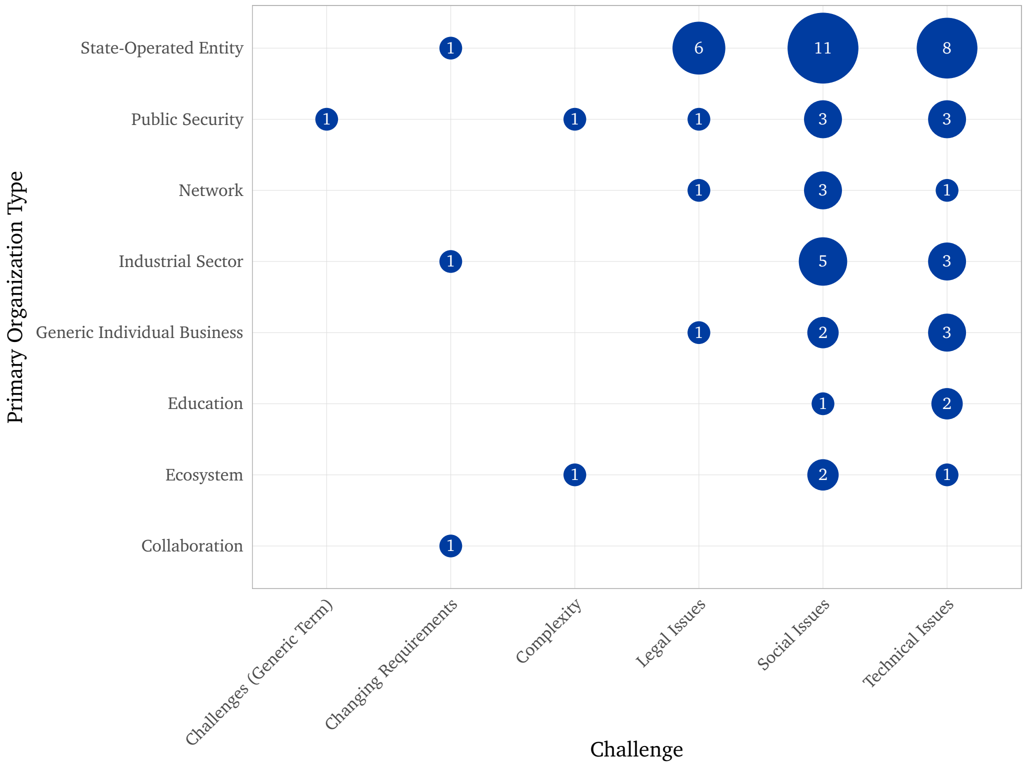

Figure 5.18: Challenges by Organization Type

When analyzing challenges encountered when engaging in interorganizational collaborative architecture in practice (see Figure 5.18), most reports were about "State-Operated Entit[ies]" with "Social Issue[s]" (11 papers). They were the most often reported combination, followed by "Technical Issue[s]" (8 papers) and "Legal Issue[s]" (6 papers). Challenges were not reported as often for other organization types. Nevertheless, except for "Collaboration", every other primary organization type was associated with "Social Issue[s]" and "Technical Issue[s]" at least once. In general, there was a more sparse distribution of observations across classes than shown in the other two diagrams based on keywording attributes (Figure 5.17 and Figure 5.18) with a number of combinations not observed at all or only once.

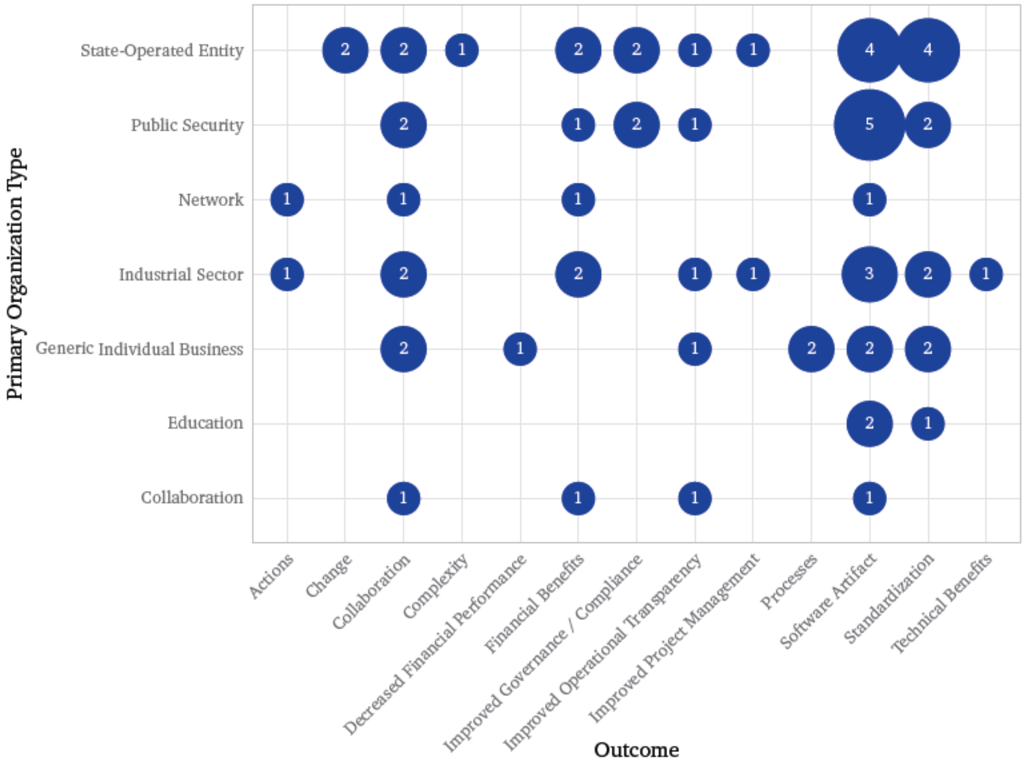

Figure 5.19: Outcomes by Organization Type

Compared to the challenges in Figure 5.18, the outcomes observed and presented in Figure 5.19 were more evenly distributed. The "Software Artifact" for organizations associated with "Public Security" was the most commonly reported combination (5 papers) in the outcome category. It was followed by "Software Artifact" and "Standardization" for "State-Operated Entit[ies]" (4 papers each), which also form the focus of outcomes for this organization type. Only one paper reported "Technical Benefits" (from organization type "Industrial Sector"). One paper with the primary organization type of "Generic Individual Business" reported "Decreased Financial Performance" in practice and another paper about "State-Operated Entit[ies]" reported "Complexity" as part of the outcomes.

Discussion

6

This chapter discusses the study's results while taking its limitations into account. Based on this, an outlook on future work is given in the next chapter.

6.1 Limitations

Wohlin et al. noted [45] conceptual threats to validity with this type of study and that "decisions taken by researchers and the judgements exercised influences the outcome both in terms of which papers are found and what the researchers conclude from their secondary studies. This is not wrong, but it must be taken into account when evaluating secondary studies." [45] By following best practices (see Section 4.1.2), these threats to validity were mitigated in a best effort manner within the scope of this work. However, it must be noted that some threats remain inherent to the type of study, which are outlined below, before discussing the results. This section is based on aspects specific to this work and informed by findings about systematic mapping studies' discussion of limitations in [35].

