

Adaptable Enterprise Business and Operation Architecture

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Acknowledgment

I want to express my gratitude to my supervisor, Prof.Yamamoto Shuichiro, whose patient guidance, continuous encouragement, and valuable expertise added considerably to my research experience. His passion, enthusiasm, and positive attitude towards his work motivated me to follow his positive perspective. This work and my research accomplishments were only possible because of the great support I had from Prof.Yamamoto, who cared about my progress and offered his advice on various occasions, including general academic issues.

A special thanks go out to Assoc.Prof.Morisaki Shuji and Prof.Edahiro Masato for their valuable comments and recommendations on this dissertation and for bearing with my questions during the review period.

In my journey towards this degree, I was blessed to receive insightful knowledge and experience from Dr.Yoshimasa Masuda. He actively involved me in many arranged meetings for enterprise architecture case studies by exchanging ideas and sharing his understanding of the latest adaptive EA trends.

I am also thankful for, Mr.Kobayashi Nobuhide, from DENSO Create Inc for his significant contribution and his active communication during a research experiment. He generously offered his knowledge and input since the beginning of this research work.

Last but not least, I want to thank my family for the love and unwavering support they have provided me throughout my life and, in particular, my younger sister, Amjad, for her interest in my latest work and assistance in editing this dissertation.

Abstract

Adaptable Enterprise Business and Operation Architecture By Nada Alolayan

In this day and age, the world's most valuable commodity is data. Digital transformation is connecting the world, and the massive amount of data collected has excellent potential to improve many aspects of modern endeavors. Today's organizations are information-driven; they are faced with many challenges such as rapid change in technology and constantly growing competition, but the main challenge will always be to align and integrate shared information strategies to a common business and technology context.

In this dissertation, we conducted a study on state-of-the-art enterprise architecture management frameworks (EAMF) to create our definition of an adaptive EA and its key features and presented an evaluation of EAMF from the point of view of digital transformation. To close the gap between business and IT, and to achieve integration with emerging services, we need to employ enterprise architecture management (EAM). However, the question still arises on how to achieve adaptability and which enterprise management system is suitable for the organization each time a change is needed, and an architecture process is evoked. The evaluation is useful for choosing a suitable EAMF for digital transformation.

In our second study, we addressed the business and operation architecture by investigating the change management process of the Enterprise Architecture (EA). We used TOGAF and its modeling language ArchiMate as the EAM framework of choice to improve adaptability. We hypothesized that employing specific standards and documentations could aid the change management process and improve the integrity of the change at every stage. Our choice was the concept of operation document (ConOps) because it addressed and described the change in three distinctive sections: current state of the system, justifications for change, and the concept for the proposed system. We pointed out that these sections contribute to the motivation extension pattern of the ArchiMate modeling language, and the higher levels of the architecture development method (ADM) of TOGAF. However, since ConOps standard documentation does not have a specific development method, we proposed a method to create ConOps using ArchiMate to benefit the adaptive EA.

Considering the importance of the healthcare industry and the emerging technologies affecting e-health systems and the need to review a case study of an enterprise system, we found it crucial to provide the means to review and improve the planning and organization of e-health systems, especially in the early stages of design. Healthcare systems are classified as enterprise information systems because of their size and complexity. Therefore, the design of frameworks and enterprise architecture can be used to reduce complexity and increase their adaptability and resilience. In this dissertation, we reviewed the latest digitization report of the Indian health care system by the Mckinsey global institute, and we were able to assess the completeness of the requirements and provide suggestions to aid the transition process.

List of Publications based on this research

I. Journal Papers

- Nada Olayan, Shuji Morisaki, Shuichiro Yamamoto, “ARM Analysis Case Study: Digital Indian Health Care System Business Model and Review”. *Acta Scientific Medical Sciences* 3.9 (2019): 77-85
- Nada Olayan, Nobuhide Kobayash, Shuji Morisaki, Shuichiro Yamamoto, “A Proposal on a Method of ArchiMate based Concept of Operation (ConOps)”, *International Journal of Computer Science and Information Security (IJCSIS)*, Vol.16, No. 1, pp.132-138, January 2018

II. International Conference Papers

- Nada Olayan, Shuichiro Yamamoto, “System Thinking Approach to Create CONOPS for the Adaptive Enterprise Architecture”, pp. 37-39, *proc. on Asia Pacific Conference on Information Management 2016*, Vietnam National University Press, Hanoi, 2016.
- Nada Olayan, Shuichiro Yamamoto, “Integration of ConOps and TOGAF ADM to benefit adaptive enterprise architecture”, *11th IADIS International Conference Information Systems 2018*, 255-259, April.14-16 Lisbon, 2018.
- Nada Olayan, Shuji Morisaki, Shuichiro Yamamoto, “Adaptive EA Evaluation-Digital Transformation Point of View”. *Journal Of Computers(JCP, ISSN: 1796-203X)*(in press), *ICCSIT 2019*, Dec.18-20 Barcelona, 2019.

III.collaborative work:

- Shuichiro Yamamoto, Nada Ibrahim Olayan, Shuji Morisaki, “Another Look at Enterprise Architecture Framework”, *Journal of Business Theory and Practice*, Vol 6, No 2, pp.172-183, 2018, DOI: <http://dx.doi.org/10.22158/jbtp.v6n2p172>.

- Shuichiro Yamamoto, Nada Ibrahim Olayan, Junkyo Fujieda, “ e-Healthcare Service Design using Model Based Jobs Theory”, InMed2018, Intelligent Interactive Multimedia Systems and Services, Proceedings of 2018 Conference, pp. 198-207, 2018.
- Shuichiro Yamamoto, Nada Ibrahim Olayan ,Shuji Morisaki, “Using ArchiMate to Design e-Health Business Models”. Acta Scientific Medical Sciences 2.7 (2018): 18-26
- Yamamoto, S., Olayan, N.I., Morisaki, S,” Analyzing e-Health business models using actor relationship matrix. Acta Sci. Med. Sci. 3(3), 105–111 (2019)

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Chapter 1

Introduction

1.1 Background

IT system technologies such as adaptive software technologies, cloud computing, and the emerging Internet of things (IoT) have become effective tools to collect data. This process is possible with the emerging field of digital transformation, assisting in handling new challenges and facilitating the full potential of the IoT and cloud technology computing services [1],[2].

With these tools, the data are made into a valuable asset to businesses via business intelligence and data analytics. However, as organizations compete for this valuable asset, enterprises are facing more challenges in aligning business with IT, which is the main goal of adaptive enterprises.

“Architecture in a broad sense, is the synergy of art and science in designing complex structures, such that functionality and complexity are controlled. The notion of architecture is used in a wide range of domains, from town planning to building and construction, and from computer hardware to information systems, each being characterized by the types of ‘structures’ or ‘systems’ being designed.”

— Lankhorst,2009, pp.ix

Architecture is a tool that helps analysts to visualize parts, connections, and the whole. Enterprise architecture (EA) was the result of enterprise modeling, in which the models and theories were applied to single systems. John Zachman, in the mid-80s, marked the beginning of the enterprise architecture era and developed a proposal on concepts of the “information systems architecture framework.” This framework took the analysis to a higher level to address the enterprise as a whole rather than addressing single systems [3],[4]. The rapid development of several EA frameworks has been recorded, for example, the federal enterprise architecture framework (FEAF) [5], the open group architecture framework (TOGAF) [6], and department of defense architecture framework (DODAF) [7].

However, the initial concern of enterprises for EA’s was the system complexity and its poor business alignment. The main concern, especially for large organizations, is that these frameworks could increase the cost of operations and offer less value. Currently, EA has changed towards sustainability and competitiveness. On this account, the quality of the architecture depends on its ability to achieve its target goals and follow business requirements. In this way, the goals to achieve the “change process” and requirements would be easy. Such quality measures can facilitate effective data collection using analytical models and tools to support strategy and operations efficiently.

Adaptation, in general, is the capacity for a system to respond and alter its state in response to changes within its environment. In this thesis, we refer to “adaptiveness,” and the adjective “adaptive” or “agile.” Adaptivity, in the same sense, means to serve or be able to adapt, showing, or contributing to adaptation.

1.2 Research motivation

This thesis focuses on the changes in operations and enterprise business models. Despite the success of many approaches to improve adaptive EA, opportunities still exist for the enhancement of the business process management and the successful application of the adaptive enterprise architecture.

An adaptive or agile enterprise is defined as an organization that can keep up with the fast-changing environment [8]. This organization optimizes information technology resources to compete effectively in the competitive business environment with the goal of achieving differentiation and increasing profits. Although no single definition exists for the adaptive enterprise, its characteristics can be observed from major literature focusing on the adaptive and agile enterprise (literature discussed in chapter 2 of this thesis). Looking at different strategies adopted by different organizations could also help to understand the adaptive enterprise. These strategies are similar in concept but different in their end goal. Each organization has a strategy to preserve its adaptive strategy. For example, HP's adaptive enterprise strategy is to synchronize business and IT to take full advantage of the change process [9]. However, the guidelines to integrate or complement EA management approaches in achieving specified adaptable EA are scarce.

Moreover, achieving successful adaptive enterprise is not an easy task as the dynamic competitive business environments surrounding organizations choosing adaptive models are growing. The practice of the EA field offers many benefits as it provides frameworks and methods that aid organizations to streamline adaptiveness [10],[11]. Furthermore, EA serves as a well-defined practice that assists in carrying out the enterprise analysis, planning, design, and implementation using an effective, comprehensive execution approach. Those complex dynamic enterprises require an adaptive holistic architecture capability [12],[13]. Thus, we need to employ enterprise architecture management (EAM) to close the gap between business and IT and

integrate it with emerging services. However, a question arises on how to achieve adaptability, and which enterprise management system is suitable for the organization each time a change is needed, and an architectural process is evoked. EAM is a function aligned with the evolution of the EA [14]. Various EA frameworks, tools, and approaches are available for organizations to select for management framework. The problems to be addressed and objectives to achieve influence the choice of EA management approach [15].

1.3 Research objective

The objective of this study is to investigate the adaptive EA framework from the point of view of adaptable enterprise business architecture and operation. Certain natural language documents could be a factor in improving adaptive EA. Based on this research, the main hypothesis is developed, revealing that the Concept of Operation document (ConOps) is the ideal document for improving adaptive EA from the point of view of adaptable enterprise business architecture and operation. The ConOps also describes the characteristics of the existing and proposed systems; its goal is to communicate qualitative and quantitative characteristics of the systems to all the stakeholders, which shows that ArchiMate could aid in creating a ConOps document.

We also assume that we can improve various concepts of the document to identify operational needs using ArchiMate concepts and viewpoints. Analysis of previous studies shows the shortcomings of the ConOps document, showing that it has still not been used to its fullest. As the intent of ConOps is to describe the system capability, it is usually implemented after the system is matured or delivered although it is supposed to be the basis of the new system [16]. Many factors are responsible for the under utilization of ConOps.

Lack of a method to carry out the analysis and acquire the content of the docu-

ment is one of the factors. The IEEE standard offers guidelines for the content and format development of a document, but no exact technique is cited [17]. In the system engineering guideline for Concept of Operation web page, MITRE Corporation noted that “Each organization that uses this guide should develop a set of practices and procedures to provide detailed guidance for preparing and updating ConOps documents” [18].

1.4 Research questions and hypothesis

Main questions guiding this research are formulated as follows:

- RQ1: Why is the ConOps standard a suitable choice for improving adaptive EA in this research? (Chapter 3)
- RQ2: How can we utilize ConOps to benefit the EA? (Chapter 3 and Chapter 4)

Our main hypothesis is that the Concept of Operation document (ConOps) is the ideal document to serve as the basis for our contribution to improving adaptive EA from the point of view of business and operation architecture.

1.5 Research approach

To realize adaptive EA from the point of view of adaptable enterprise business and operation architecture, we must consider the key aspects of enterprise business and operation architecture. The research follows the scientific approach:

1. To understand adaptive EA, we have to create our own definition for it. The definition includes general characteristics (key features) of the adaptive EA and the categories and elements of the chosen point of view or the point of view of

interest (digital transformation in our case). We first review and evaluate the selected state-of-the-art adaptive enterprise architecture management frameworks (AEAMF) to characterize and specify our definition for adaptive EA (Ch.2).

2. To improve AEA, we conducted exploratory research and detected room for improvement in the EA level context of adaptability and decided to use ConOps to benefit the AEA in the strategic level (high-level ConOps system view) and the system level of the EA (ConOps operational view)(Ch.3).
3. Analyze and establish connections between ConOps and TOGAF and its modeling language ArchiMate (Ch.3,Ch.4).

1.6 Research contribution

In this section, we discuss the contribution of this research.

In our efforts to create an adaptive EA definition, we carried out a thorough evaluation of our selected enterprise architecture management frameworks. Resulting evaluation could assist considerably in the process of choosing an appropriate AEAMF.

In adaptive EA, the business requirements keep changing, and the architecture ought to respond to these changes accordingly. On this account, we focused on one of the most important key aspects to improve the adaptiveness of EA, which is the “requirements management process.” We were then able to examine the role of the motivation extension of ArchiMate [19] and its relation to the adaptiveness of the EA [20],[21]; we concluded that there is a strong relationship between the two.

The IEEE standard 1362-1998 for the definition of system concept of operation (ConOps) [17] document is an essential component for understanding any system clearly in early stages and for guiding a better change process from current state to the desired state. As we observed the strong connection between system success and

early identification of users' needs, we decided to use ConOps to improve the adaptive EA.

Based on our research, we found out that the ConOps is the ideal document to base our research for so many viable reasons. ConOps could be the right candidate because it supports the architectural transition and solves the business problem by identifying changes within the EA and its environment to meet the organizations changing business requirements.

In this study, we also present a basic meta-model based on the IEEE 1362-1998 ConOps standard and suggest an integration of TOGAF ADM iteration cycles and ConOps elements.

Creating a ConOps document could be challenging as there is no exact technique to collect and analyze data. For this reason, we suggested using ArchiMate as a tool for analysis and communication to create ConOps and vice versa. We also presented a method to create ConOps based on ArchiMate. To connect ConOps and ArchiMate properly, we presented a mapping table between the concepts of ArchiMate and ConOps clauses based on the ontology definition. Moreover, we asserted our claim by presenting an experiment to prove that using ArchiMate to represent ConOps promotes understandability by measuring the changes in the level of accuracy and difficulty. Measuring understandability levels determined that using ArchiMate to represent ConOps is of significant value. We also presented a case study for using ArchiMate to create ConOps clauses for a "Man-hour management system." The process of creating ConOps from ArchiMate was efficient and resulted in a good problem definition and analysis with straightforward communication and less ambiguous concepts and definitions of relations.