Methods

First, this work does not provide a complete picture of the field's research landscape. It relied on automated search using a limited set of databases. Relevant work may not be indexed by these databases or published recently (see Section 4.2.3). Fuzzy definitions of key terms in existing literature (see Chapter 2) further complicated scoping search terms and relevancy criteria. Therefore, search leaned towards breadth to include as many relevant papers as possible. Additionally, the full texts of some papers were not available to the author (see Table 5.2). This led to 129 accepted papers out of 1 192 deduplicated results.
Another point the author would like to stress is that, apart from applying the exclusion criteria, no quality assessment of the papers was conducted. Even though

some papers prompted concerns about the quality of research presented, assessing e.g. a paper's methodical approach in depth would have required a thorough review outside the scope of this work ([35] reported this tradeoff to be common in SMS). Nevertheless, these papers are part of the field's corpus of which this study aims to provide an overview of and could be assessed in future work (see Chapter 7).
With regards to data extraction, tradeoffs between review depth and scope of this work were made. Unlike systematic literature reviews, systematic mapping studies do not rely on full text reviews. Therefore, dynamic reading depth [33] was employed with the review focussing on the abstracts and conclusions, with cursory review of other parts only performed when statements were unclear (e.g. for distinguishing between challenges, motivations and outcomes). The reasoning behind this was that these sections would contain relevant information if they were part of the study's core findings. Yet this led to the omission of findings reported in other parts of the paper which were not reviewed. Also, some attributes, such as methods (*A11*), were reduced to the primary method in the case of mixed methods research. This was done to facilitate analyses, which led to loss of information in these cases. It was attempted to minimize this loss of information by selecting the "primary" method employed in these cases. In other cases, where there was no such "hierarchy" of attributes (e.g. motivations (*A1*), challenges (*A2*) and outcomes (*A3*)) no primary value was picked, which led to more complex (to interpret) analysis.

Bias

Different kinds of biases have or may have influenced this work's results. They can be grouped into publication bias, bias during search and bias during classification.
Out of 129 selected papers only 2 reported negative outcomes. The author doubts this is a representative presentation of outcomes of interorganizational collaborative architecture projects. This may hint towards a publication bias towards favoring publishing reports of positive outcomes. When interpreting results, this should be taken into account.
Search too was affected by bias. The search results for evaluating the search string were selected by the advisor. Also, the set of databases selected for search was based on personal experience of the author and the advisor. This could have led to relevant literature not being selected in the study. However, considering the guidelines [35] (which cite [9] in turn), this approach seems to represent the state of the art for conducting systematic mapping studies. Selection criteria were applied and search terms defined collaboratively by the author and the advisor to reduce researcher

bias during study search and selection. Conflicts were resolved by discussion.
Data extraction and analysis were conducted by the author alone and thus may carry a greater risk of researcher bias. As there were problems reported [45] for the classification for paper type (*A10*) from [43], guidelines from [35] were taken into account when assigning classes to papers. Also, an additional class was added to augment the schema for papers not matching the proposed classes. Nevertheless, the classification of papers was inherently based on interpretation and thus carries the risk of researcher bias. Section 5.3.1 notes similar concerns for keywording and clustering attributes. First, the selection of keywords is based on the reviewer's interpretation of the paper. Second, the clustering is also the reviewer's choice. This not only includes the selection of a keyword but also the choice of semantic category to pick for aggregating results into clusters. As already noted, the clusters presented show *a* way rather than *the* way to cluster the keywords. While this process was inherently biased by the author, it also forms one of this works core contributions by proposing a way of structuring the field. For transparency and to enable others to perform their own clustering, the raw keyword mappings are listed in the appendix.

Repetitive Manual Work and Automation

Supporting software was used in multiple phases of the study, e.g. for performing the search, deduplicating results and performing graph analysis. This software may have errors, which may have impacted the results. On the other hand, there were manual processes which may be subject to human error, such as linking keywords to categories. An approach of augmenting the respective manual or software-based process was taken. When e.g. software was used for deduplication, the results were checked manually and the source code put into this work's appendix. In the case of the manual linking of keywords to categories in the spreadsheet, a script was used to perform basic plausibility checks, such as that no keyword was missing from the linking table or listing keywords which did not have references from papers of their own. Other strategies for controlling risk of errors included, among other things, taking regular breaks when reviewing papers (see Section 4.2.4 and [10]). Still, a residual risk for errors in both repetitive manual work and software remains.

Conclusions

When interpreting the results presented in the previous section, above limitations must be taken into account. Regarding limitations inspired by [34], [35] descriptive, interpretive and theoretical validity were discussed above. Measures were taken to enable repeatability by reporting exact search terms and settings, publishing source code of supporting software for search result processing and study deduplication as well as the publication of base keyword/class mappings. Generalizability of the findings is limited by the selection of papers as well as the interpretation of their contents. The goal of this study is to provide an overview of available research and to identify research gaps for which generalizability is not as big of a concern as for e.g. devising a generic analytical framework for assessing interorganizational collaborative architecture. Nevertheless, by leaning towards breadth during paper selection it was attempted to capture a relevant subset of the underlying "population" of papers on interorganizational collaborative architecture. This was done to enable analysis aspiring to be applicable to and valid for other current and future works.

6.2 Discussion of Results

This work aims to provide an overview of the current state of research in interorganizational collaborative architecture management and to uncover potential gaps in research for future works. Following the presentation of results in Chapter 5 and their limitations in Section 6.1, this section discusses the results in the context of the research questions from Section 1.3 and outlines hypotheses around implications in the findings, which could be investigated in future work (see also Chapter 7).

6.2.1 Motivations, Challenges and Outcomes

RQ 1.1 – What motivations for engaging in interorganizational collaborative architecture were reported in and by research?

The three most reported motivations for engaging in interorganizational collaborative architecture in selected research are related to "Reacting to External Stimuli", "Working Across Organizations" and "Financial Benefits".

In general, these results may indicate a "reactive" stance towards motivations for engaging in interorganizational collaborative architecture, with 69 out of 129 papers reporting motivations from the "Reacting to External Stimuli" cluster root (see Figure 5.1). Driving factors seem to be rooted in "Improving Reaction Speed", be it from strategic (e.g. "Improving Reaction Time to Market") or operational (e.g. "Improving Cycle Time") concerns, "Following Trends", such as the "Emergence of Business Networks" and "Compliance" reasons. This cluster indicates a viewpoint towards an organization which is subject to numerous external pressures, such as dynamic markets, outpacing competition, updated legislation and global trends in management, the environment or both.

The second biggest cluster (49 out of 129 papers) lists "Working Across Organizations" as motivation, which may hint towards a (felt) need to collaborate with other organizations. This may be related to organizations already engaging in collaboration ("Improving Collaboration") or anticipated benefits, such as "Providing Cross-Organizational Services".

This cluster is closely followed by "Financial Benefits" (42 out of 129 papers). These motivations may have been confounded by motivations for change in organizations in general. It could be argued that ultimately "Financial Benefits" or "Adapting to Changing Market Environment" may significantly motivate change in any organization subject to economic pressures. It is thus unclear to which degree these motivations are specific to the field. Motivations not only covered potentially immediately self-serving aspects. Notably, these economic motivations are contrasted by other motivations including "Achieving Accountability" (1 paper), "Working towards Circular Economy" (1 paper), "More Disasters Requiring Collaboration" (4 papers), "Reducing Loss of Life" (1 paper) and "Empowering Users" (1 paper). This hints towards a diverse set of motivations for engaging in interorganizational collaborative architecture.

When analyzing motivations by organization type in Figure 5.17, "Public Security" organizations seem to have a mostly homogenous set of motivations across the categories. For the other organization types the distribution of motivations seems mostly consistent with the numbers reported for clusters above.

RQ 1.2 – What challenges were encountered when engaging in interorganizational collaborative architecture in practice?

The main challenges reported when engaging in interorganizational collaborative architecture in practice were categorized as "Social Issues" (27 papers) and followed by “Technical Issues” (21 papers) (see Figure 5.2). While “Social Issues” included categories, such as “Power Dynamics” (19 papers), “Ignorance” (8 papers) and “Trust” (5 papers), “Technical Issues” were not clustered in a similar manner, hinting towards what might be a more heterogenous set of challenges. The distribution of papers between the root nodes shows that social challenges may pose even greater risks than risks stemming from technical issues. These findings could inform future research to put equal emphasis on technical as well as social aspects when designing or evaluating novel approaches. When analyzing challenges reported by organization type (see Figure 5.18) it can be observed that “State-Operated Entity” was the primary organization type, with the most papers reporting challenges compared to the other individual types (26 Papers). Legal issues were reported by 9 papers of which 6 belong to the “State-Operated Entity” category. The reasons for this remain unclear. As somewhat of an outlier, legal issues listed “Ensuring the Separation of Powers” as a challenge encountered in practice, a concern which could be addressed in future works e.g. on E-Government. No other organization type’s distribution of challenges stood out when compared to the cluster’s distribution as a whole. Even though the motivations refer to interorganizational collaborative architecture as a means for managing complexity, it was also listed as a challenge. A similar situation can be observed with the challenge “Changing Requirements” and interorganizational collaborative architecture for achieving agility-related goals. It should be noted however, that these challenges were only reported in a comparatively small number of papers (2 papers) and data does not permit inferring a causal relationship.