In our research on business and operation architecture, we recognized the need to assess business requirements; for this reason, we chose to review a case study of an enterprise system. Because health care information systems could be classified as

enterprise information systems for their size and complexity and because we recognize the need to address healthcare systems and e-health services as one of the most critical sectors in the information systems, we chose to review and model the “Digital Indian Health Care System,” using ARM and ArchiMate. Given the importance of the health care industry and the emerging technologies for e-health systems, it is crucial to review and improve the system planning and organization, especially in its early stages of design. In our review, we used the actor relationship matrix (ARM) based on a previous collaborative research [22],[23], this offers a great potential to recognize crucial missing requirements in the system using the stakeholders (actors) interaction to recognize the important business model elements: Actors, Data, Actions, Values, and Goals known as the ASOMG. It is also useful to model the elements using the ARM pattern in ArchiMate to analyze the missing requirements further. We were able to review the case successfully and construct ArchiMate models and offer suggestions for system improvement.

1.7 Summary of the remaining chapters of this thesis

Chapter 2: A comparative review of adaptive enterprise architecture-digital transformation point of view-

In this chapter, we review and evaluate the state-of-the-art EA frameworks and features to create our characterization of adaptive EA. We also objectively evaluate EAF adaptive concept items based on our definition of adaptive EA. The model, ability, process, governance, and ecosystem were extracted as classification items for comparing adaptive EAFs from the viewpoint of digital transformation. We review and evaluate the selected state-of-the-art enterprise architecture management frameworks against those classifications, and we suggest that our evaluation using the selected

frameworks and features can help to choose an appropriate AEAMF.

Chapter 3: The role of ConOps in improving adaptive EA

In this chapter, we examine the role of the motivation extension of the ArchiMate Architectural modeling language and its relation to the adaptiveness of the EA. Then, we explain why ConOps is the ideal document to be leveraged for the adaptive EA improvement. We work on integrating ConOps to enterprise architecture using ArchiMate Architectural modeling language as a common representation between both. To integrate ConOps as a textual document in EA, we propose a basic ConOps meta-model to base the alignment on. In addition to the ConOps meta-model, we present a description of the integration of TOGAF and ConOps elements and suggest an integrated table for TOGAF ADM iteration cycles and ConOps elements based on ConOps analysis.

Chapter 4: A Proposal for a Method of ArchiMate based ConOps

After presenting the relationship between ConOps and the adaptive EA, we present a proposal for a method to create ConOps based on ArchiMate and vice versa. To investigate the significance of our approach, we perform an experiment to examine the changes in the level of accuracy and difficulty. We also present a case study to create ArchiMate then ConOps clauses for the “Man-hour management system.”

Chapter 5: Healthcare ARM analysis case study

In this chapter, we review the Indian health care system report using ARM as a case study and analyze the system by applying the ARM to assess the completeness of the requirements. We also produced an ArchiMate model of the ARM for the requirements assessment and proposed some important system design enhancements and the technologies associated with addressing some of the related problems in the healthcare system.

Chapter 2

A Comparative Review of Adaptive Enterprise Architecture (digital transformation point of view)

2.1 Introduction

As discussed in section 2.1, complex dynamic enterprises require an adaptive holistic architecture capability [12],[13]. Thus, we need to employ enterprise architecture management (EAM) to close the gap between business and IT and integrate it with emerging services. However, a question arises on how to achieve adaptability, and which enterprise management system is suitable for the organization each time a change is needed, and an architectural process is evoked.

EAM is a function aligned with the evolution of the EA [14]. Various EA frameworks, tools, and approaches are available for organizations to select from management frameworks. The problems to be addressed and objectives to achieve influence

the choice of EA management approach [15]. Dealing with adaptive EA is not covered adequately in research even with the existence of prominent well-defined EA frameworks such as TOGAF [6], there is a need to explore and evaluate other management methods to choose, combine and build an appropriate adaptive enterprise architecture suitable for each system. One of the most important references for adaptive enterprise architecture description is the work of Yu [11]; Yu points out that even though TOGAF provides guidelines for major architectural changes, those guidelines still do not address the adaptations in other types of time cycles.

Enterprise architecture management frameworks (EAMF) are needed for the development and management of adaptive EA. However, for a successful alignment between IT and business, we should not only seek adaptability. EA management as a governing instrument must also confirm consistency, efficiency, compliance, and stability throughout the process [24][15].

In section 2.2, we introduce an overview of the selected state-of-the-art EAMF and a short discussion of the rationale and reasoning behind our selection. In the same section, we propose key features of prominent adaptive EA management methods then present a characterization of Enterprise architecture frameworks in terms of the key features. In section 2.3, we evaluate the selected EAMF from the digital transformation point of view. Section 2.4 presents a discussion and related work for section 2.3. Finally, section 2.5 contains the chapter summary.

2.2 Background

In this section, we introduce an overview of the selected state-of-the-art EA management frameworks. The overview will introduce each framework and discuss the rationale and reasoning behind our selection.

The Open Group Architecture Framework (TOGAF)

TOGAF by the Open Group[6] is one of the prominent most cited frameworks which offers a standardized approach with a specific method and resources for EA management, design, planning, and a method for visualization. The vital characteristic of the TOGAF framework and primary contribution to EA management is its architecture development method (ADM), which guides major architectural changes. This “architecture change management” is used to monitor the performance of the EA management process and contributes to the adaptability of the EA by monitoring the changes in the environment to decide whether or not to undergo a new improving architectural cycle or to change the framework and principles defined in the vision phase [29]. In their effort to support EA management, TOGAF also presents the core content meta-model showing core entity and relationships. TOGAF is not widely used and faced with criticism for being bulky and incomplete, but it is still one of the most comprehensive EA frameworks for so many reasons. One of the main reasons is its agreement with other EA management approaches by distinguishing different architecture domains and serving as a blueprint.

Adaptive Cloud Enterprise Architecture (ACEA)

To address the lack of agility in TOGAF and the need for agile EA capability, the “Adaptive cloud enterprise architecture” was introduced by Gill [30],[10] to avoid risks concerning the adoption of cloud technology for any organization [31]. The adaptive cloud enterprise architecture is a service-oriented holistic and strategic approach deliberating the Gill framework and the adaptive enterprise service system (AESS) meta-model. The Gill framework is a meta-framework with the life cycle management approach ADOMS (Adapting, Defining, Operating, Managing, and Supporting). The framework is organized in an outer and an inner layer with the external layer consisting of assessment, context, rationalization, realization, and un-realization. The outer layer presents the adapting capability of the framework, while the inner layer

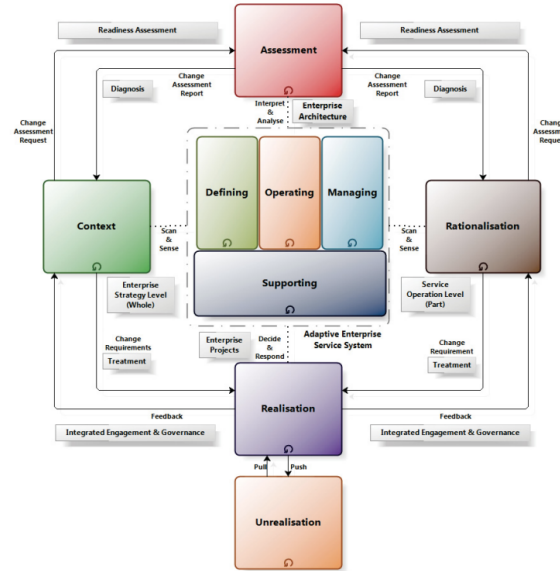


Figure 2.1: Adaptive enterprise architecture framework (The Gill framework) form [10].

consists of the capabilities of defining, operation, managing, and supporting, as shown in Figure 2.1.

The Open Group Architecture Framework (TOGAF) for EA management and the “Adaptive cloud enterprise architecture” based on the Gill framework [10] (framework based on TOGAF) are excellent candidates to incorporate new services from technology, achieve proper integration of business process, support change management and guide development for transformation.

Enterprise Service Architecture Reference Cube (ESARC)

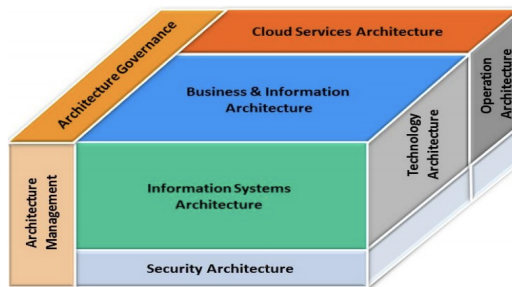


Figure 2.2: Enterprise services architecture reference cube from [24].

The ESARC by Zimmermann et al.[24] originates from state-of-the-art archi-

itecture frameworks. It extends the enterprise architecture management to service-oriented digital enterprise architecture. ESARC groups eight important architectural domains to provide a holistic classification model, as shown in Figure 2.2. The holistic classification supports the process of optimization, quality evaluation, and examination of service-oriented architectures coherently. To achieve architecture evaluation and optimization of enterprise and software architectures, the ESARC model presented is applied in a repeated cycle in the dynamic enterprise architecture environments to support the transformation of internet-of-things (IoT) [32]. The service-oriented EA reference model is later extended to digital EA and is referred to as an adaptable digitization architecture framework after the integration of new architecture for the internet-of-things to benefit the digital transformation [33].

Dynamic Enterprise Architecture (DYA)

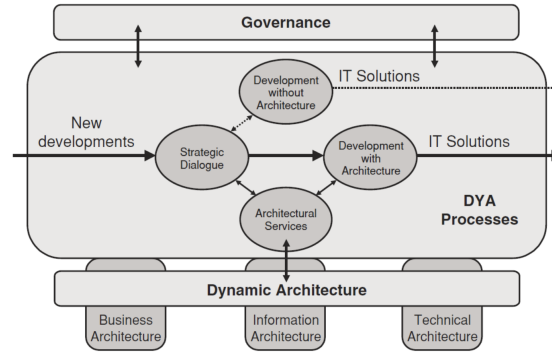


Figure 2.3: Dynamic Enterprise Architecture model from [34].

For more comprehensive and conclusive guidelines on dynamic EA, the framework “Dynamic EA” was introduced by Wagter et al., in [34] in which it supports agility by applying the notion of doing just enough just in time. The framework aims to make the change easy by applying agility principles for both aspects of architecture in the content of the architecture and in the process of making the architecture while preserving coherence. The framework describes a process, content which includes a theoretical and working model, and a set of principles and architectural guidelines.

The model for the DYA is shown in Figure 2.3.

A situated approach to enterprise architecture management (SAEAM)

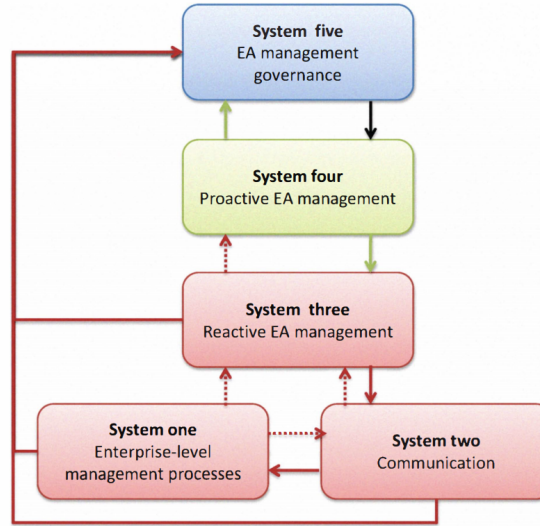


Figure 2.4: Application of a viable system perspective to EA management from [15].

Buckle et al. propose another interesting approach in the EAM field in [15]. They presented a situated EA management approach that offers a nexus to aid the selection decision and a system to choose an appropriate EA management function from available methods by major research groups in the field of EA. Figure 2.4 shows their application of the viable system perspective to EA management. The incorporation of the situated approach as a selection principle for the change management process could improve EA adaptability to aid the decision.

2.2.1 Selected EA key features overview and EAMF characterization

In this section, we propose some distinctive features that we recognized and believe are prevalent and common to the prominent adaptive EA management methods previously discussed. Those features could help analyze and distinguish the adaptive

advantages in every management method to improve adaptability in any proposed adaptive EA [35]. The following are the candidate features and a summary:

- **Content framework**

The content framework presents a structural model for architectural content to allow the major work products that an architect creates to be consistently defined, structured, and presented [6]. Generally, a content framework helps to keep track of the mapping process between the contents of one framework or different frameworks used for the architecture. “Content framework” could also refer to the category of EA frameworks such as TOGAF and The Department of Defense Architecture Framework (DoDAF) [36]; both frameworks describe the necessary artifacts to be produced by EA [37].

- **Reference model and reference architecture**

Model and reference architecture are not properly differentiated when defined or used in literature; the relation between the two is that of architecture and a model. The generic reference model could serve as an outline to guide the specification from the generic reference model to an organization-specific one [38][39]. A reference model serves a different purpose from reference architecture. Based on [40], a reference model is a division of functionality into elements together with the data flow among these elements. In contrast, a reference architecture is a reference model mapped into software elements that implement the functionality defined in the reference model. A reference model is not necessarily mapped into software, but it is known to be a frequent case.

- **Architecture capability framework or map**

According to the TOGAF 9.1 standard [6], a capability is the ability to deliver a service that requires a combination of organization, people, processes, and technology. Architecture capability is the architecture practice sought to

achieve a solution or sustainable architecture practice that increases value and benefit. According to [41], architecture capability is a framework that contains resources to complete the EA, such as skill framework, maturity models, architecture board, and architecture governance. The architecture capability framework description differs in each framework, for example, TOGAF provides an architecture capability framework, which also has a set of reference materials for how to establish such an architecture function and guidelines to support key activities. TOGAF facilitates the establishment of an enterprise architecture capability using the TOGAF architecture development method (ADM). The steps of establishing an architecture practice are also explained in TOGAF.

- **Architecture development method (Working model)**

An architecture development method refers to any step by step method to develop architecture. According to The Open Group library, their architecture development method (ADM) describes a method for developing an enterprise architecture that forms the core of TOGAF. It integrates elements of TOGAF along with other available architectural assets, to fulfill the business and IT needs of any organization [6].

- **Architecture continuum**

Enterprise system architecture is a variety of architectures related to various levels and organization entities; those architectures are the basis for evolution [42]. The architecture continuum serves as a foundation to build upon and leverage during the architecture process. It mainly consists of a repository of all the architecture artifacts. According to TOGAF [6], their enterprise continuum assists in the classifying of solutions and architectures from generic to organization tailored artifacts in the IT industry, such as architectural models, architectural patterns ,and architecture descriptions.

The Enterprise Continuum is a way of classifying solutions and architectures on a continuum ranging from generic foundation architectures to tailored organization-specific architectures both within and outside the Architecture repository. The TOGAF Enterprise Continuum has both an Architecture Continuum and a Solutions Continuum. The Architecture Continuum arranges reusable architecture assets, including rules, representations, and relationships of the information systems available to the enterprise in a structure, while the solutions continuum defines reusable solutions.