RQ 1.3 – What outcomes were documented when engaging in interorganizational collaborative architecture in practice?

Outcomes were centered around “Software Artifact[s]”, such as “Interorganizational Information System[s]”, “Standardization” and “Collaboration”, yet also include singular cases of “Decreased Financial Performance” and “Complexity” (see Figure 5.3). While some outcomes mirror motivations, such as “Financial Benefits” or “Improved Operational Transparency”, the distribution of classes at large does not. At the same time, practical outcomes (see Table 5.5) were not reported as often as (theoretical) motivations (see Table 5.3). This may hint towards a lack of research on the effectiveness of interorganizational collaborative architecture for achieving aspirations set by motivations (more on this in Section 6.2.3). Also, with a technical “Software Artifact” being reported by 18 papers as the most common cluster, this raises questions regarding the inclusion of handling social issues in practice (see above). Yet overall reported outcomes seem to lean towards positive effects on organizations (see Figure 5.3). Whether this is related to publication bias remains unclear (see Section 6.1). When checking for a potential relationship between outcomes and primary organization type in Figure 5.19, no primary organization type stands out.

6.2.2 Structure of Research

RQ 2.1 – Who published research?

Except for Antarctica, papers on interorganizational collaborative architecture were published by authors associated with institutions on all continents. There are three main geographical clusters for publications: Europe, the United States of America and Australia (see Figure 5.4). In general, there was no single dominating cluster of researchers on the topic. The top individual author and organization were "Vargas, Alix" (6 papers) from the Universitat Politècnica de València (7 papers) in Spain (8 papers) (see Tables 5.6, 5.7 and 5.8). Even though no US-based organization published more than two papers (selected in this work) while being one of the top-publishing regions, this may hint towards a distributed nature of research in the field within the region. The distributed nature of publication origins over the continents may indicate a global importance of the field.

RQ 2.2 – Where was research published?

The majority of selected papers were published on conferences (84 out of 129), with a minority of papers published in journals (32 papers) and workshops (13 papers, see Figure 5.5 and Table 5.9). The "Americas Conference on Information Systems (AMCIS)" was the publication venue with most papers (8 papers, see Table 5.10). Therefore, no individual venue in particular published a majority of papers, which may imply a cross-sectional character of the field.

RQ 2.3 – When was research published?

The number of papers selected peaked in 2012, with 14 publications (see Figure 5.6). However, the number of papers per year sharply decreased in 2014 (6 papers) and 2015 (4 papers) and only recovered recently in 2019 (12 papers). Given this past volatility, no clear trend is discernible and it remains unclear whether interest will keep increasing. With the earliest paper being published in 2000, it also hints towards the field carrying some degree of relevance for almost two decades by now.

RQ 2.4 – What types of research were published?

The three most common classes of research paper were the "Proposal of [a] Solution" (59 papers) followed by "Evaluation Research" (33 papers) and "Validation Research" (16 papers, see Table 5.11), hinting towards practice-oriented research. When relating paper classes to primary contribution types, the most common contribution for proposals of solutions was the qualitative or descriptive model (see Figure 5.14). This indicates a focus on proposing models or frameworks for specific problems with less emphasis on evaluation or validation.

RQ 2.5 – What methods were employed in research?

The by far most common method consisted of "Frameworks and Conceptual Model[s]" (63 out of 129 papers) followed by "Case Stud[ies]" (19 out of 129) and "Field Stud[ies]" (17 out of 129, see Table 5.12). Therefore, this aspect too focused on models and controlled experimental approaches took a less pronounced role. Papers primarily featuring the "Frameworks and Conceptual Model" method contributed the "Qualitative or descriptive model" contribution type (40 out of 63 papers, see Figure 5.13). A third of all papers used that primary method to propose a solution (see Figure 5.12). While there were at least two papers for each primary organization type, model-centered or framework-centered papers were mainly published in the contexts of "State-Operated Entit[ies]" and "Generic Individual Business[es]" (see Figure 5.16). As methods were not applied consistently across organization types, this might show a gap for future research employing alternative methods for less covered organization types. Even though a wide variety of methods was observed in the papers selected for this work, there were no papers which were primarily based on content analysis.

RQ 2.6 – What types of contributions were made?

The most common primary types of contribution were the "Report" (44 papers out of 129), "Qualitative or descriptive model[s]" (43 papers) and "Specific solution[s], prototype[s] answer[s] or judgement[s]" (31 papers, see Table 5.13), which again highlights a possible focus on specific examples from practice and descriptive models. However, there were no papers whose primary contributions were empirical or analytic models. This may imply a more descriptive approach than a predictive one, which might be related to the relatively low (see above) prevalence of research designs featuring experiments, e.g. for validating models. When splitting primary contribution types by primary organization type (see Figure 5.15), there are no anomalous distributions obvious to the author when compared to the general distribution of papers between primary contribution types.

RQ 2.7 – What types of organization were examined?

Research selected focused on "State-Operated Entit[ies]" (34 papers[17]), "Generic Individual Business[es]" (25 papers) and "Network[s]" (20 papers, see Table 5.14). Other clusters included "Public Security", "Industrial Sector[s]", "Education", "Ecosystem[s]" and "Collaboration[s]". The relationship between organization types and other attributes were described in the sections of the other research questions.
Why exactly public entities were covered comparatively extensively remains unclear. Categories included both singular entities, such as individual businesses as well as entities composed of multiple organizations, such as governments. Therefore, future avenues for research may include comparing and evaluating differences in approaches when engaging in interorganizational collaborative architecture. For example, comparing approaches taking a narrow view on one organization with approaches including its immediate environment and large-scale efforts, such as E-Government initiatives. Also, exploring differences between the "composite" organization types, such as "Network", "Ecosystem" and "Collaboration" (see Figure 5.11) could yield novel insights.

[17]Papers may cover multiple organization types, therefore the numbers do not add up to 129.

6.2.3 Research Gaps

***RQ 3* – What research gaps can be identified?**

The discussion around the research questions above already led to multiple possible directions for future research. This section focuses on research gaps emerging from the discussion above, while Chapter 7 expands on selected aspects in a more general context. Future work (e.g. field experiments or SLRs) could investigate these research gaps.

The geographic distribution of publication's origins may indicate a global relevance of the field, which could justify future work. With regards to motivations, the possible prevalence of a "reactive" stance towards the subject matter could be investigated, which may lead to insights regarding organization's different approaches. Also, the relationship between motivations for change in an organization for engaging in interorganizational collaborative architecture and more generic motivations for change in organizations could be analyzed. This could help separate generic motivations from ones specific to the field.

Further research on challenges (and especially social challenges) in different types of organizations could yield insights for informing future approaches for approaching interorganizational collaborative architecture grounded in evidence from practice.

As themes around complexity were listed in motivations, challenges and outcomes, it may prove worthwhile to evaluate means for controlling complexity in the field. For example, whether applying interorganizational collaborative architecture increases or decreases complexity when collaborating.

Taking into account *RQs 1.1 - 1.3* and *RQ 2.7*, properties of approaches featuring *inside-out* and *outside-in* perspectives on organizations (e.g. viewing an organization in isolation with points of interactions with the external world versus analyzing a group of organizations, such as nation states or an ecosystem) could be investigated e.g. for informing the development of future approaches.