- **Decision support system (EA management approach)**

Architecture has always been considered an important tool for decision making and agreements [34]. However, as a clear decision support system in the intended context, here is a system that provides a decision support system for choosing management approaches for EA.

- **Provides description for process and content**

This feature represents the ability to describe the process and content of the framework, such as the architecture development method (ADM) of TOGAF.

- **Supports architecture Agility**

All enterprise management frameworks of interest support the agility of transformations for system architectures, which is defined as the ability to facilitate the transformation process from the current to the future state of the architecture.

- **Supports coherence**

This characteristic concerns the framework taking the coherence of the whole organization into consideration. Coherence is defined in dynamic architecture as a necessary characteristic to ensure the correct interaction of the various

business processes and to allow the organization to present itself as a uniform entity [34].

- **Supports change management**

Explicitly supports and describes change management.

- **Supports EA framework tailoring (situation-specific)**

Explicitly supports and describes framework tailoring.

- **Service-Oriented architecture**

In the past decade, SOA (service-oriented architecture) took the lead as a system architecture paradigm, the concept of SOA revolves around the service delivery. In general, the description “service-oriented” indicates that the framework or method supports the organization of the software that supports the enterprise’s business operations. In particular, we refer to the management method as service-oriented because it handles the enterprise as a service system.

- **Technology Oriented**

Technology oriented systems support the integration of technology objects such as IoT objects in a well-defined and clear manner, regarding business categories, processes, applications, platforms, and infrastructure. The only known enterprise architecture method properly addressing the technology aspect is the digital enterprise architecture by Zimmerman et al. in [24].

In Table 2.1, we present a general evaluation of the state-of-the-art EA management frameworks previously discussed in section 2.2 based on the prevalent features of adaptive enterprise architecture management frameworks (AEAMF) discussed in this chapter. The characterization table includes the following EA management frameworks: SAEAM (Situating adaptive enterprise architecture approach), DYA (dynamic enterprise architecture), ACEA (adaptive enterprise service system), digital enterprise

Table 2.1: Characterization of EAMF in terms of the key features.

EA framework key features	SAEAM	DYA	ACEA	ESARC	TOGAF
1. Content framework	×	×	×	×	✓
2. Reference model and reference architecture	×	×	×	×	✓
3. Capability framework or map	×	×	×	✓	✓
4. Architecture development method	×	Not clear	Not clear	Not clear	✓
5. Architecture continuum	×	✓	×	×	✓
6. Provides a decision support system	✓	×	×	×	×
7. Provide Principles and guidelines	✓	✓	×	×	✓
8. Provides description for process and content	✓	✓	✓	×	✓
9. Supports agility	✓	✓	✓	Not clear	✓
10. Supports coherence	Not clear	✓	✓	Not clear	✓
11. Supports change management	Not clear	✓	✓	Not clear	✓
12. Supports EA framework tailoring (situation-specific)	✓	×	✓	✓	✓
13. Service oriented	×	Not clear	✓	✓	✓
14. Technology oriented	×	×	×	✓	×

architecture or the Enterprise service architecture reference cube (ESARC) and The Open Group Architecture Framework (TOGAF). The frameworks are checked against each feature of adaptive EA previously discussed in this chapter.

2.3 Adaptable enterprise architecture frameworks evaluation from a digital transformation viewpoint

Organizations are competing to adapt their business to digital trends and initiatives. However, mature companies cannot compete easily with new companies that have

been digital from the start because those new companies have the correct technology infrastructures from the beginning and are dealing with less risk. When mature companies experience digital transformation, they continue to build complicated systems to stand up to the competition of fast-changing technologies. They might deploy patches and fixes rapidly without a plan for the future or a road map.

Employing EA is essential for mature companies to keep up with technological trends through digital transformation with reduced risk and rapid processes. From our realization of the importance of EA and digital transformation, we chose to evaluate adaptable EA frameworks from the previous section from the point of view of digital transformation. The model, ability, process, governance, and ecosystem were extracted as classification items for comparing AEAMF from the viewpoint of digital transformation. Among these, models, capabilities, and processes are basic elements that are commonly required in enterprise architecture.

In the digital enterprise, it is necessary to adapt to business changes and technological environment changes. For this reason, an ecosystem was added to evaluate adaptability to the digital business ecosystem. Governance was added to evaluate adaptability to changes in the technical environment. Also, for specific comparison, five concept elements were defined as shown in Table 2.2 for each of these classification items. Evaluation is based on the realization level of the five concept elements in Table 2.3. Based on the realization levels and common categories of the EA, we present our evaluation table for the adaptive EA frameworks in Table 2.4. In the next section, we also discuss related work and our evaluation table for the adaptive EA frameworks for each EA framework.

Table 2.2: Common required categories and elements of EA and adaptable digital enterprise.

Category	Elements
Model	Ref. Architecture, Continuum, Meta-model, Language, Agile Architecture
Capability	Capability Framework, Capability Map, Capability Based Planning, Capability Increment, Capability Maturity model
Process	Change management, Tailoring, Decision management, Variability management, Forum
Governance	Principle, Coherence, Risk management, Compliance, Governance Framework
Ecosystem	Service orientation, Business transformation, Interoperability, Standard, DevOps

Table 2.3: Concept realization levels.

level	Explanation
4	There is a certification system that evaluates the understanding of concepts
3	Concepts are guided
2	Application of the concepts is described
1	Concepts are explained
0	No concept description

2.4 Discussion and related work

Wilkinson [9] proposed the governance, organization, and technology aspects necessary to make IT successful in Adaptive Enterprise; he described four architectural principles: modularity, simplification, integration, and standardization. In our research, we consider the principles mentioned by Wilkinson, and the measure the maturity of adaptive enterprises based on five levels: ad hoc, individualization, documentation, departments, and institutionalization.

Korhonen et al. classify EA research into Enterprise IT Architecture (EITA), Enterprise Integration (EI), and Enterprise Ecological Adaptation (EEA) [25]. In addition to the previous classification, we consider three levels of EA: ecosystem architecture, social technology, and technology architecture. At the EEA level, EA evolves in conjunction with business ecosystems, industries, markets, and large so-

Table 2.4: Enterprise Architecture frameworks (EAF) evaluation.

Category	Elements	DYA	SAEAM	ACEA	ESARC	TOGAF
Model	Ref. Architecture	0	0	3	3	4
	Continuum	0	0	0	0	4
	Meta-model	0	0	3	3	3
	Language	0	0	0	1	4
	Agile Architecture	3	0	3	1	3
Capability	C Framework	0	0	3	1	4
	C Map	0	0	0	0	3
	CB Planning	0	1	0	0	4
	C Increment	0	0	3	0	4
	Maturity model	1	0	3	0	3
Process	Change management	1	1	3	0	4
	Tailoring	0	0	3	0	3
	Decision management	0	3	3	3	3
	Variability,management	0	3	3	0	1
	Forum	0	0	0	0	2
Governance	Principle	3	1	3	0	4
	Coherence	3	0	3	0	4
	Risk management	0	1	3	0	4
	Compliance	3	1	3	3	4
	Governance FW	3	3	3	3	3
Ecosystem	Service orientation	1	0	3	3	3
	Business	0	2	3	3	4
	transformation	0	0	3	0	3
	Interoperability Standard	3	3	3	3	3
	DevOps	2	3	3	1	4
Total		23	22	60	28	85

cieties. This collaboration is structurally incorporated in the free interaction with the external environment, partners, and others. Also, Korhonen et al. compared the aspects of digital functions for digital transformation at two levels: enterprise strategy EA and EEA [26]. The digital function aspect consists of business digitization, work digitization, collaboration connection, customer engagement, information technology management, and resource utilization.

Masuda [27] and others have proposed an adaptive integrated digital architecture framework (AIDAF). In AIDAF, the adaptability of EAF is qualitatively compared from the viewpoint of quickness, responsiveness, flexibility, simplicity, and learning. In this paper, EAF was objectively evaluated using adaptive concept items. AIDAF

also has process and governance concepts but lacks capabilities and models as well as ecosystem concepts. Van de Wetering [28] classifies the components of EA's Dynamic Capability into analysis capability, mobility, and transformation capability. The ability to change means restructurability, adaptability, and response to unexpected events.

The scores in Table 2.4 represent the level to accommodate framework adaptability features for each framework for digital transformation. We can see that TOGAF scores higher but to make use of the evaluation to choose among frameworks, each element must be considered to match precise features required by each system and its requirements and goals:

DYA

DYA offers guidance for agile architecture by providing architecture maturity, theoretical, and working models. However, reference architecture, continuum, meta-model, and an architecture description language are missing. As for capability, only the concept of a capability maturity model is described, but there is no mention of capability frameworks, capability maps, capability-based plans, or capability increments. The DYA process explains the concept of change management to the architecture itself, not the organization. There is no mention of tailoring, decision management, change point management, or forums. For governance, DYA guides architectural principles, consistency management, compliance, and governance frameworks, but there is no mention of risk management. DYA explains a service-oriented description of the ecosystem, it guides standardization and explains the case of DevOps, but it does not mention business transformation and interoperability.

SAEAM

No models are mentioned in SAEAM. As for capabilities, the capability-based plan is explained in SAEAM but there is no mention of other capability plans. The SAEAM

process provides guidelines for decision management and change point management, but nothing further is mentioned concerning other process elements. Regarding governance, SAEAM explains architectural principles, risk management, and compliance. It also guides the governance framework, but there is no mention of consistency management. For the ecosystem, guidance on standardization is presented. Also, it conducts the cooperation between architecture development and operation. SAEAM offer examples and explanation of business transformation, but there is no mention of service orientation and interoperability.

ACEA

The ACEA model provides guidance on the reference architecture, the architecture meta-model, and the agile architecture. However, it does not mention continuum and architecture description language. ACEA guides capability framework, capability increment, and capability maturity model, but it does not mention the capability maps and capability-based plans. Guidance on change management, tailoring, decision management, and change point management for processes are provided, but the forum is not mentioned. ACEA guides governance principles, consistency management, risk management, compliance, and governance framework. Also, there is guidance on the ecosystem, service orientation, business transformation, interoperability, standardization, and DevOps.

ESARC

The ESARC guides the reference architecture and an architecture meta-model and describes an architecture description language and an agile architecture, but not a continuum. The capability framework is described in ESARC, but there is no mention of a capability map, capability-based planning, capability increment, or capability maturity model. The ESARC process guides decision management, but no change management, tailoring, or change point management; also forums are not mentioned in ESARC. For governance, ESARC guides compliance and governance frameworks.

However, it does not mention architectural principles, consistency management, or risk management. For the ecosystem, there is guidance on service orientation, business transformation, and standardization. ESARC explains DevOps but does not mention interoperability.

TOGAF

TOGAF offers certified reference architecture, continuum, and architecture description language. It provides guidance on architectural meta-models and agile architectures. TOGAF also has certified capability frameworks, capability-based plans, and capability increments and provides guidance on capability maps and capability maturity models. The TOGAF change management knowledge is certified for the process. It provides tailoring and decision management guidance. There are examples of forums and an explanation of how to manage variable points. For governance, TOGAF has certified knowledge of architectural principles, consistency management, risk management, and compliance. TOGAF also provides guidance on the governance framework and service orientation, interoperability, and standardization for ecosystems and certifies knowledge of business transformation and DevOps.

2.5 Chapter summary

In this chapter, we attempted to study and review adaptive EAMF. We presented an evaluation and a general review of the selected state-of-the-art EAMF considered to support adaptability. First, we presented a characterization table of the selected EAMF in terms of the nominated key features of adaptive EA discussed in this chapter. Then, an evaluation considered categories and elements of adaptable EA from the point of view of digital transformation. Those elements must be examined against the requirements and goals of the system to help choose the appropriate framework or frameworks in a project.

Chapter 3

The Role of Concept of Operation (ConOps) in Improving Adaptive Enterprise Architecture (EA)

3.1 Introduction

In this section, we continue our research to find the means to improve adaptive enterprise architecture. Certain natural language documents could be a factor in the improvement of adaptive EA. Based on the previous examination [43],[21], we found out that the Concept of Operation document [17] is the ideal document to serve as a basis for our research for so many reasons. Based on [17], the ConOps document is used to guide the transition of systems; it provides a clear description of the current and desired system as well as the description of transition and change. ConOps is an essential component for understanding any system clearly and for guiding an efficient change process from the current state to the desired state.

According to TOGAF 9.1 [14], when applying the Architecture Development Methodology (ADM), there are three levels of partitioning for enterprise architec-

ture in organizations: strategic level architecture (long term main objective and goal for the organization), segment level architecture (parts of the organizations such as departments) and capability level architecture. ConOps can be related to each level, as shown in Figure 3.1. Enterprise architecture can be applied to any of the segments (the segment by itself can be identified as an enterprise). As the organization matures each segment would create synergy with the strategic level, so this should provide a well-built enterprise architecture that enables flexibility for changes on every level and lead to creating value and balance to resist failure in the long term.

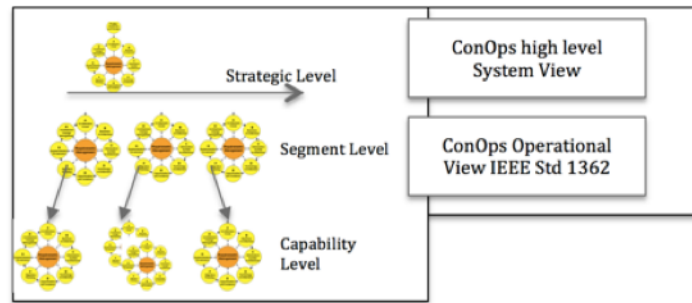


Figure 3.1: Clarification of architecture landscape in relation to the ConOps document.

In this chapter, we start by examining and analyzing the role of the motivation extension of the ArchiMate architectural modeling language and its relation to the adaptiveness of the EA in section 3.2. After understanding the motivation extension and its elements from the requirements point of view in section 3.3, we argue that ConOps is the ideal document to be leveraged in order to improve the adaptive EA in general. Then we present reasons to justify considering ConOps for this research and present the ConOps levels of consideration in 3.3.1.

In our research, we work on integrating ConOps to enterprise architecture using ArchiMate architecture modeling language as a common representation between the two. In 3.3.2, we show the relation of ArchiMate to ConOps. In 3.3.3, we present the ConOps meta-model and explain the methodology and bases for extracting and connecting elements of the meta-model. Section 3.3.4 suggests integrating the TOGAF

ADM and ConOps, and section 3.4 concludes the main contribution of the chapter.