When considering the structure of research (*RQs 2.1 - 2.7*), the papers seemed to be mainly practice oriented with solution proposals, frameworks and conceptual models, and qualitative or descriptive models being popular classifications of research classes, methods and contribution types (see also Figure 5.12). However, only a minority of papers focused on validating or evaluating their proposals. These observations and conclusions in this subfield are consistent with other studies' [11], [27] findings in the EA space. Therefore, an approach grounded in empirical evidence is proposed. Future research may put more emphasis on not only deriving proposals from practice but also evaluating them, e.g. in controlled field experiments. While this may prove challenging, it could be a valuable step in moving the field forward in an empirically oriented way. Existing literature's findings could be assessed by an in-depth review including evaluation of research quality to aggregate available reliable evidence for future work. Also, alternatives to descriptive models could be further explored, e.g. for creating practically applicable and empirically proven procedures, methods or other means for approaching implementing interorganizational collaborative architecture with a holistic (including social concerns among other aspects) perspective.

On the matter of expanding perspectives, interorganizational collaborative architecture's potential contributions towards achieving goals which are not immediately self-serving for an organization, such as environmental concerns, transparency or accountability, could be explored in future research.

All in all, existing research has shown glimpses of varying size into the subject matter in research and application. This could be expanded upon. A reconceptualized holistic approach incorporating past findings could yield new insights and advance the field's maturity. Possible approaches for this are proposed in the next chapter.

7 Future Work

After the previous chapter discussed results in detail, this second last chapter outlines selected opportunities for future work based on them. Looking back at the original problem statement (see Section 1.2), two main issues were investigated. First, the issue of EAM approaches and governance potentially struggling in dynamic (and cross-organizational) settings in practice. And second, calls for a solid empirical foundation of EAM. This work aimed to contribute a step towards these goals by identifying and presenting the current state of research on interorganizational collaborative architecture and by proposing directions for future research.

While considering these two aspects and the discussion of the previous chapter, three themes for possible directions are discussed in this chapter. The first theme is centered around *strengthening the field's empirical foundation*. The second theme seeks to *enhance the holistic view* of research in present applications. Finally, the third theme aims to provide directions for *exploring future applications* of the field's concepts.

First, when looking at motivations, challenges and outcomes reported in research, they do not necessarily map cleanly to each other in the sense of evaluating whether an interorganizational collaborative architecture approach actually yielded the anticipated benefits which motivated its application in the first place. For example, only a minority of papers reported measurable improvements in performance. However, one might expect research checking whether e.g. applying a proposed reference model led to the benefits stated as motivating reasons. Another possible question would be whether macro-trends actually influence an organization's operations at the scale anticipated. To strengthen the field's empirical foundations, future studies could gather evidence on proposed approaches' performance at achieving motivations. They could then also document challenges encountered during implementation. Applying these models in highly complex real-world contexts could prove challenging, as variables may be difficult to control. An alternative approach would be devising controlled lab experiments for verifying e.g. a model's performance by letting subjects apply them to standardized cases. It may also prove challenging to conduct large-scale evaluations in current academic settings. However, as the geographical distribution of papers indicates, these may be global issues which may require large-scale collaborative solutions transcending individual working groups or labs. Even if the design of these studies may pose challenges, moving in a direction where solution proposals are routinely validated and evaluated with regards to their ability of aiding in achieving anticipated benefits while controlling risks and challenges could *strengthen the field's empirical basis*. This may allow for the targeted incremental refinement of approaches.

Second, social issues were shown to be the biggest cluster when analyzing challenges encountered in practice. Considering calls for flexible bottom-up EA governance (see Section 1.2), the author anticipates this would involve not only the creation of intricate architecture models, process maps or interorganizational information systems but also significant changes to an organization's culture. Together with aspirations towards holistic approaches for engaging in architecture-related activities, future work could focus on overcoming these social challenges in practice and develop methods and guidelines grounded in evidence for overcoming them. This could contribute towards *enhancing the holistic view* of the field by acknowledging the at least equal importance of social aspects when designing, verifying and evaluating contributions in the field.

Third, interorganizational collaborative architecture could contribute to organizations achieving goals which are not immediately self-serving, such as transparency, accountability or ecological concerns. This potential was indicated by isolated reports in the papers selected for analysis. As organizations may require thinking in larger contexts, e.g. for achieving goals in the face of global challenges or adopting common-good oriented values, *exploring these future applications* based on a reproducible methodical foundation may prove worthwhile for aiding organizations in tackling these challenges.

8 Conclusion

This final chapter summarizes this study's findings and concludes this work. Prompted by research, this work presented a systematic mapping study on an overview of the current state of research on interorganizational collaborative architecture. Based on the analysis of 129 papers, three themes were proposed for future research: 1) *Strengthening the field's empirical foundation*, e.g. by empirically validating and evaluating solution proposals. 2) *Enhancing the holistic view* of research, e.g. by treating social aspects with at least equal importance as technical aspects. 3) *Exploring future applications* of the field's concepts for assisting organizations at achieving large-context goals in the face of global challenges or the adoption of common-good oriented values.

To reach these conclusions, after defining the research questions, fundamentals of Enterprise Architecture and interorganizational collaboration were derived from literature and related work was discussed. Then, the best-practices-oriented research approach of a systematic mapping study was detailed. Exclusion criteria, data extraction attributes and component-based search queries were (partly) derived from the research questions. Results were collected from four literature databases and deduplicated. Using a custom-made tool called *MapMaker*, the search results were then vetted collaboratively based on the exclusion criteria. Data was then extracted from the selected papers. After updating the search and excluding additional papers during data extraction, 129 papers remained. A diagram called *Semantic Map* was developed for visualizing the results of clustering keyword-based attributes.

After the limitations of the approach were discussed, the review yielded the following summarized results: The organizations commonly mentioned in papers were state-operated entities, generic individual businesses, and networks. Common motivations for engaging in interorganizational collaborative architecture were centered around reacting to external stimuli, working across organizations, and financial benefits, which may indicate a "reactive" stance towards the topic. Regarding the top clusters in challenges, social issues were reported by more papers than technical issues. The most common reports for outcomes were software artifacts, standardization, and collaborations, but also singular cases of negative outcomes, such as decreased financial performance, and complexity.

Except for Antarctica, papers were published by authors whose organizations are

spread over all continents. The majority of papers was published on conferences. There was no clearly discernible trend in publication count over time. Common paper classes were proposals of solutions, evaluation research and validation research. Methods commonly used in papers as primary methods were frameworks and conceptual models, case studies, and field studies. Contribution types centered around reports, “qualitative or descriptive models”, and “specific solutions, prototypes, answers or judgements”.[18]
Supplementary data and information is available in the appendix.

[18]Quotes were added for clarity.

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Appendix A

A.1 Raw Data

A.1.1 Search Results

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A.1.2 Mappings

Paper Class	Papers
C1	[R7], [R10], [R14], [R20]–[R22], [R25], [R33], [R34], [R39], [R41], [R42], [R48], [R55], [R58], [R66], [R76], [R79], [R89], [R90], [R92], [R93], [R95], [R101]–[R103], [R109], [R110], [R113], [R117], [R125], [R126], [R129]
C2	[R1], [R2], [R4], [R6], [R9], [R13], [R15], [R16], [R18], [R19], [R23], [R24], [R26], [R28], [R32], [R37], [R40], [R43], [R52], [R53], [R57], [R59], [R61], [R64], [R65], [R67]–[R70], [R74], [R75], [R78], [R80], [R81], [R84]–[R86], [R88], [R91], [R94], [R96]–[R98], [R100], [R104], [R105], [R107], [R108], [R112], [R114]–[R116], [R118], [R120]–[R124], [R128]
C3	[R5], [R29], [R35], [R44], [R45], [R49], [R60], [R71]–[R73], [R77], [R83], [R87], [R99], [R106], [R127]
C4	[R12], [R17], [R27]
C5	[R47], [R50], [R56], [R63]
C6	[R8], [R11], [R36], [R51], [R54], [R62]
C7	[R3], [R30], [R31], [R38], [R46], [R82], [R111], [R119]