3.2 Adaptive enterprise architecture and the role of the motivation extension

It is essential to understand the role of the motivation extension [44] of the adaptive EA to follow the logic of this research. In this chapter, we refer to the TOGAF framework [6] for the Adaptive Enterprise Architecture. TOGAF is considered as the basis for customized Enterprise Architecture (EA), and its most important element is the Architecture Development Methodology (ADM). According to [19], the ADM defines the full life cycle processes to create EA; phases of the ADM from TOGAF are shown in Figure 3.2. In this thesis, we refer to “Adaptiveness” and the adjective “Adaptive,” which means to serve or be able to adapt by showing or contributing to adaptation. Adaptation is the capacity for a system to respond and alter its state in response to change within its environment [45]. The three main domains of business, applications, infrastructure must be considered to address the issue in any EA, such as [46] :

- **Strategy, Goals and Objectives**
- **Business to support the strategy operational organization.**
- **Application and systems: applications support the business and implement the business functions in the IT systems.**
- **Information and Data.**
- **Network and infrastructure: technical components as in servers and network and technology as in platforms.**

In this research, we mainly focus on the business process and operation transition process.

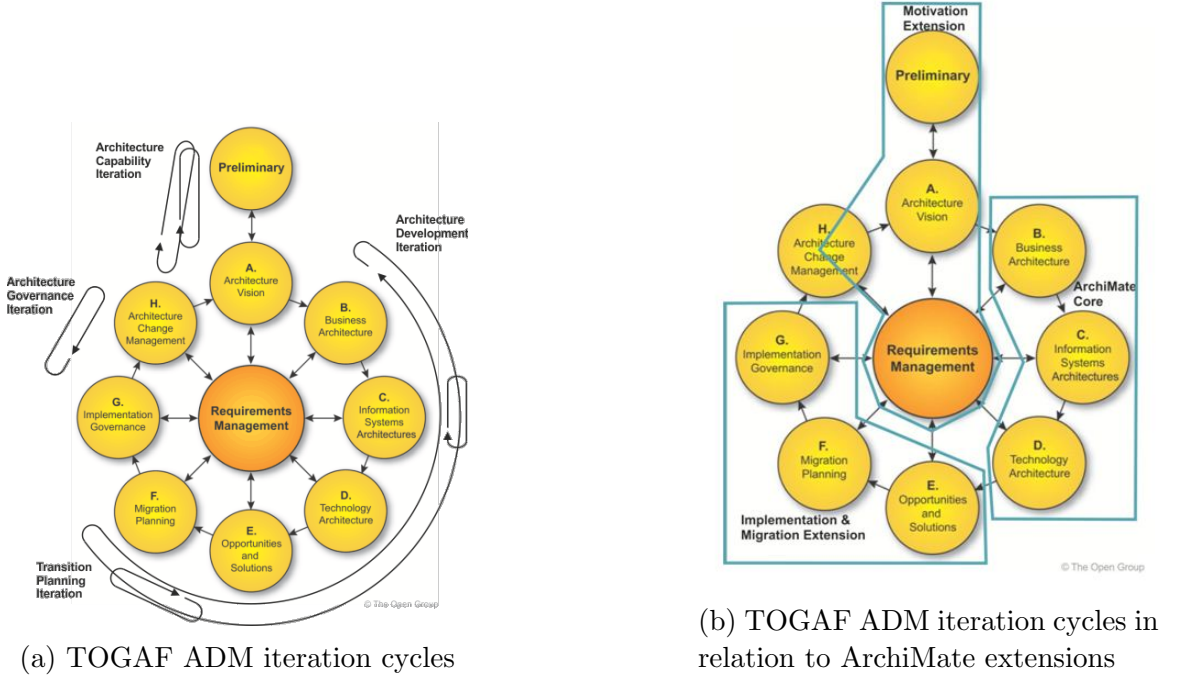


Figure 3.2: The TOGAF ADM from [6].

In adaptive EA requirements keep changing, and the architecture should respond efficiently to these changes. For this reason, the key to improve adaptiveness for Enterprise architecture is the improvement of the “requirements management process,” which sits in the heart of the TOGAF ADM cycle. Multiple factors could be related to the improvement of the adaptiveness of EA, and we do not assume the completeness of the research in addressing all known factors in the literature. In this research, we solely focus on the requirement acquisition because of its direct relation to “requirements management” phase and the “change management” of TOGAF ADM [47].

To support the analysis of the architecture, we utilize the ArchiMate standard. ArchiMate is an open independent modeling and common language for enterprise architecture with clear concepts and uniform structure, as described by [19]. It describes, analyzes, and visualizes relationships between architecture domains within

and across business domains in an unambiguous way. ArchiMate 3.0 introduced in 2016, consists of a core language, which focuses on the description of the four architecture domains defined by TOGAF standard: business architecture, data architecture, application architecture, and technology architecture and two extensions: “Motivation and Strategy” and “Implementation and migration” [19]. According to [6], there were many improvements in the latest addition including the addition of the strategy elements.

In Figure 3.2.b, we can see that the motivation extension from ArchiMate supports: preliminary phase, architecture vision phase, requirements management, and architecture change management phases of TOGAF ADM. For this reason, we decided to look further into the motivation extension to improve the adaptiveness of the EA.

3.2.1 Analyzing the role of the motivation extension

ArchiMate motivation extension is based on standards and techniques such as KAOS, OMG’s business motivation model, and i* framework [44]. The primary role of the motivation extension is to model and help analyze the reasons and needs for the enterprise architecture change to help guide, influence, and constrain the design of the architecture. It addresses the early needs of the requirement management process and other TOGAF phases. The meta-model from the ArchiMate specification guide of the Open Group is shown in Figure 3.3; it shows the main concepts of the motivation extension as: stakeholder, driver, assessment, goal, requirement, constraint and principle.

Requirements represent the needs that must be met by the system to achieve a goal. Requirements at a high level deal with goals, but at a detailed level, it reaches to the system itself.

To understand the essence of the concept of “requirement” in the motivation

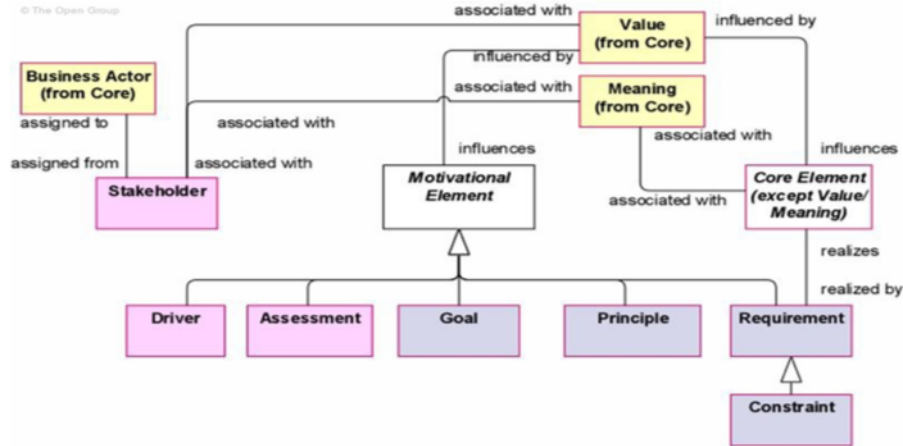


Figure 3.3: Relationship between the motivation extension and ArchiMate core concepts from [6].

extension and to detect any room for enhancement, we produced a Systemigram based on the motivation extension, the Systemigram should explain the role of other concepts in producing the requirements as shown in Figure 3.4. We also simplify the previous Systemigram to create a pattern as shown in Figure 3.5.

We believe that detecting motivations can be complicated. Capturing such concerns in the form of drivers from stakeholders or the environment can be confusing. For this reason, we suggest leveraging a document that covers the motivation extension aspects, shares its concepts, and supports the notion of architecture transition from present to the desired state. In the next chapter, we explain why the concept of operation documentation (ConOps) is the perfect candidate to leverage in order to benefit the adaptive EA.

3.3 ConOps and its relation to EA

The concept of operations (ConOps) is a document describing system operations and how it functions in natural language for simplicity as shown in Figure 3.6. Simple language is usually used to communicate knowledge about the system to stakeholders with or without a technical background to reach an agreement and clarify the purpose

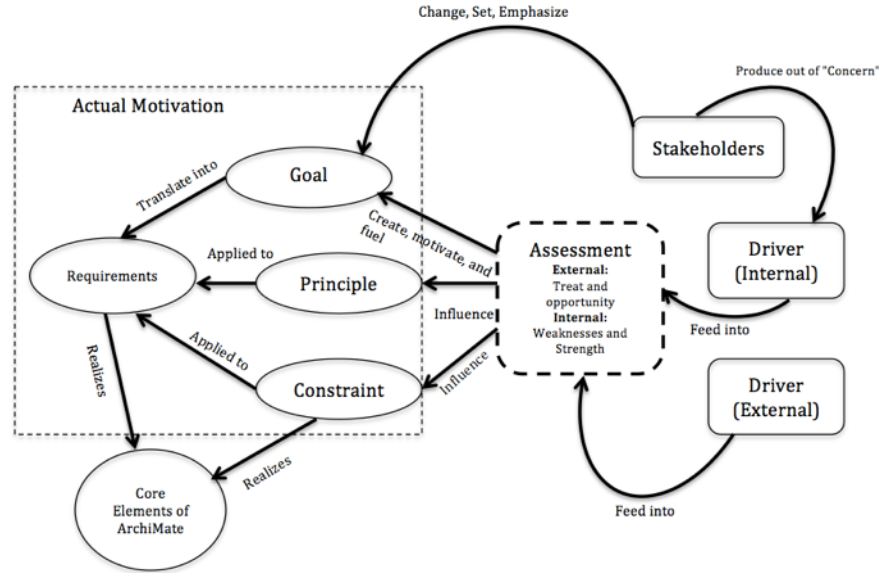


Figure 3.4: Systemigram for the requirement concept of the motivation extension.

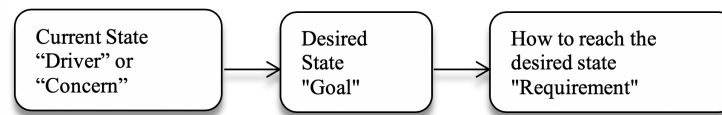


Figure 3.5: Main parts of the motivation extension from the Systemigram.

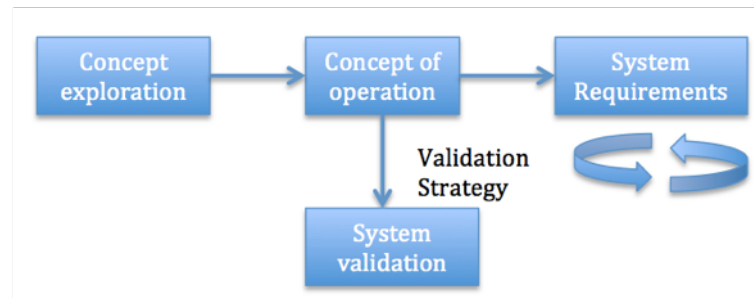


Figure 3.6: Basic concept of operation process

of the system. ConOps could improve the quality of enterprise architecture because the quality of the architecture depends on the ability to capture and analyze the goals and requirements to be realized by the architecture in such a way that the “change process” of goals and requirements would be easy. Such quality measures can ensure that the gathered data in analytical models and tools are used efficiently to support operational and strategic necessities [48],[20]. There are different standards

and institution documents used to guide the creation of the ConOps document, such as the ANSI/AIAA guide for the preparation of operational concept documents [49], IEEE 1362-1998 [17] or guidelines such as the Carnegie Mellon University Guidelines for developing a product line Concept of Operations [50].

We chose The IEEE 1362-1998 standard because it is the only standard that describes the current state of the system, justifications for change and the concept for the proposed system, which contributes to the motivation extension pattern in Figure 3.5 to guide the transition from the current state to a future state [17]

3.3.1 ConOps levels of consideration

To relate ConOps to ArchiMate motivation extension, we considered two primary levels of ConOps:

- **ConOps scenarios and diagrams supporting the organizational level (strategic view)**

On the organizational level, ConOps is used to specify the overall objective of a system. In the case of EA, it supports strategic planning. To guide the enterprise over a long period, the enterprise needs a strategic plan, which is a fused set of EA artifacts. ConOps scenarios are among the important artifacts to support the enterprise strategy because the scenarios describe the system from a high-level perspective along with the activities. The artifacts in this level also include several future scenarios that explain drivers identified by the SWOT analysis. Another important artifact to support the enterprise strategy is the graphical representation of the ConOps scenario, which focuses on the surrounding environment [51].

Table 3.1: Main contents of ConOps IEEE Std 1362.

Motivation extension main parts	IEEE Std 1362
Overview	1.3 System Overview
Current System	3.3. Description
	3.4 Modes of operation
	3.5 User classes
	3.6 Support environment
The Change	4.1 Justification for change
	4.2 Description of the desired change
	4.3 Priorities among changes
Proposed System	5.3 Description
	5.4 Modes of operation
	5.5 User classes
	5.6 Support environment

Table 3.2: Matching ArchiMate to the system level of ConOps.

ArchiMate extension	System level ConOps
Current State “Driver or Concern”	Current System
Desired State “Goal”	The Change
How to reach the desired state “Requirement”	Proposed System

- **ConOps for the system level (operational view)**

The IEEE 1362-1998 standard [17] best describes the system-level ConOps. In Table 3.1, we listed the ConOps elements which we believe relate to the concepts of ArchiMate motivation extension.

Based on the previously suggested ConOps level of involvement and the analysis of the strategic level and system level of ConOps, we summarised the main ConOps topics to be leveraged in Table 3.2. Also, based on the previous finding, we suggest a summary of ConOps elements and main parts, as shown in Figure 3.7.

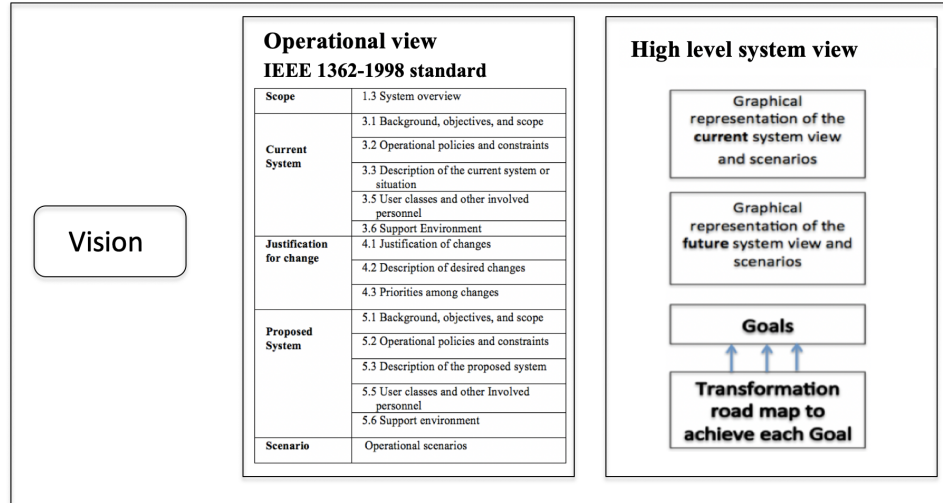


Figure 3.7: Our suggested classification of ConOps elements summary.