Table A.1: Mappings for Paper Class

Primary Method	Papers
M1	[R43]
M2	[R1], [R2], [R4], [R9], [R12], [R13], [R15]–[R19], [R21]–[R24], [R26], [R29], [R35], [R37], [R52], [R53], [R57], [R59]–[R61], [R64], [R66], [R72]–[R75], [R77], [R80], [R81], [R83]–[R91], [R94], [R96]–[R100], [R105], [R106], [R112], [R114]–[R118], [R120]–[R122], [R127]–[R129]
M3	[R30]–[R32], [R45]–[R47], [R50], [R56], [R63], [R78], [R119]
M4	[R3], [R69], [R71], [R82], [R111]
M5	[R8], [R11], [R14], [R20], [R27], [R28], [R36], [R42], [R51], [R54], [R62], [R68], [R70], [R76], [R104], [R107], [R108], [R123], [R125]
M6	[R41]
M7	[R6], [R7], [R10], [R33], [R34], [R38], [R40], [R58], [R67], [R92], [R93], [R95], [R102], [R109], [R113], [R124], [R126]
M8	[R25], [R48], [R79], [R103]
M9	[R49]
M10	[R44]
M11	[R5], [R39], [R101]
M12	[R55]
M13	[R65], [R110]

Table A.2: Mappings for Primary Method

Primary Contribution Type	Papers
T1	[R6], [R16], [R35], [R43], [R60], [R79], [R86], [R96], [R99], [R123]
T2	[R1], [R2], [R4], [R9], [R12], [R13], [R15], [R18], [R19], [R21], [R22], [R24], [R29], [R37], [R48], [R52], [R53], [R59], [R61], [R66], [R69], [R72], [R74], [R77], [R80], [R81], [R83], [R87]–[R89], [R94], [R97], [R98], [R106], [R112], [R114], [R117], [R120]–[R122], [R124], [R128], [R129]
T5	[R20]
T6	[R3], [R5], [R7], [R25], [R26], [R33], [R42], [R44], [R49], [R57], [R64], [R65], [R67], [R71], [R73], [R78], [R84], [R85], [R90], [R95], [R100], [R101], [R104], [R105], [R107], [R108], [R115], [R116], [R118], [R126], [R127]
T7	[R8], [R10], [R11], [R14], [R17], [R23], [R27], [R28], [R30]–[R32], [R34], [R36], [R38]–[R41], [R45]–[R47], [R50], [R51], [R54]–[R56], [R58], [R62], [R63], [R68], [R70], [R75], [R76], [R82], [R91]–[R93], [R102], [R103], [R109]–[R111], [R113], [R119], [R125]

Table A.3: Mappings for Primary Contribution Type

Organization Type	Papers
Aerospace	[R41]
Air Traffic Management Organization	[R35]
B2B Collaborations	[R60]
Business Network	[R90]
Businesses	[R19]
Collaborating Group of Enterprises	[R112]
Collaborative Network	[R44], [R77], [R82], [R117], [R118], [R120]
Collaborative Networked Organizations	[R52], [R79]
Collaborative Organization	[R122]
Companies	[R100]
Digital Ecosystem	[R56], [R91]
EMS	[R103]
Ecosystem	[R5], [R13], [R17], [R24], [R87]
Electricity Distribution	[R25]
Emergency Response Services	[R65], [R66], [R78]
Enterprise	[R12], [R16], [R57], [R59], [R83], [R94], [R96], [R97], [R105], [R106], [R111], [R119], [R121]
Extended Enterprise	[R21], [R49], [R95]
Firms	[R93]
Forest Products	[R67]
Government	[R1], [R2], [R7], [R9], [R14], [R23], [R36], [R37], [R39], [R51], [R54], [R58], [R61], [R75], [R76], [R80], [R81], [R98], [R99], [R102], [R107]–[R109], [R116], [R123], [R128], [R129]
Healthcare	[R11], [R27], [R28], [R50], [R68], [R125]–[R127]
Higher Education Institution	[R32], [R42]
Innovation Network	[R34]
Library	[R115]
Manufacturing	[R15], [R62]
Military Coalition	[R26], [R38]
Multi-Partner Network	[R6]
Nation State	[R33], [R84], [R85]
National Park	[R104]
Network Organization	[R71], [R124]
Networked Enterprise	[R29]
Partner Network	[R47]
Port Authority	[R113]
Port Cluster	[R114]
Public Protection and Disaster Relief	[R72], [R73]
Public Safety Network	[R101]
Public Sector	[R40]
Research Institution	[R8], [R89]
SME	[R3], [R4], [R10], [R46], [R55], [R88]
Strategic Alliances	[R110]
Telecommunication Companies	[R22]
Transport and Logistics	[R64]
Value Network	[R69], [R92]
Value Web	[R86]
Virtual Enterprise	[R30], [R31], [R43], [R53], [R63], [R70], [R74]
Virtual Enterprise Chain	[R18]
Virtual Organization	[R20], [R45], [R48]

Table A.4: Mappings for Organization Type

Motivations	Papers
Achieving Accountability	[R23]
Achieving Agility	[R15], [R43], [R53]
Achieving Collaboration	[R15], [R29], [R127]
Achieving Interoperability	[R2], [R10], [R17], [R33], [R53], [R58], [R61], [R72], [R73], [R98], [R101], [R119]
Achieving Operational Excellence Across Organizations	[R103]
Achieving Shared Goals	[R38]
Achieving Transparency	[R23], [R42], [R50], [R116]
Adapting to Business Partner's Demands	[R93], [R94]
Adapting to Changing Customer Demands	[R12], [R29], [R43], [R93], [R94]
Adapting to Changing Market Environment	[R3], [R5], [R18], [R19], [R22], [R43], [R45], [R46], [R48], [R53], [R63], [R69], [R87], [R94], [R122]
Adapting to Globalization	[R43], [R45]
Advancing e-Government Initiative	[R7], [R75], [R99]
Avoiding Data Redundancy	[R89]
Avoiding Technology Redundancy	[R1], [R42], [R89], [R117], [R118], [R121]
Creating new Opportunities	[R3], [R8], [R11], [R22]
Dealing with Challenges Requiring Collaboration	[R16], [R26], [R77], [R84], [R85], [R103], [R104], [R128]
Dealing with Complex Environment	[R5], [R18], [R19], [R24]
Dealing with Complex Supply Chain	[R16]
Dealing with Decentralization	[R97]
Dealing with Growth of Complex Systems	[R14]
Dealing with Increased Collaboration	[R26], [R39], [R114], [R119]
Dealing with Interdependence between Organizations	[R6], [R56], [R67], [R111]
Dealing with Limited Natural Resources	[R59]
Dealing with Limited Resources	[R3], [R4], [R8]
Diffusing Innovation	[R112]
Discovering Service Providers	[R16], [R83]
Emergence of Business Networks	[R6], [R17], [R55], [R91], [R97], [R124]
Emergence of Service Oriented Architecture	[R91]
Empowering Users	[R29]
Enabling Co-Evolution of Structures	[R122]
Enabling Collaboration	[R60], [R110]
Enabling Innovation	[R14], [R92]
Exploiting Data	[R50], [R63]
Facilitating Access to Services	[R33], [R61]
Facilitating Change	[R30]
Facilitating Integration	[R30], [R80], [R100], [R114], [R117], [R118], [R121], [R126], [R127]
Facilitating Interactions with Environment	[R1]
Facilitating Interoperability	[R78], [R121]
Facilitating Outsourcing	[R22]
Formalizing Collaboration	[R74]
Implementing External Policies	[R9], [R25], [R33], [R36], [R80], [R81], [R104]
Improving Adaptability	[R28]
Improving Agility	[R30]
Improving Alignment within and across Organizations	[R21], [R28], [R61], [R68], [R72], [R73], [R80], [R117], [R118], [R121], [R124]
Improving Collaboration	[R32], [R38], [R40], [R78], [R100], [R119], [R129]
Improving Competitiveness	[R45], [R47], [R48], [R53], [R92]
Improving Coordination	[R81], [R117]
Improving Cycle Time	[R23], [R72], [R73], [R121]
Improving Efficiency	[R18], [R32], [R43], [R80], [R88], [R113], [R114], [R116]
Improving Flexibility	[R7], [R29], [R46], [R56], [R128]
Improving Growth	[R92], [R93]
Improving IT Project Management	[R39], [R40]
Improving Integration	[R55], [R88]
Improving Interoperability	[R125], [R126]
Improving Knowledge Management	[R26], [R32], [R46], [R56], [R101]
Improving Knowledge Sharing	[R9], [R114]
Improving Performance	[R35], [R64], [R123]
Improving Productivity	[R29]
Improving Quality	[R23], [R25], [R33], [R50], [R61], [R72], [R73], [R80], [R107], [R117], [R118], [R127]
Improving Reaction Time to Market	[R46]–[R48], [R117], [R121]
Improving Speed of implementing Integration	[R88]
Internet Adoption	[R6], [R16], [R24], [R62], [R122]
Leveraging Opportunities	[R31]
Market Competition	[R4], [R70]
More Disasters Requiring Collaboration	[R2], [R72], [R73], [R78]
Operational Flexibility	[R69], [R83], [R97], [R103]
Operational Needs	[R33]
Outdated Systems	[R35]
Overcoming Failure of Past Attempts at Achieving Interoperability	[R13], [R51], [R61]
Overcoming Limitations of Traditional Approaches	[R94]
Performing Digital Transformation	[R13]
Protecting the Organization's Interests	[R28]
Providing Cross-Organizational Services	[R29], [R107], [R115]
Reacting to Adoption of E-Government	[R37]
Reacting to Increased Collaboration	[R70], [R74]
Reducing Cost	[R23], [R35], [R36], [R50], [R55], [R117], [R118], [R121], [R123], [R127]
Reducing Loss of Life	[R38]
Reducing Redundancy	[R6]
Reducing Risk when Collaborating	[R9], [R39], [R81], [R88], [R90], [R117], [R118], [R121]
Retaining Customers	[R63]
Serving a wide Variety of Demands	[R129]
Standardizing Processes	[R11], [R25], [R36], [R117], [R121]
Technological Progress	[R20], [R49], [R90], [R127], [R128]
Urgent Need	[R21]
Working towards Circular Economy	[R59]

Table A.5: Mappings for Motivations

Challenges	Papers
A Lot of Stakeholder Commitment Required	[R108]
Adapting to Dynamic Environment	[R62], [R108]
Adherence to „old“ Procedures	[R129]
Building Understanding of Current and Future Processes Business Rules Policies and Procedures	[R108]
Bureaucracy	[R98]
Challenges (Generic Term)	[R103]
Challenges in Technical Support	[R37]
Collaborating	[R76]
Collaboration is an Afterthought during Information System Design	[R67]
Conflicting Functionalities	[R37]
Conflicts around differing Security and Privacy Targets	[R37]
Coordination of Consolidation is an Afterthought	[R27]
Dealing with Complex Sociotechnical Interdependencies	[R27]
Dealing with Conflicts	[R58]
Dealing with Data Consistency Issues	[R62], [R125]
Dealing with Dynamic Governance Culture	[R8]
Dealing with Information Integrity	[R37]
Dealing with Legacy System Architecture	[R3], [R93]
Dealing with Legal Barriers	[R33], [R111]
Dealing with Limited Resources	[R37]
Dealing with Oversimplified Sequential Maturity Models	[R58]
Dealing with Poor Existing Operational Practices	[R129]
Dealing with Privacy	[R37], [R68], [R90], [R129]
Dealing with Social Barriers	[R111]
Dealing with Standardized Interfaces	[R68]
Dealing with System Security	[R68], [R90]
Dealing with Technological Heterogeneity	[R13], [R39]
Dealing with Unclear Jurisdiction	[R58], [R129]
Dealing with Unclear Responsibilities and Roles	[R39], [R54], [R58], [R61], [R65], [R78]
Dealing with Variety of Culture	[R33], [R39], [R78]
Dealing with Variety of Goals	[R34], [R39], [R58]
Dealing with Varying Quality of Data	[R113]
Dealing with a Changing Business Environment	[R20]
Dealing with the Complexity of Ecosystems	[R13]
Dealing with the Need of a Focal Point for Efforts	[R40]
Dealing with the Variety of Available Frameworks	[R38]
Defining Who Owns Strategy	[R41]
Differences in Ethics and Personal Values	[R37]
Diversity of Management Styles	[R8]
Ensuring Separation of Powers	[R102]
Fear of Losing Competitive Advantage	[R41]
Gap in Flexibility Between Modeling and Visualization	[R113]
Gaps between Framework and Implementation	[R98]
Hierarchies	[R78]
Implementation as a Short-Term Project	[R54]
Implementing Change in the Organization	[R22]
Implementing EA Already Proved Too Challenging	[R24]
Implementing Performance Measures	[R8]
Implementing Semantic Interoperability	[R7], [R62], [R89]
Incompetent Staff	[R129]
Insufficient Communication	[R76]
Insufficient Consideration of Social Issues	[R71]
Insufficient Cross-Organizational Governance	[R54], [R71]
Insufficient Data Protection	[R54]
Insufficient EA-Related Knowledge	[R93]
Insufficient Enforcement of Compliance	[R98]
Insufficient Financial Governance	[R54]
Insufficient Integration	[R78]
Insufficient Transparency between Partners	[R111]
Integration Challenges	[R36], [R93]
Integration Challenging Due to Nature of Business	[R64]
Issues when Communicating ROI for Information Security	[R37]
Issues with Organization’s Structure	[R37]
Issues with Project Management	[R37]
Lack of Cleary Defined Goals	[R34], [R54], [R58], [R76]
Lack of Funding	[R33]
Lack of Governance	[R28]
Lack of Guidelines	[R33], [R64], [R78]
Lack of Innovation in Design	[R61]
Lack of Long-Term Perspective in Project Valuation	[R93]
Lack of Participation by Stakeholders	[R37]
Lack of Participation of Members	[R61]
Lack of Security Awareness Standards	[R37]
Lack of Security Vision and Policy	[R37]
Lack of Skilled Staff	[R33]
Lack of Structure	[R28]
Lack of Top Management Support	[R33], [R37], [R93]
Lack of Trust	[R41], [R78], [R129]
Missing Lifecycle Perspective	[R78]
No Sharing of Solutions Yet	[R113]
Organizational Issues	[R37]
Organizational Politics	[R33], [R37], [R78]
Overcoming Challenges Specific to Governments	[R102]
Social Issues	[R37]
Structural Mismatches between EA and Organization	[R97]
Technical Issues	[R37]
Time-Consuming Effort	[R108], [R129]
Trust Issues	[R90]
Use of Promotion Language / Marketing Messages	[R37]
Working with Inexperienced Stakeholders	[R76]
Working with Many Actors	[R13]

Table A.6: Mappings for Challenges

Outcomes	Papers
Application of EA Methods	[R22], [R79]
Building Blocks for Processes	[R1]
Centralization	[R102]
Collaboration Platform	[R20], [R113]
Collaborative Business Process	[R21]
Cross-Organizational Business Processes	[R93]
Data Exchange Platform	[R11]
Decline in Efficiency	[R93]
Deployment of System in Other Organization	[R89], [R103], [R125], [R129]
Documentation of Data Sources	[R36]
Early Detection of Problems in Project	[R76]
Effective Requirements Elicitation	[R67]
Enablement of Governance	[R14]
Establishment of Interoperability Collaboration	[R33]
Establishment of Partner Network	[R48]
Faster Development and Acceptation of e-Government	[R1]
Federated Governance	[R126]
Federated Identity Management	[R7]
Flexible IT Architecture can Increase Value of Alliances	[R110]
IT-Based Collaboration	[R101]
Improved Collaboration	[R67]
Improved Collaboration with Actual Stakeholders Contributing their Expertise	[R66]
Improved Efficiency	[R67], [R90]
Improved Goal Definitions	[R66]
Improved Information Integrity	[R67]
Improved Insights into Organization	[R21], [R67]
Improved Integration	[R67]
Improved Knowledge Sharing	[R113]
Improved Performance Measures	[R66]
Increased Complexity	[R37]
Increased Cycle Time	[R93]
Integrated View through EA Modeling	[R48]
Interorganizational Information System	[R51], [R62], [R89], [R90], [R101], [R103], [R125], [R129]
Measurable CN Performance Improvements	[R25]
Measurable Performance Improvements	[R36]
Migration of Legacy Systems into Integrated Solutions	[R36]
National EA Program	[R33]
New Opportunities around Shared Data	[R11]
Organizational Change	[R14]
Service Catalogue	[R42], [R95], [R114]
Shared Technology Reference Architecture	[R109]
Software Bridge	[R10], [R126]
Standardization	[R1], [R10], [R22], [R67], [R89], [R93], [R102]
Support of Innovation	[R14]
Synergy Effects	[R95]
System Integration	[R10]
Using EA for Coordination	[R90]