3.3.2 ConOps and ArchiMate

The main challenge in aligning ConOps with EA at first was that ConOps is a textual document with no specific meta-model or graphical representation. For ConOps to be aligned and integrated within EA, we had to find a common reference and representation modeling language that could help integrate and validate the integration. We believe that ArchiMate can serve as a common reference, and its concepts can represent ConOps graphically because they cover common related elements and concepts. Integrating ConOps into EA adds value either by using already written ConOps documents to aid EA or by updating or creating new ConOps from an EA perspective. In order to properly integrate ConOps into EA, we need a meta-model. However, no ConOps meta-model description can be found in literature, for this reason, we decided to create a general ConOps meta-model as a first step.

The various ConOps document standards lacks traceability from document specification to implementation. Giving ConOps holistic visibility by presenting a meta-model would solve this problem and would also aid the process of creating ConOps at the analysis phase. For this reason, our focus was mainly on the problem and solution space represented by traditional system engineering and ArchiMate motivation

extension.

3.3.3 ConOps analysis and meta-model

In order to conceptualize and create ConOps meta-model, we employed experts' knowledge, and literature review and then represented the finding in a structure to assist the meta-design following the research by [52]. Our method includes analyzing and identifying core concepts from ConOps standards, industry ConOps documents, and related literature, taking into consideration ConOps in relation to EA. To cover the domain of problem and solution, we also identify related possible requirement engineering elements along with elements from traditional system engineering. In our previous research [43], we extensively examined several online accessible ConOps documents (IEEE standard in government and industry). In each document, we analyzed each ConOps element and then extracted all the possible ArchiMate concepts in each element. The mapping of the ArchiMate elements to each concept in the ConOps elements was based on the ArchiMate standard definition and ArchiMate ontology based on the work of [53]. The concept had to occur in all the examined documents in the specific ConOps element for the mapping to be acknowledged.

Based on a study on different types of ConOps standards by [54], six categories of commonly occurring information were identified: background, system descriptions, analysis of the system, impacts, supportability, and operational scenarios. The categories are broken into subcategories, which can be referred to as ConOps elements. Using the previously mentioned categories, analysis of ConOps standards and our previous analysis of ConOps documents based on ArchiMate concepts and traditional systems engineering, we were able to initially identify the main core concepts of ConOps as shown below in Table 3.3.

For meta-model representation, we referred to the definition of each concept from the layers in ArchiMate meta-models and ArchiMate motivation extension ontology

Table 3.3: Assignment of our derived ConOps core concepts to main common ConOps categories.

Categories of commonly occurring information in ConOps (Frittman,Edson,2009)	Derived preliminary ConOps core concepts
Background	problem, goal, concern, description of future system "To be",user
System descriptions	Description of current system "As is", constraints, future system,"To be"
Analysis of system	capabilities, limitations,goal,environment, system view, interface, system model
Impacts	Process, stakeholders
Supportability	System Boundary
Operational scenarios	Operational Scenarios

definition [53]. However, since ArchiMate doesn't cover all the derived concepts for our meta-model, we defined the rest of the concepts in the context of the literature by Edson et al. in [55],[54] and their guidelines for creating ConOps [16]. We also identified and defined some concepts based on Cloutier et al.[56] in their proposal for an agile ConOps creation process, using stages from the conceptual and specification phase. Figure 3.8 consolidates our resulting meta-model.

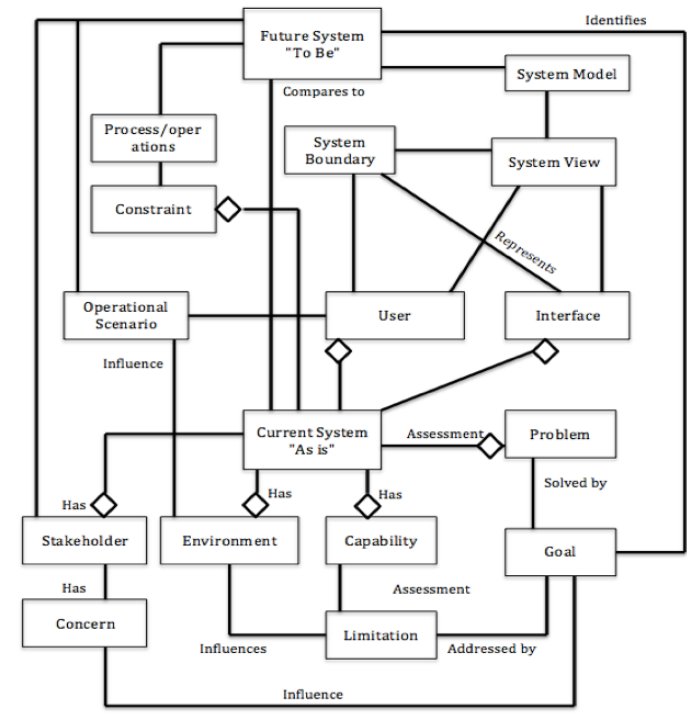


Figure 3.8: Our basic meta-model for ConOps concepts and main elements.

3.3.4 ConOps supporting TOGAF ADM cycle

We first proposed that ConOps could support EA because ConOps can play an essential role in bridging the current status where we want to move from to the desired status that we wish to reach. According to IEEE, the heart of the IEEE standard is described in the following clauses of the ConOps document: clause three “description of the existing system” (which the user wishes to replace), clause four “justification for a new or modified system” and clause five “description of proposed system.” This format could serve in tracing and consistently applying changes according to [18].

Based on our analysis of the main elements and clauses of the ConOps document, we observed potential alignment between ConOps and EA. To support TOGAF, we decided to aid the ADM, which is the iterative Core of TOGAF. The whole Architecture Development Methodology (ADM) wheel is iterative; there are several iterations within the ADM iteration cycle, as shown in Figure 3.2.a. The iteration cycles for ADM include: “Architecture context iteration”, “architecture definition iteration”, “transition planning iteration” and “architecture governance iteration”.

The development of ConOps is iterative, and by aligning the related ADM phases and cycles, we could achieve better responsive architecture with less ambiguity and better communication [57]. ConOps can be used for any system [17]; our target ConOps in this section is associated with “architectural requirement” and not “system requirements.”

The suggested integration of ConOps elements from the IEEE 1362-1998 into ADM phases Iteration is shown in Figure 3.9.

TOGAF ADM phases iteration	ConOps elements
Architecture context and Capability Iteration: Preliminary Phase A. Architecture vision H. Architecture change management	1. Architecture Scope <ul style="list-style-type: none"> 1.3 Architecture Overview 3. Current Architecture <ul style="list-style-type: none"> 3.1 Architecture background, objective and scope 3.2 Operational policies and constraints 4. Justification for and nature of changes <ul style="list-style-type: none"> 4.1 Justification of change (factors to influence the Architecture change) 4.2 Description of desired changes 5. Proposed Architecture <ul style="list-style-type: none"> 5.1 Background, objective and scope of the proposed architecture 5.2 Operational policy and constraints for the proposed architecture 7. Summary of impacts <ul style="list-style-type: none"> 7.1 Operational impacts 7.2 Organizational impacts 7.3 Impacts during development
Baseline iteration: B. Business Architecture C. Information system architecture D. Technology architecture	3. Current Architecture <ul style="list-style-type: none"> 3.3 Description of the current architecture (current component description) 3.4 Modes of operation for the current architecture 3.5 User classes and other involved personal in the current architecture 3.6 Support environment for the current architecture 5. Proposed Architecture <ul style="list-style-type: none"> 5.3 Description of the proposed architecture (proposed component description) 5.4 Modes of operation for the proposed architecture 5.5 User classes and other involved personal 5.6 Support environment. 6. Operational Scenario <ul style="list-style-type: none"> Architectural Operational scenario
Transition planning iteration: E. Opportunity and solution F. Immigration planning	Justification for and nature of changes <ul style="list-style-type: none"> Priorities among changes (based on factors) Changes considered but not included

Figure 3.9: Suggesting integration of ConOps elements and ADM cycle iterations

3.4 Chapter conclusion

In this chapter, we presented a meta-model based on the IEEE 1362-1998 ConOps standard and suggested an integration of TOGAF ADM iteration cycles and ConOps elements. Our suggestion came from the clear need for a better quality adaptive EA architecture, which promotes better understandability and responsiveness to changes. In future research, we will complete the definition of integration between ConOps and EA and plan to present a meta-model evaluation using an evaluation case study.

Chapter 4

A Proposal for a Method of ArchiMate Based Concept of Operation (ConOps)

4.1 Introduction

There is a strong connection between system success and early identification of users' needs. The ConOps document is an important component for understanding any system clearly in the early stages and for guiding a better change process from the current state to the desired state. In this chapter, we attempt to relate ConOps to the ArchiMate Modeling language then prove that ConOps document and ArchiMate modeling language could represent each other efficiently. In this chapter, we also argue that producing ConOps from ArchiMate and vice versa, promotes better communication and improves understandability of users' needs.

In a previous study [21], we examined the role of the motivation extension of ArchiMate [19] and its relation to the adaptiveness of the EA. We believe that certain natural language documents could be a factor in the improvement of adaptive

EA. Based on the previous examination, we found out that the Concept of Operation document (ConOps) is the ideal document to serve as a basis for our research for so many reasons. The IEEE standard 1362-1998 system definition ConOps [17] document is widely used for its well-developed guidelines. It is used to guide the transition of systems and provides a clear description of the current and desired system as well as the description of transition and change.

In this chapter, we start by presenting the research background and problem in section 4.2, then research methodology and questions in section 4.3. Next, in order to prove our claim, which states that ArchiMate could aid the process of creating ConOps and vice versa, we first need to establish a connection between ConOps and ArchiMate by mapping their elements and showing a simple demonstration of creating ArchiMate model from ConOps clause by analysis in section 4.4. In section 4.5, we present an experiment to show how using ArchiMate to create ConOps prompts accuracy and reduces the difficulty. In section 4.6, we present an experimental case study to confirm that using ArchiMate promotes efficient communication and better understanding. Finally, we present discussion and findings in section 4.7 and a conclusion and future research in section 4.8.

4.2 Background and research problem

There are many benefits to creating ConOps document as the basis for any system definition. Not only does ConOps facilitate communication and consensus among stakeholders, but it also plays an essential role in the whole system development life-cycle because it is used to derive requirements and later used to evaluate the system. After system implementation, the system is validated and verified against the ConOps, which gives a baseline for measuring efficiency [18].

- **ConOps and Enterprise Architecture**

ConOps IEEE 1362-1998 is the only concept of operation standard that describes “current state of system”, “justifications for change”, and the concept for the proposed system, which contributes to guiding the transition from the current state to a future state [17]. This format could serve in tracing and applying changes consistently.

- **ConOps and ArchiMate motivation extension**

In this research, we utilize ArchiMate to support analysis and problem definition. ArchiMate is an open and independent enterprise architecture modeling language to support the description, analysis, and visualization of architecture within and across business domains unambiguously. ArchiMate 3.0 [19] consists of a core language, which focuses on the description of the four architecture domains defined by TOGAF standard [6] as business architecture, data architecture, application architecture, and technology architecture along with two extensions: motivation and migration.

The main objective of ConOps is to make sure various users clearly understand the operational needs. We hypothesize that we can improve the understandability of the various concepts of the ConOps document and help identify operational needs by using ArchiMate concepts and viewpoints. However, detecting motivations can be complicated; capturing such concerns in the form of drivers from stakeholders or the environment can be confusing. That is why we also suggest leveraging the ConOps document to get the ArchiMate motivation extension aspects and support the architecture transition from present to the desired state.

4.3 Research methodology

The ConOps document is still not used to its fullest potential; in many systems, it is usually made after the system is matured or delivered [16],[57]. The ConOps document is considered underutilized for so many reasons; one significant reason is the lack of a method for analyzing and acquiring the content of the document. The IEEE standard provides guidelines, content, and format but not an exact technique [54]. To use the IEEE guide appropriately, each organization should develop a set of practices to create detailed guidelines for creating and updating its ConOps document [18]. This research is conducted using traditional analysis, including background study, comparative, and data analysis. We hypothesize that ArchiMate could aid in the process of creating a ConOps document. The questions guiding the research are formulated as:

- **Q1: To what extent can we model ConOps using ArchiMate? (Mapping and evaluation, section 4.4.1)**
- **Q2: How to produce ArchiMate models from ConOps clauses? (Method and demonstration, section 4.4.2)**
- **Q3: Would deriving the ArchiMate model from ConOps promote understandability and facilitate communication? (Experiment and quantitative analysis, section 4.5)**
- **Q4: Is it efficient to create ConOps using ArchiMate? (Case study, section 4.6)**

4.4 Proposal for using ArchiMate to create ConOps

4.4.1 Mapping ArchiMate concepts to ConOps clauses

Our efforts to establish a connection between ArchiMate and ConOps started with creating ArchiMate models from several ConOps documents. Based on ontology definitions and the created ArchiMate models, we were able to present the coverage of ConOps clauses by ArchiMate elements. In Chapter 3, we explained that one of the reasons ConOps document was chosen in our study as a means to benefit the adaptive EA is the direct relation of ConOps concepts to the elements of the “Motivation Extension” of ArchiMate. The ConOps concepts can also be mapped to the business and application layer of ArchiMate. Motivation elements are classified mainly as problem, intention and strategy elements [53] as shown in Table 4.1. The mapped elements are presented as follows :

- Specialization problem element meta-classes: Stakeholder (S), Driver (D) and Assessment (A).
- Specialization intention meta-classes (actual motivation elements): Goal (G), Principle (P), Requirement (R), Constraints (Con), Outcome (O) and Value (V)
- Strategy elements: Capability (C), Course of action (CA) and Resource (R)
- “Business layer” and “application layer” elements, including all elements in behavior entities, passive entities, and active entities, as shown in Table 4.2.

The complete coverage of related ArchiMate elements to ConOps parts is shown in Table4.3.

Table 4.1: Mapping Motivation ArchiMate elements to ConOps clauses.

ConOps Element	ConOps Clause	Problem Elements			Intention Elements				Strategy Elements				
		S	D	A	G	P	R	Con	O	V	C	CA	R
Scope	1.3 System Overview				✓	✓							
Current System	3.1 Background, Objectives and Scope		✓	✓	✓	✓	✓						
	3.2 Operational policies and constrains						✓	✓					
Justification and nature of change	4.1 Justification of change	✓	✓	✓	✓		✓						
	4.2 Description of Desired changes	✓							✓	✓	✓	✓	✓
Proposed System	5.1 Background, Objectives and Scope		✓	✓	✓	✓	✓						
	5.2 Operational policies and constrains						✓	✓					

Table 4.2: Mapping the rest of ArchiMate layers to ConOps clause.

ConOps Element	ConOps Clause	ArchiMate Layer
Current System	3.3 Description of the current system	Business Layer
		Application Layer
	3.5 User classes and other involved personnel	Business Layer
Proposed System	5.3 Description of the proposed system	Business Layer
		Application Layer
	5.5 User classes and other involved personnel	Business Layer
	6.0 Operational Scenario	Business Layer

Table 4.3: ArchiMate elements coverage of ConOps clauses.

ConOps Main Parts	Subsection	related ArchiMate element
Scope	1.1 Identification	Out of scope
	1.2 Document overview	Out of scope
	1.3 System overview	Motivation extension
Current system	3.1 Background, Objective and scope	Motivation extension
	3.2 Operational policies and constrains	Motivation extension
	3.3 Description of the current system or situation	Business layer Application layer
	3.4 Modes of operation	Out of scope
	3.5 User Classes and other involved personnel	Business layer
	3.6 Support environment	Out of scope
Justification and nature of change	4.1 Justification of changes	Motivation extension
	4.2 Description of desired changes	Strategy Elements
	4.3 Priorities among changes	Out of scope
	4.4 Changes considered but not included	
Concept of proposed system	5.1 Background, objective and scope	Motivation extension
	5.2 Operational policies and constrains	Motivation extension
	5.3 Description of proposed System	Business layer
	5.4 Modes of operation	Out of scope
	5.5 User Classes and other involved personnel	Business layer
	5.6 Support environment	Out of scope
Operational scenario	6.0 Operational scenario	Business layer
Summary of impact	7.0 Summary of impact	Out of scope
Analysis of proposed system	8.0 Analysis of the proposed System	Out of scope

4.4.2 Method and demonstration (producing ArchiMate model from a ConOps clause)

To demonstrate modeling ConOps using ArchiMate, we used the “United States Government Printing Office (ConOps V2.0)” [58] as an example. Figure 4.1 shows the ArchiMate model derived from a portion of the ConOps clause “1.3 System Overview”.

The process of deriving ArchiMate from ConOps begins with identifying lead words in each section of the ConOps. “Lead words” are words related to ArchiMate elements. Examples of lead words identified include: “future system,” “will be,”

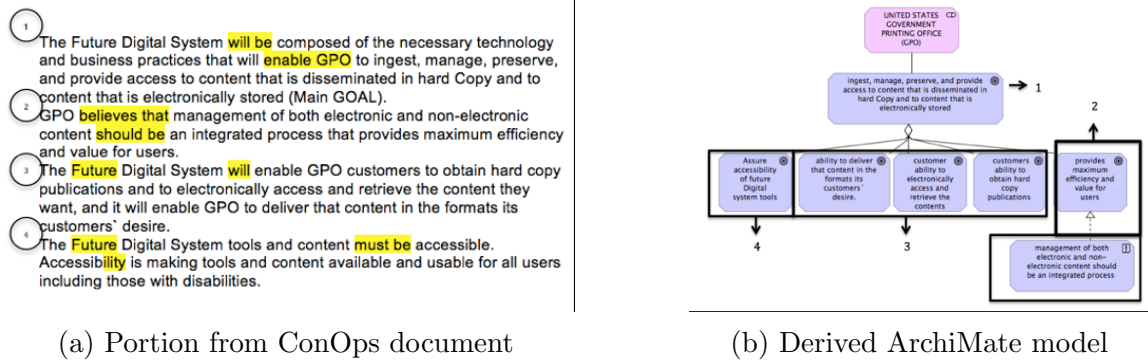


Figure 4.1: Creating ArchiMate from ConOps

“proposed system,” “believe that,” “should be,” “primarily,” “services,” “however,” “as a result,” “issue,” “failed,” “must.” After identifying lead words, we can match the sentence to the appropriate ArchiMate element based on the ontological analysis. In Figure 4.1a, we show how sentences are divided based on lead words, and in Figure 4.1b, we can see how the sentences are assigned to the appropriate ArchiMate element. Deriving the ArchiMate model is based on the analysis shown in Table 4.2 and 4.4 [53],[59],[60]. The recognition of lead words in ConOps could assist in automating the process in the future by creating domain ontology from textual documents [61].

Table 4.4: Analysis method used to create the corresponding ArchiMate model.

ConOps: 1.3 System overview		
Lead words	ArchiMate element	Reasoning (Ontological analysis)
-Future system... -Will be... -proposed system... -...ility(quality)	Goal (Main)	(Proposition) <u>A goal of an undetermined agent.</u> A goal is the propositional content of <u>an agent's intention</u> . From the ME definition, we can observe that: I. A stakeholder is committed to achieving a goal. II. achieving the goal means bringing out certain effects in reality.
-believe that...should be...	Principle	<u>Desire</u> which have as content propositions, the propositional content P of the desire is the result of the application of the predicate Q on all system\\, in a given context, i.e., $P = \forall s((System(s) \wedge ContextPrinciple(s)) \rightarrow Q(s))$ where System holds for all systems and Context Principle holds for all systems, in the context of application of the principle and Q holds for the system that show the sought properties stated in the principle

4.5 Using ArchiMate to represent ConOps clauses promotes understandability (Experiment)

Our second assumption is that using ArchiMate models produced from ConOps can promote understandability against the natural language ConOps document. ArchiMate, on its own, promotes better understandability and can, therefore, ease communication and support consensus among stakeholders. Based on the findings from the previous section, we can safely assume that using ArchiMate to model ConOps is valid. To prove the claim that using ArchiMate to represent ConOps clauses promote understandability, we chose to prove that using ArchiMate to model ConOps benefits communication as opposed to a natural language ConOps document. To prove our claim, we conducted an experiment to measure the changes in the level of accuracy and difficulty. Also, measuring understandability levels would determine if using ArchiMate to represent ConOps is of significant value.

For this experiment, we had a group of 10 postgraduate students from Yamamoto lab of Nagoya University's department of information science; they were divided into two groups randomly. The participants were familiar with ArchiMate and had participated in a semester-long ArchiMate session at the university. As for their knowledge of ConOps, we introduced the document elements from the IEEE 1362-1998 standard before the experiment.

For the experiment, we produced several ArchiMate models from ConOps (natural language-based) documents [58]. Our experiment included four different questionnaires designed by us; the questionnaires were designed to serve the goal of testing accuracy and difficulty levels. The questionnaires included two main problems (P1, P2); the first problem included three ConOps clauses (natural language) and three derived ArchiMate models (modeling language). The second problem included five ConOps clauses (natural language) and five derived ArchiMate models (modeling lan-

guage). The experiments are added to the appendix section of this paper as follows:

- **Questionnaire 1 (Q1)** : Problem 1 (P1) in Natural Language (NL) aspect using ConOps for Group 1 (G1) in (AppendixA).
- **Questionnaire 2 (Q2)** : Problem 1 (P1) in Modeling Language (ML) aspect using derived ArchiMate for Group 2 (G2) in (AppendixB).
- **Questionnaire 3 (Q3)** : Problem 2 (P2) in Modeling Language (ML) aspect using derived ArchiMate for Group 1 (G1) in (AppendixC).
- **Questionnaire 4 (Q4)** : Problem 2 (P2) in Natural Language (NL) aspect using ConOps for Group 2 (G2) in (AppendixD).

Table 4.5 summarises the experiment problems, questions, and groups.

Table 4.5: Table summary of experiment.

	G1	G2
Activity 1	Q1:P1 in NL	Q2:P1 in ML
Activity 2	Q3:P2 in ML	Q4:P2 in NL

Problem 1 Results: Preliminary results in Table 4.6 and 4.7 show that answering questions using the ArchiMate model in group 2 was easy (calculated difficulty Level 1/5) and accurate (accuracy 93%) compared to the results from group 1 using Natural Language ConOps (calculated difficulty level 2.5/5) and the accuracy level dropped significantly (accuracy 53%).

Extra experiment Notes:

- Both groups described Question 3 in modeling and natural language and the corresponding Figure 3 as confusing. This shows consistency of the answers about the problem's difficulty level regardless of the approached method. Question 2 was only described as confusing when the natural text approach method was presented in group 1.

- It was not possible to measure improvement in each participant's experience because some questionnaires were anonymous.

Table 4.6: Results from questionnaire 1 for group 1 on problem1 (Natural Language).

Name	Q1	Q2	Q3	Q4	Q5
Correct answer	C	B	C	-	-
participant 1	C	A	D	Difficult	Q2
participant 2	B	A	no answer	no answer	Q3
participant 3	C	B	C	Easy	Q3
participant 4	C	A	C	no answer	no answer
participant 5	C	B	no answer	no answer	no answer
Final Results	4/5	2/5	2/5	Easy: 1 Difficult: 1	Confusing Question: 2 and 3
	Correct Answers: 53%			Difficulty Level: 2.5	

Table 4.7: Results from questionnaire 2 for group 2 on problem1 (ArchiMate Model).

Name	Q1	Q2	Q3	Q4	Q5
Correct answer	C	B	C	-	-
participant 1	C	B	C	Easy	Q3
participant 2	C	B	C	Easy	Q3
participant 3	C	B	C	Easy	Q3
participant 4	C	B	B	Easy	Q3
participant 5	C	B	C	Easy	Q3
Final Results	5/5	5/5	4/5	Easy: 5	Confusing Question: 3
	Correct Answers: 93%			Difficulty Level: 1	

Problem 2 Results: Preliminary results in Table 4.8 and 4.9 show that answering the question using the ArchiMate model is easier (difficulty level calculated 2/5) and more accurate (accuracy 56%) compared to Natural language (difficulty level calculated 3.6/5 and accuracy 24%).

Extra experiment Notes: Common confusing questions between participants of both groups were 5 and 3.

Table 4.8: Results from questionnaire 3 for group 1 on problem 2 (ArchiMate model).

Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct answers	4	5	2	3	1	-	-
participant 1	2	5	4	3	1	Easy	5
participant 2	2	5	4	3	1	Easy	5
participant 3	2	5	4	3	1	Very Easy	None
participant 4	2	5	3	4	1	no answer	no answer
participant 5	2	5	4	3	1	Difficult	3
Results	0/5	5/5	0/5	0/5	5/5	Difficult: 1 Easy: 2 Very Easy: 1	Confusing problems: 5 and 3
	Correct Answers: 56%					Difficulty level:2	

Table 4.9: Results from questionnaire 4 for group 2 on problem 2 (Natural Language).

Name	Q1	Q2	Q3	Q4	Q5	Q6	Q7
Correct answers	4-D	5-E	1-A	3-C	2-B	-	-
participant 1	D	A	E	B	C	Very Difficult	2-B
participant 2	D	A	E	C	B	Difficult	5-E
participant 3	C	E	D	A	B	Very Difficult	5-E
participant 4	A	E	D	C	B	Very Difficult	3-C, 4-D
participant 5	C	A	E	D	B	Difficult	1-A
Results	2/5	2/5	0/5	2/5	4/5	Difficult: 2 Very Difficult: 3	Confusing problems: 1, 2, 3, 4 and 5
	Correct Answers: 24%					Difficulty level:3.6	

Table 4.10: Experiment preliminary results for problem 1 and 2.

		Problem 1	Problem 2
Group 1	Difficulty Level	2.5	2
	Accuracy	53%	56%
Group 2	Difficulty Level	1	3.6
	Accuracy	93%	24%

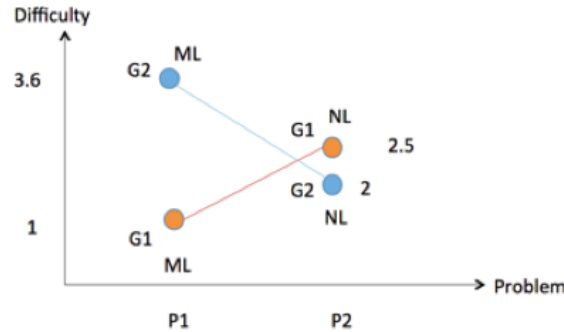
Table 4.11: Experiment average difficulty and accuracy.

		Natural Language: ConOps	Modeling Language: ArchiMate
Group 1	Difficulty Level	2.5	2
	Accuracy	53%	56%
Group 2	Difficulty Level	3.6	1
	Accuracy	24%	93%
Average Difficulty Level		3.05	1.5
Average Accuracy		38.5%	74.5%

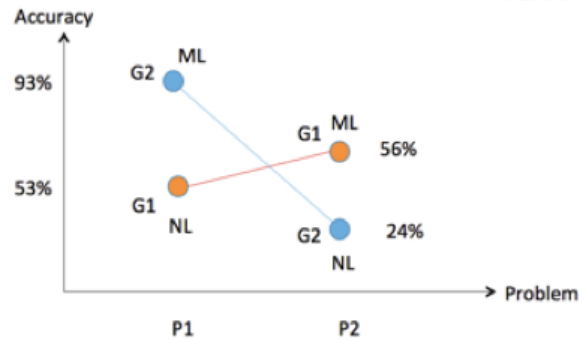
The results from the questionnaires are summarised in Table 4.10 and 4.11. The preliminary experiment results were as follows:

- **Activity1: Problem 1 (P1) for Group 1 (G1):** Examined accuracy and understandability using a set of questions (Q1) based on the original ConOps (Natural language). Accuracy level: 53%, difficulty level: 2.5
- **Activity1: Problem 1 (P1) for group 2 (G2):** Examined accuracy and understandability using a set of questions (Q2) based on derived ArchiMate from ConOps (Modeling language). Accuracy level: 93%, difficulty level: 1
- **Activity2: Problem 2 (P2) for Group 1 (G1):** Examined accuracy and understandability using a set of questions (Q3) based on derived ArchiMate from ConOps (Modeling language). Accuracy level: 56%, difficulty level: 2
- **Activity2: Problem 2 (P2) for Group 1 (G2):** Examined accuracy and understandability using a set of questions (Q4) based on the original

ConOps (Natural language). Accuracy level: 24%, difficulty level: 3.6



(a) "Difficulty" level results



(b) "Accuracy" results

Figure 4.2: The effects of natural language and modeling language on difficulty and accuracy (ML:modeling language of ArchiMate and NL:natural Language of ConOps)

Figure 4.2b shows significant improvement in the level of accuracy when the ArchiMate modeling language (ML) is used to represent ConOps as opposed to natural language (NL). Figure 4.2a also shows the difficulty level decreased when the participant answered questions from ArchiMate models based on ConOps.

Figure 4.3 shows the linear regression model for the relationship between difficulty and accuracy in the experiment with the sample regression line equation: $Y = y\text{-intercept} + \text{Slope}(x)$. The negative slope value shows the relation between accuracy and difficulty is negative, so when difficulty increases, accuracy will decrease. The correlation between accuracy and difficulty (value or R) is .983, which shows a strong linear correlation between the two.