Table A.7: Mappings for Outcomes

A.2 MapMaker Screenshots

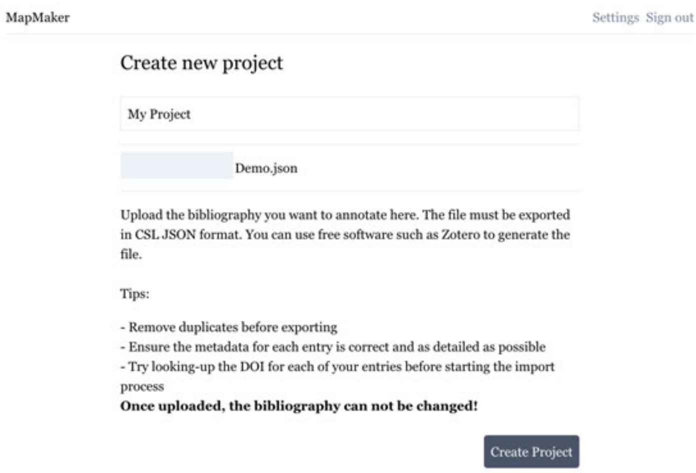

Figure A.1: Project Creation Screen (Button Removed)

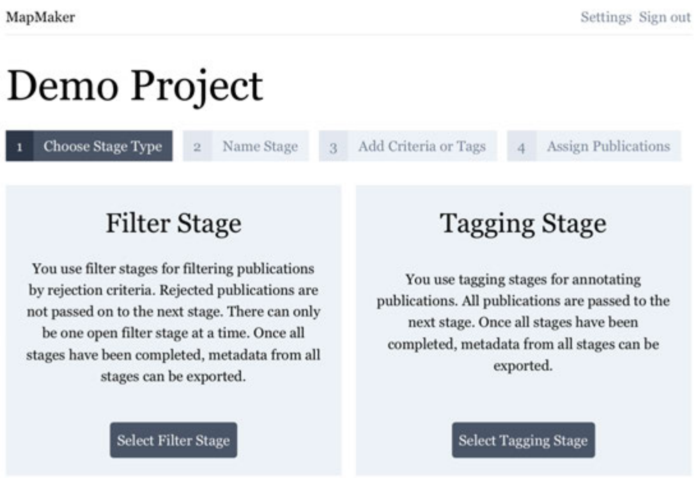

Figure A.2: Stage Creation: Choice Between Filter Stage and Tagging Stage During Stage Creation

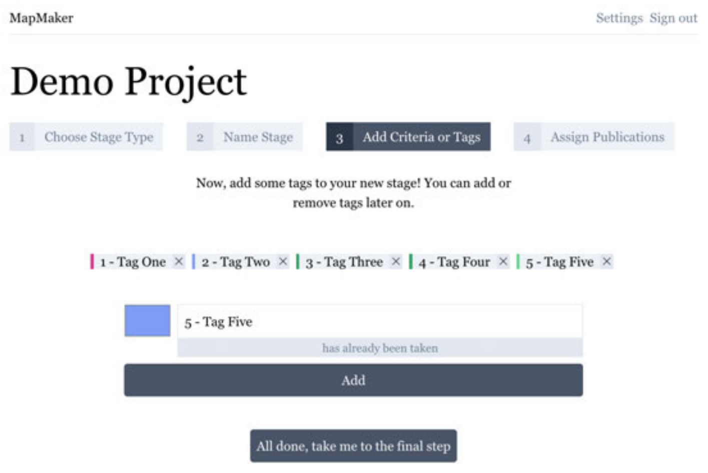

Figure A.3: Stage Creation: Adding Tags to a Stage

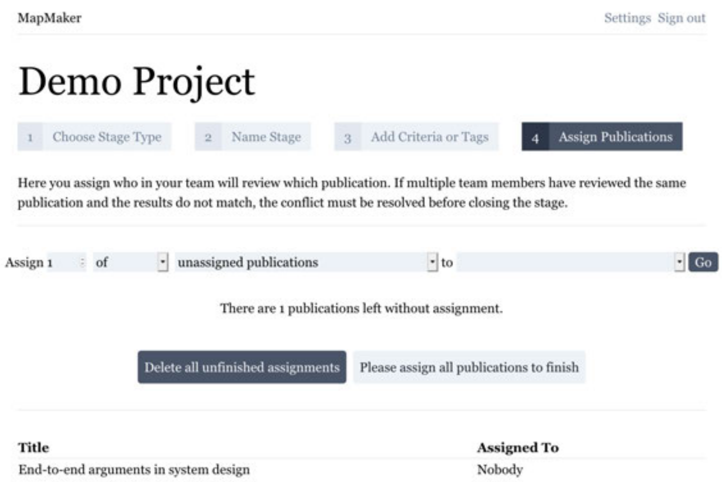

Figure A.4: Stage Creation: Assigning Publications for Review to Team Members (Email Address Removed)