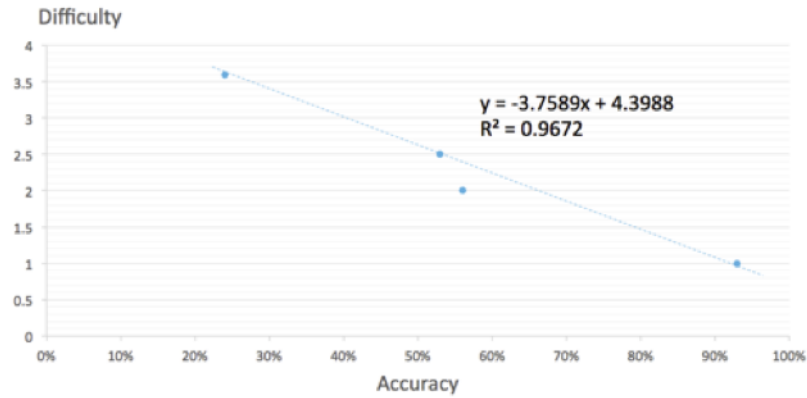


Figure 4.3: Regression model for the relationship between difficulty and accuracy in the experiment

4.6 Case Study: Using ArchiMate to create ConOps clauses for the “Man-hour management” system

Case background: The company had problems with the productivity of software development. There was a need for improvement. However, it was challenging to find the problem. After the discussion, it was determined that the problem affecting productivity was the lack of a man-hour management system. There was also a concern from the accounting department concerning their procedures of payroll management; their procedure involved manual labor that required a lot of time and effort because they relied on paper forms for payment procedures.

To assess the efficacy of creating ConOps using ArchiMate, we used ArchiMate as the primary tool of communication with the engineer to discuss the creation of ConOps clauses for the new “Man-hour management” system. Since there is no existing system, we skipped the step of creating “current system” clause of ConOps and included “justification for change” and “description of the proposed system” clauses for this case. In this experiment, we attempt to assess the effectiveness of producing ConOps using the ArchiMate modeling language. We measured the time of execution

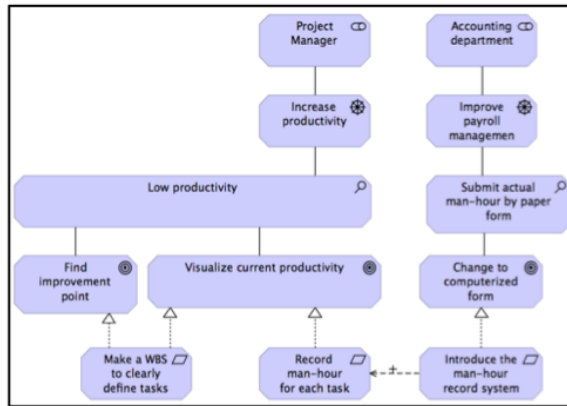
for the two main activities (2 ConOps clauses): creating “justification for change” ConOps clause and creating “description of the proposed system” ConOps clause.

The process of creating ConOps from ArchiMate was efficient and resulted in a good problem definition and analysis with easy communication and less ambiguous concepts and definition of relations.

4.6.1 Simplified process of creating ConOps clauses with the aid of ArchiMate and the time required for the process

After creating the “motivation” model of ArchiMate, we needed extra communication in order to create the corresponding ConOps clauses. It took 20 minutes to create the motivation model, as shown in Figure 4.4a, and another 16 minutes were spent on exchanging the extra information shown in Figure 4.4b. From the motivation model of ArchiMate and the extra information, we were able to derive the ConOps clause “Justification for and nature of change” in Figure 4.5, the process of deriving ConOps from the ArchiMate model took 10 minutes.

We then created the ArchiMate business model in 40 minutes, as shown in Figure 4.6. From the ArchiMate business model we were able to derive the ConOps clause “concepts of the proposed system” in 15 minutes as shown in Figure 4.7.



(a) Motivation model using ArchiMate

e) What are the proposed system major components?

The major component is the project management tool (it was not clearly described in this ArchiMate model). It can provide 4 functions, which were Planning, Analyzing, Recording, and Browsing and the recorded information can be used in payroll management.

f) What are the main capabilities and functions of the proposed system?

The main capabilities are increasing productivity, and improving payroll management such as reducing operating time. And functions are Planning, Analyzing, Recording, and Browsing.

(b) Exchange of extra information

Figure 4.4: ArchiMate motivation model and extra communication

4.0 Justification for and nature of changes (Time 10 minutes)

Project manager is concerned about productivity; the current system mainly suffers from low productivity .to address the low productivity issue, visualization of the current productivity and finding improvement points are needed, to achieve the goal of visualization of current productivity there is a need to have a record of man-hour for each task.to find improvement points there is also a need to make work breakdown structure (WBS) to clearly define tasks. There is also a concern raised from the Accounting department. The department wishes to improve payroll management, the analysis shows that the man-hour system is paper based. To improve the payroll management system, based on the previous analysis, change to computerized form is needed.to achieve a fully computerized (automated) system.

Figure 4.5: Derived ConOps clause from the ArchiMate model

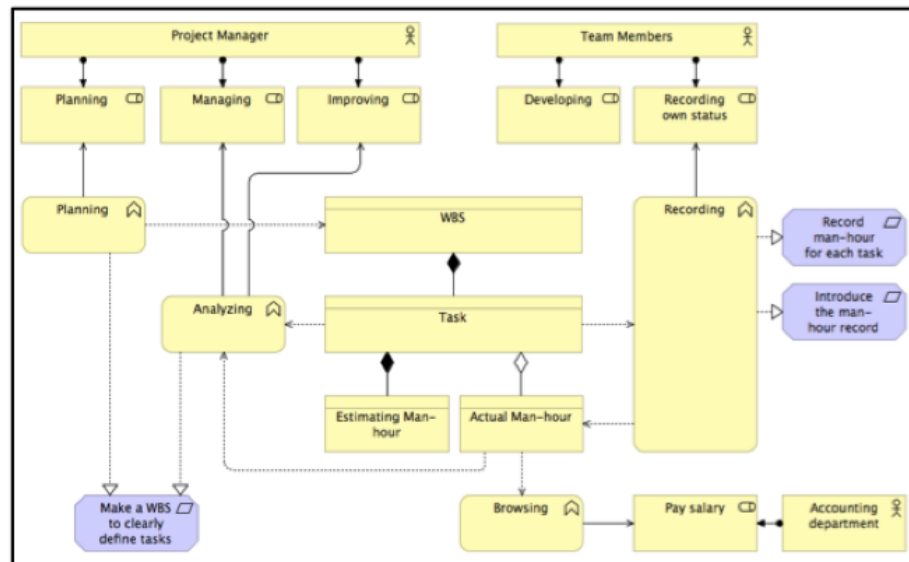


Figure 4.6: Produced business model using ArchiMate for the man-hour management system

Produced ConOps clause:**5.0 Concepts of the proposed system (Time 15minutes)**

The proposed new system "project management" will provide the following functions: planning, analyzing, recording and browsing. **"Recording" function:** This function fulfills the requirement "creating the man-hour record "and "Record man-hour ". the function serves the role of "recording status" for "team members" stakeholder. Recording function will use information from the object "Task" and send information to "actual man-hour" object. "Task" object as whole is part of "WBS" object and "actual man-hour" is partially part of the object "task". "Estimating Man-hour" object as whole is part of object "Task". **"Analyzing" function:** This function fulfills the requirement "make WBS clearly define tasks". It serves the role of "improvement" and "managing "for the stakeholder "project management". The function receives information from the "actual man-hour "and "task "object. **"Planning" function:** This function fulfills the requirement " make WBS clearly define tasks ". It serves the role of "planning" for the stakeholder "project management". The function sends results to "WBS" object. **"Browsing" function:** This function serves the role "Pay salary" for the accounting department. It receives data from the object "Actual man-hour".

Figure 4.7: Derived ConOps clause "concept of the proposed system".

4.7 Discussion and summary of the findings

This chapter mainly investigates the relation between ArchiMate as a modeling language and ConOps as a natural language-based document. In section 4.3 of this chapter (Research Methodology), we formulated the research questions guiding our investigation. In this section, we will show the main findings (F1, F2, F3, F4) of this chapter based on the research questions:

F1: In section 4.4 we presented a mapping table based on ArchiMate classification for the "Motivation extension", the "Business Layer" and the "Application Layer" as shown in Table 4.1 and 4.2. During our investigation, we examined a set of ConOps documents and established a connection by modeling all the ConOps clauses using ArchiMate. The collective results showed us the extent of coverage, as shown in Table 4.3.

F2: In section 4.2, we have shown how to model ArchiMate from a ConOps clause by demonstration in Figure 4.2. We had to depend on ontological analysis to extract the corresponding ArchiMate elements because ConOps is a textual document dependent on the author; there are sets of guidelines by the IEEE standard 1362-1998, however no specific method for analysis or explicit rules. Using corresponding sentences using lead words proved to be useful.

F3: The results of the experiment and quantitative analysis show an increase in

accuracy related to the decrease in difficulty, this determines that the level of understandability of ArchiMate models (derived from ConOps) was significantly higher compared to natural language ConOps. With better understandability, higher levels of consonance could also be achieved among stakeholders. The results showed that using ArchiMate to create ConOps is necessary to improve understandability and consonance among stakeholders.

F4: In the experimental case study, we conclude that creating ConOps from ArchiMate has many benefits; there were, however, some shortcomings in creating ConOps from ArchiMate. During communication, there were some ambiguous concepts. Some concepts referred to in the ConOps document and their meaning in ArchiMate, such as the concept of “capability” and “component” mentioned in Figure 4.7, were not clear in the communication and needed more elaboration.

If ArchiMate meta-model concepts and relations are specified using OWL-DL specification, then the process of producing ConOps from ArchiMate can be automated and checked for consistency [62]. The process should include using NLP (natural language processing), domain ontologies, and ontology models.

Based on the previous findings, we assert that ArchiMate can be used to facilitate the analysis process, improve understandability, and, therefore, communication. Other modeling tools have been known to aid in the process of creating the ConOps document; using ArchiMate in combination with these tools could promote better coverage. There have been efforts to describe the advantages of using various systems thinking methods and modeling tools by papers such as [54]. This paper focuses on the relationship between ConOps and ArchiMate specifically, and the proposal of further modeling tools or frameworks to create ConOps is out of this paper’s scope.

4.8 Conclusion and future work

In this chapter, we investigated the relationship between ConOps and enterprise architecture; we then explained the relationship between ArchiMate concepts and ConOps. Creating the ConOps document itself can be challenging because there is no exact technique to collect and analyze the data. For this reason, we suggest the use of ArchiMate as a tool for analysis and communication. Based on our findings, we know that using ArchiMate could significantly improve understandability and promote better communication. We presented a mapping table between concepts of ArchiMate and ConOps clauses based on ontology definition. However, there is still a need for a complete definition of concepts found in domain-specific ConOps documents. To further ease communication and to achieve a better connection between ConOps and ArchiMate, we wish to create an accurate definition for the widely used (most used) concepts defined by the ConOps document guidelines and a specific domain ontology and map it to ArchiMate concepts. Based on our future research activities, we also aim to create a tool based on our definition. The tool should aid in the process of creating a consistent ConOps document and automating the process of identifying concepts based on a set of rules using natural language processing and domain ontology to derive and generate the corresponding ArchiMate models.

Chapter 5

ARM Analysis Case Study: Digital Indian Health Care System Business Model and Review

5.1 Introduction

Because of the importance of the healthcare industry and the emerging technologies affecting e-health systems, it is crucial to provide the means to review and improve the planning and organization of its systems, especially in the early stages of design. The actor relationship matrix (ARM) offers great potential to recognize crucial requirements missing in the system using the stakeholders (actors) interaction with each other to acknowledge the critical business model elements: actors, data, actions, values, and goals known as the ASOMG. It is also useful to model the elements using the ARM pattern in ArchiMate to analyze the missing requirements further.

With the widespread application of digital technologies in India, the McKinsey Global Institute recognized the need to prepare a report [63] to shed some light on the potential value for a new ecosystem where the private sector and the government

work together to create more value to boost the Indian economy. The report studies and thoroughly reviews four sectors in India to benefit from potential digitization: agriculture, healthcare, retail, and logistics. The project was the result of a collaboration between the institute and major sectors, such as the government of India's Ministry of Electronics and Information Technology and many other experts in the fields of information technology, telecommunication, agriculture, finance, and others. The partnership led to the report on "India's Trillion Dollar Digital Opportunity." The report addressed some of the main problems, limitations, and circumstances affecting the Indian healthcare environment; the report was able to indicate some goals and suggested a schema for the digital ecosystem.

To achieve adequate digitization, periodically reviewing the system in light of the current advances is essential to check the completeness of the requirement and to draw attention to potential improvement opportunities. This chapter starts with a related work section and a preview of the ARM method in section 5.2, and in section 5.3, a general review of the Indian health care system report and an analysis are presented. Based on the analysis, the ARM is developed and used to assess the completeness of the requirements in section 5.4. We then present the ArchiMate model of the ARM to support the requirements assessment in 5.5, and in section 5.6, a general evaluation is performed based on the previous analysis and model. In 5.7, some suggestions are made to support significant system design enhancements and the associated technologies. Finally, we present a summary in section 5.8.

5.2 Related work

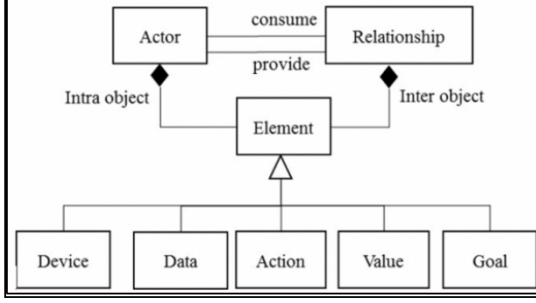
According to Orlikoff and Totten [64], the term e-health refers to "The use of the Internet and related information systems and technology in all aspects of health care." It is vital to create a business model for the success of the collaboration of e-health

services. ARM is a two-dimensional matrix that defines relationships among actors to analyze the requirements from the point of the relationship. It was first introduced to check and ensure the completeness of the strategic dependency model (SD) of the well-known goal-oriented requirements analysis known as the i*framework [44]. It was suggested a basis for i* modeling because it was difficult to check the completeness of the SD model systematically. Especially with a large number of actors in business cases and the growing complexity of the relationships between them, ARM proved to organize requirements and goals among those actors [65]. The five key business model elements of the e-health business model referred to as ASOMG were extracted after reviewing several case studies. The extracted elements from existing e-health case studies consisted of essential elements for the e-health models' innovation. It was concluded that they could also represent any business model based on the work of Yamamoto et al., in [66]. The elements included: Actors, Data, Actions, Values, and Goals. The elements are included in the developed meta-model for ARM in [22]. The work of Yamamoto [67] on deriving business values for ArchiMate from the actor relationship matrix and the work of Yamamoto et al.[66] on proposing a business modeling method for e-Healthcare based on ASOMG analysis, resulted in creating a meta-model for the ARM to analyze e-health business models as shown in 5.1a.