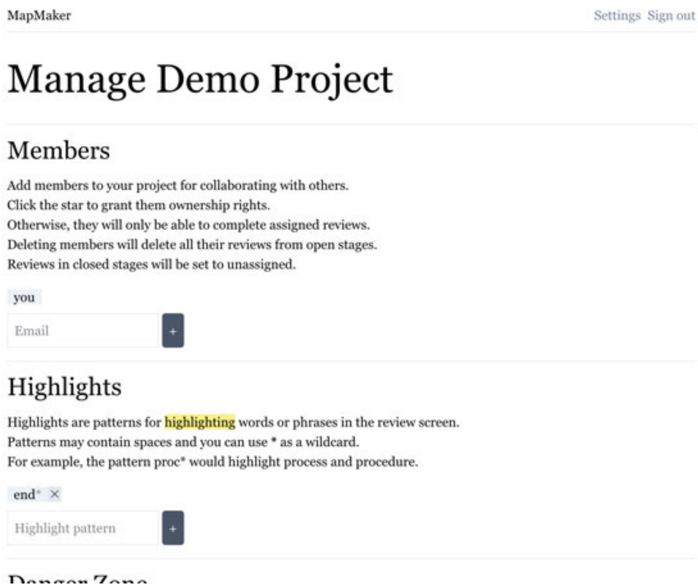

Figure A.5: Highlight Pattern and Member Management

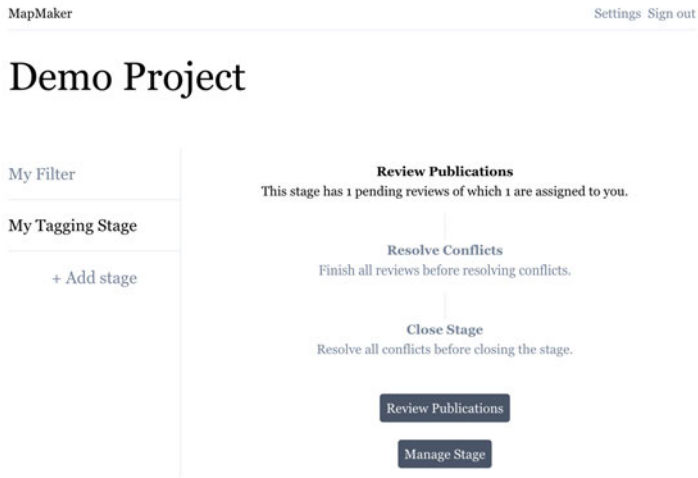

Figure A.6: Project Overview

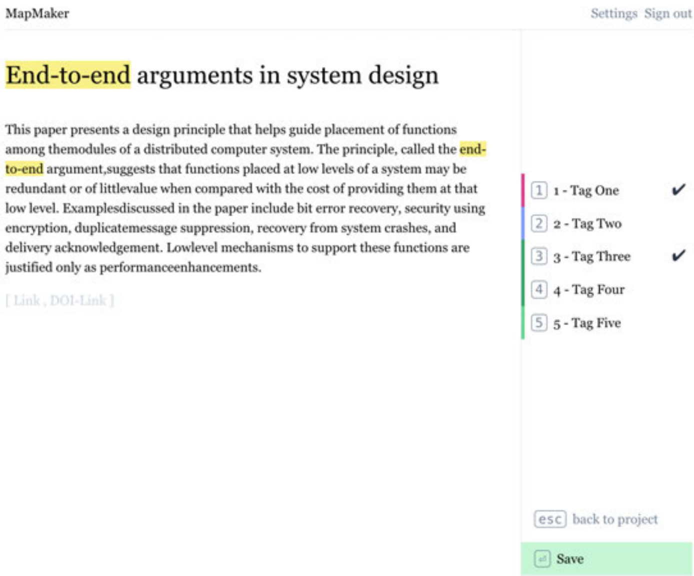

Figure A.7: Review Screen with Keyboard Shortcuts

A.3 Source Code

A.3.1 AISeL Import Script

```python
#
# This script tries to salvage the malformatted bibliography returned by AISeL
#
# By default the bibliography entries do not all contain the %0 attribute which
# signifies the document type. This breaks the import into Zotero.
#
# This script assigns either the "Journal Paper" or "Conference Paper" type
# based on a simple heuristic.
#

with open('aisel.txt') as f:
    with open('aisel_converted.txt', 'w') as out:
        # Split into one chunk per individual publication
        chunks = f.read().split('\n\n')

        for chunk in chunks:
            # Build map of attributes
            # If an attribute occurs multiple times (e.g. author), it is stored as a list of strings
            attributes = {}

            # Each line corresponds to an attribute, iterate over those
            for line in chunk.split('\n'):

                # Attribute keys and values are separated by
                # the first space in the line
                attrs = line.split(' ', 1)

                # If we have a valid pair, add it to map
                if len(attrs) == 2:
                    if attrs[0] in attributes:
                        # Add to value list if it already exists
                        attributes[attrs[0]].append(attrs[1])
                    else:
                        # Make a new list with one element for the attribute
                        attributes[attrs[0]] = [attrs[1]]
                elif attrs != ['']:
                    # We hit an invalid non-zero string!
                    print("Error - invalid attributes: " + str(attrs))

            # The heuristic for conference papers is that the publication title
            # contains Proceedings or (Conference but not Paper)
            if '%B' in attributes and (('Proceedings' in attributes['%B'][0]) or ('Conference' in attributes['%B'][0] and not 'Paper' in attributes['%B'][0])):
                # Apparently this is a conference paper
```

```
                attributes['%0'] = ['Conference Paper']
            else:
                # And this could be a journal article
                attributes['%0'] = ['Journal Article']

            # Write new attributes to converted file
            for key, value in attributes.items():
                # For the Zotero import %0 needs to come directly after %B
                if key == '%0':
                    continue

                if key == '%T':
                    out.write(f'%T {value[0]}\n%0 {attributes["%0"][0]}\n')
                else:
                    # Just write out all the other attributes
                    for list_item in value:
                        out.write(f'{key} {list_item}\n')

            out.write('\n\n')
```

A.3.2 Deduplication Script

```
#
# Check a CSV export for duplicate titles
#

import collections
import csv
import re

title_dict = {}
num_publications = 0

# Open the export
with open('Search.csv') as csv_file:
    reader = csv.DictReader(csv_file)

    for row in reader:
        num_publications += 1

        # Take all letters of the lowercase title
        short_title = re.sub(r'[^a-z]+', '', row['Title'].lower())

        # Add-up all occurences of the shortened title
        if short_title in title_dict:
            title_dict[short_title] += 1
        else:
            title_dict[short_title] = 1

# Store shortened titles with more than one occurence
duplicate_items = {}

for (title, count) in title_dict.items():
    if count > 1:
```

```
            duplicate_items[title] = count

# Sort by title
ordered_titles = collections.OrderedDict(sorted(duplicate_items.items()))

# Print
num_duplicates = sum(duplicate_items.values()) -
    len(duplicate_items.values())
print("There are %d duplicates in %d entries.\nAfter deduplication %d
    entries are left." % (len(ordered_titles), num_publications,
    num_publications - num_duplicates))
for (title, count) in ordered_titles.items():
    print("%d %s" % (count, title))
```

A.3.3 Results Difference Script

```
#
# This script compares search results obtained from
# literature databases. This allows to update the results.
# Result files are put into a new/old directory.
# The script outputs which titles are present in which set.
#

import re

def shorten(s):
    # Shorten a title by converting to lower case and removing spaces
    return re.sub(r'[^a-z]+', '', s.lower())

def process_file(path, extractor):
    # Take a result file and extraction function and build
    # a set of titles found.

    # Base set
    result = set()

    # Read file line by line
    with open(path) as f:
        # Split into lines
        lines = f.read().split('\n')

        # Count all entries including duplicates
        total_entries = 0

        for line in lines:
            # Try to extract a title from the line
            # If no title was found, return None
            title = extractor(line)

            if title is not None:
                total_entries += 1
                if title in result:
                    # Notify on duplicate title
                    print(f"Duplicate title within '{path}': {line}")
```

```
                else:
                    result.add(title)

        return (total_entries, result)

def compare(old, new, extractor):
    # Compare the entries found in two files
    (total_old, old_entries) = process_file(old, extractor)
    (total_new, new_entries) = process_file(new, extractor)

    old_not_in_new = old_entries.difference(new_entries)
    new_not_in_old = new_entries.difference(old_entries)

    print(f"Comparing old list {old} to new list {new}")
    print(f"There are {total_old} old entries and {total_new} new entries (difference of {abs(total_old-total_new)}). {len(old_not_in_new)} entries are in the old set but could not be found in the new one. {len(new_not_in_old)} entries were added in the new list.")
    print(f"Entries missing in new results: {old_not_in_new}\n")
    print(f"New results: {new_not_in_old}\n\n")

#
# ACM
#

def extract_acm(line):
    # Title extraction function for ACM
    if line.replace(" ", "").startswith('title={'):
        return shorten(line.replace(" ", "").replace('title={', ''))
    else:
        return None

compare('old/acm.bib', 'new/acm.bib', extract_acm)

#
# AISeL
#

def extract_aisel(line):
    # Title extraction function for AISeL
    if line.startswith('%T '):
        return shorten(line.replace('%T ', ''))
    else:
        return None

compare('old/aisel.txt', 'new/aisel.txt', extract_aisel)

#
# IEEE
#

def extract_ieee(line):
    # Title extraction function for IEEE
    if line.startswith('TI  - '):
        return shorten(line.replace('TI  - ', ''))
```

```python
    else:
        return None

compare('old/ieee.ris', 'new/ieee.ris', extract_ieee)


#
# Scopus
#

def extract_scopus(line):
    # Title extraction function for Scopus
    if line.replace(" ", "").startswith('title={'):
        return shorten(line.replace(" ", "").replace('title={', ''))
    else:
        return None

compare('old/scopus.bib', 'new/scopus.bib', extract_scopus)
```

Declaration

I confirm that this is my own work and that I documented all sources, material and contributions of others.

Hamburg, September 24, 2020

[redacted]

Sebastian Wagner