ArchiMate supports a precise analysis of the e-healthcare business models using ARM. ArchiMate is a standardized language to model enterprise architecture based on TOGAF, which is the most popular enterprise architecture framework [6],[68], the expressive power of ArchiMate and its rich features enhance the clarity of the architecture business model elements and aids in the analysis of the architecture.

The use of the ArchiMate modeling language was proposed to describe the e-health business model in [66]. It was proven to be applicable and proper for the elements of the e-health business model. The elements were later mapped to the elements of the ArchiMate modeling language, and an ArchiMate pattern was created representing

ARM. Figure 5.1 shows the mapping of ARM elements to the ArchiMate elements from [22].



(a) ARM meta-model

ARM elements	ArchiMate elements
Actor	Business Actor
Data	Business Object
Action	Business Service/ Process
Value	Business value
Goal	Business Goal

(b) ARM elements mapped to their corresponding ArchiMate elements

Figure 5.1: ARM meta-model and ArchiMate elements.

5.2.1 ARM definition and overview

We assume the two-dimensional matrix M for actor A_k where $K \in \{1, \dots, n\}$.

$M[A_i, A_j]$ represents elements actor A_i expects from actor A_j where $M[A_i, A_i]$ represents expectations of actor A_i from and by itself (goals).

G_a in a diagonal manner as intra-elements refers to the goals of A while E_{ab} as inter-elements in a none-diagonal manner mean the expectations of A from B .

Summary of Actor relationship matrix shown in Table 5.1.

Table 5.1: Actor relationship matrix.

	Actor A	Actor B	Actor C
Actor A	G_a	E_{ab}	E_{ac}
Actor B	E_{ba}	G_b	E_{bc}
Actor C	E_{ca}	E_{cb}	G_c

5.3 General review of the Indian digital health care system

To keep up with the growth of digital technologies and to take advantage of the rapid adoption of technology in India to support a new digital ecosystem, the McKinsey Global Institute prepared a report in [63]. The report focuses on the potential of digitization and the collaboration between different private and public sectors to create more value, based on supporting economic and management decision making. The report studies and thoroughly reviews four sectors in India to benefit from potential digitization: agriculture, healthcare, retail, and logistics. In this research, we only focus on their report concerning the health care sector, which discusses the current situation of the healthcare system in India and offers excellent insight on how to reach a digital transformation based on available services. The main argument of the health care system section of the report is that India needs an improved health care system to avoid the increasing morbidity and mortality rates. The report concluded and categorized the main problems into:

- Access: the shortage of doctors, patients access to general care, high prices of premium insurance, high costs in general.
- Quality: extremely fragmented outcomes of providers, the results are not measured, poor channels of communication hinder sharing best practice and cause doctors and health practitioners to lose contact and follow-up with patients and finally the lack of specialists.
- Patient experience: low patient satisfaction due to lack of access to information such as the unknown doctors' and health practitioners' qualifications and quality of work, absence or failure of doctors to see the patient even with an appointment.

The report proposed a solution by recognizing three main tasks using practical digital technologies and innovation: Improve connectivity, automate routine tasks, and analyze patient data to improve care decisions.

5.3.1 Initial analysis of the report

It is essential to appreciate the role of a clear business model to understand the economic value of the digital transformation for healthcare solutions proposed in the report. In this initial analysis of the report, we recognize the five key business model elements referred to as ASOMG. The report in [63] presents 3 main exhibits in the healthcare section to illustrate the desired digital transformation. The first exhibit is a schema shown in Figure 5.2 (depicted from exhibit E8 in the report[63]). It shows how the Indian healthcare landscape would look in five to ten years after adopting digital applications. From the exhibit, we defined the main actors in the schema: patients, doctors, clinical staff, distributors, pharma companies, and Insurance companies.

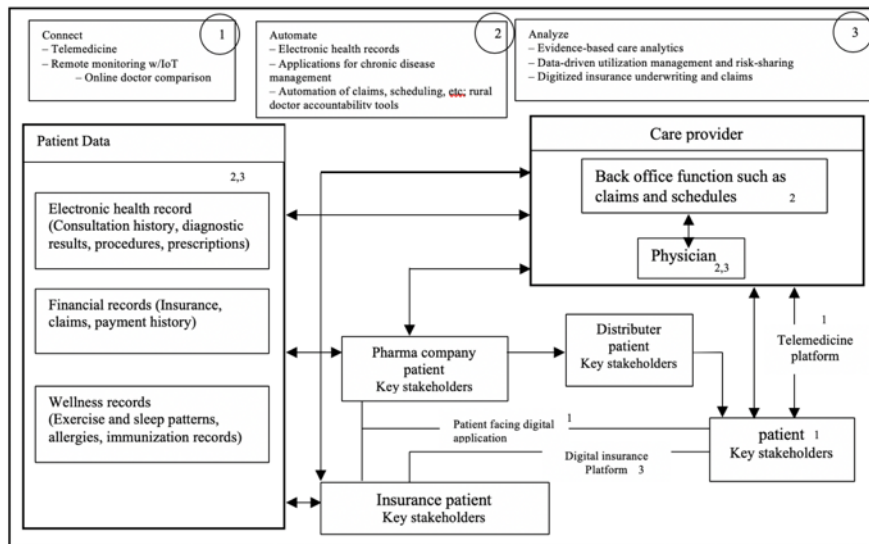


Figure 5.2: The schema shows how the Indian healthcare landscape would look in five to ten years after adopting digital applications.

It also shows the means used to achieve the proposed digital transformation. The means include applications and technologies such as patients facing digital appli-

cations, digital insurance platform, telemedicine platform, telemedicine, electronic health records, chronic disease management, and evidence-based care analytics. Other technology means include diagnostic devices, management apps (chronic diseases management apps, pharmacy mobile app), and wearable devices. Another exhibit demonstrates the patients’ experience in rural, remote clinics with health extension workers; we regard the flow as the “patient actions” or “business process.” Figure 5.3 shows the result of our initial analysis.

Services	<ol style="list-style-type: none"> 1. Telemedicine 2. Monitoring with IoT peripherals 3. Online doctor comparison 4. Automated Health record system 5. Automated Applications for chronic diseases management 6. Automation of claims and scheduling 7. Accountability tools 8. Evidence-based care analytics 9. Data-driven utilization management and risk sharing 10. Digitized insurance underwriting and claims
Data/Business objects	Patients data (electronic health records, financial records, wellness records)
Business goals	<ul style="list-style-type: none"> • better connecting people with services • automating routine tasks • analyzing patient data to improve care decisions • patient centric health care with integrated, seamless delivery of personalized health solutions. • Improve the quality of patient experience • Save time • Accelerate diagnosis and treatment • Cost effective • Changes in the digital driven new paradigm should enable care focusing on patients throughout their cycle of treatment, starting with pre-diagnosis. • Such digitally driven changes can save time, accelerate diagnosis and treatment, and make it simpler to manage chronic diseases at every step.

Figure 5.3: Key business model elements extracted

5.4 Developing ARM for the Indian digital health care system

In this section, we review the proposed health care system case by applying the ARM. Then in a later section, we evaluate the case based on the results. In Table 5.2, we show a simple ARM for the proposed digital health care system where the primary consumer is the patient, and the providers are doctors, clinic staff, distributors, pharma company and insurance companies. A number sometimes represents the

elements of the matrix; the number refers to their relation to services in Figure 5.3. According to the report, the goals of patients, doctors, and medical staff were specific while the goals of the distributor, pharma company, and insurance company were not specified clearly. We assumed some of the goals and requirements from the context of the report, but we believe that there is still a need to specify some clear goals and requirements (concerns to be addressed) to achieve a sound and precise analysis and transformation plan. Further evaluation of the case is presented in a later section. Table 5.2 elements can be summarised as shown in Figure 5.4

Table 5.2: ARM for the Indian digital health care system.

	Patient	Doctor	Clinic staff	Distributor	Pharma company	Insurance company
Patient	Patient's goals: -Increase Healthcare integrity. -Reduce cost. -Convenience. -Privacy.	-Accurate diagnosis -Accurate course of treatment and availability.	-Helping in checking in. -Leading to teleconsultation room. -Extracting records and recording vital signs and symptoms in anelectronic health record (EHR)	Not specific	Not specific but generally: Medication	Not specific but generally: Insurance
Doctor	Not specific but generally: experience and cooperation	Doctor's goals: -Aid in diagnosis and treatment (1,8) -Accuracy (4,5,2) -Convenience in communication and in sending and receiving data and health records(1,4)	-Extracted medical records. -Recorded vital signs. -initiating the video call	Not specific	Not specific but generally: Medication	Not specific but generally: Insurance
Clinic staff	-Required information for checking in the patient -Recorded vital signs and symptoms	- prescribed medication to be supplied to the patient directly from the clinic. -info about the next appointment to be followed. - full info of diagnosis and medication to be recorded on the (HER)	Clinic Staff Goals: reduce workload (4,5,6,7)	Not specific	Not specific but generally: Medication	Not specific but generally: insurance
Distributor	Not specific	Not specific	Not specific	Not specific but generally: automation	Not specific	Not specific
Pharma company	Not specific	Not specific	Not specific	Not specific	Not specific but generally: Increase in sales automation	Not specific
Insurance company	Not specific	Not specific	Not specific	Not specific	Not specific	Not specific but generally: Increase in sales & automation

Patient:
Intra elements ARM [Patient, Patient] are increase healthcare integrity, reduce cost, convenience, privacy.
Inter elements ARM [Patient, Doctor] are accurate diagnosis, accurate course of treatment and availability.
Inter elements ARM [Patient, Clinic Staff] are helping in checking in, leading to teleconsultation room, extracting records and recording vital signs and symptoms in an electronic health record (EHR)
Inter elements ARM [Patient, Distributer] is not specific
Inter elements ARM [Patient, Pharma Company] is not specific but generally Medication
Inter elements ARM [Patient, Insurance Company] is not specific but generally Insurance
Doctor:
Inter elements ARM [Doctor, Patient] is not specific but generally Experience and cooperation.
Intra elements ARM [Doctor, Doctor] are aid in diagnosis and treatment (1,8), accuracy (4,5,2), convenience in communication and in sending and receiving data and health records (1,4)
Inter elements ARM [Doctor, Clinic Staff] are extracted medical records, recorded vital signs, initiating the video call
Inter elements ARM [Doctor, Distributer] is not specific
Inter elements ARM [Doctor, Pharma Company] is not specific but generally Medication
Inter elements ARM [Doctor, Insurance Company] is not specific but generally insurance
Clinic staff:
Inter elements ARM [Clinic Staff, Patient] are required information for checking in the patient, recorded vital signs and symptoms
Inter elements ARM [Clinic Staff, Doctor] are prescribed medication to be supplied to the patient directly from the clinic, info about the next appointment to be followed and full info of diagnosis and medication to be recorded on the (HER)
Intra elements ARM [Clinic Staff, Clinic Staff] are reduce work load (4,5,6,7)
Inter elements ARM [Clinic Staff, Distributer] is not specific
Inter elements ARM [Clinic Staff, Pharma Company] is not specific but generally Medication
Inter elements ARM [Clinic Staff, Insurance Company] is not specific but generally insurance

Figure 5.4: ARM elements of the Indian digital health care system

5.5 ArchiMate model based on ARM elements

Based on the ArchiMate pattern of e-Health service [22] and using the ARM elements and the initial analysis of the digital healthcare case, we produced the following ArchiMate models to further review the services in the report. The model was divided into two parts; the first part shows the Digital health care system process and its relation to the healthcare staff, doctors, and patients, and the second part shows services provided by and used by actors. Note the assignment and association relation arrows. The ArchiMate model is shown in Figure 5.5 and Figure 5.6. Even though “executives” and their roles were not regraded as actors in the report, we deliberately and accordingly added “executive” as an actor in the model for reasons argued in section 5.6

5.6 General evaluation of the Indian digital health care system completeness based on ARM

ARM was proven to be useful in detecting missing requirements. In this section, we assess the completeness of the case study [63] using the ARM table approach and the

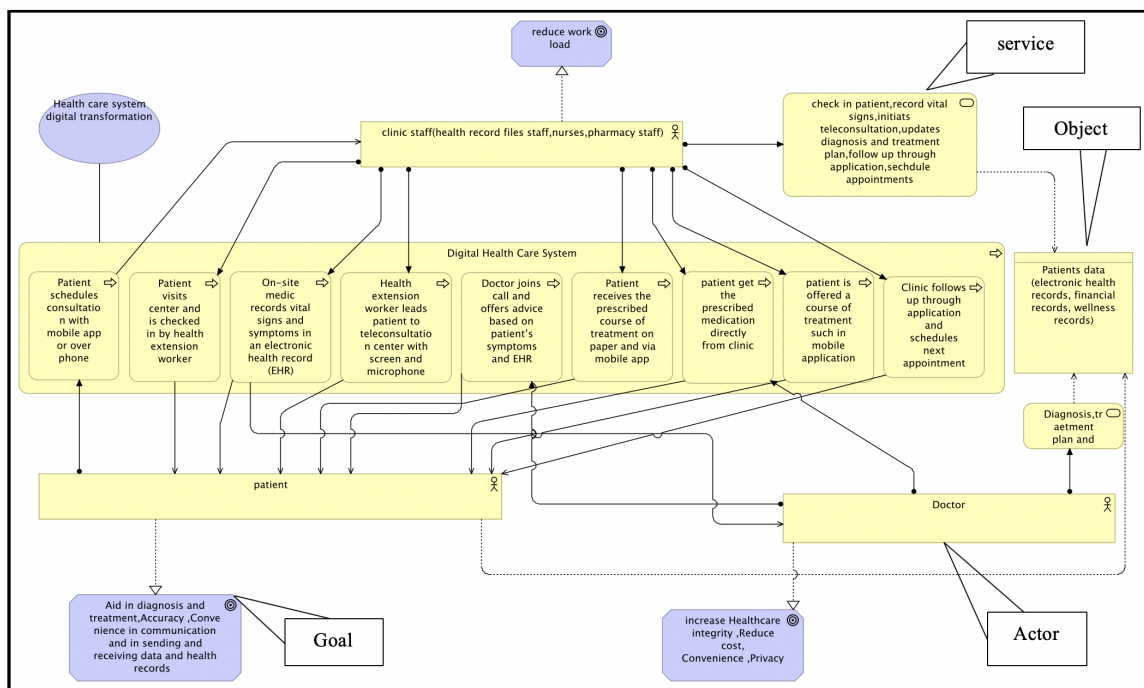


Figure 5.5: ArchiMate model for the Digital health care system process and its relation to actors

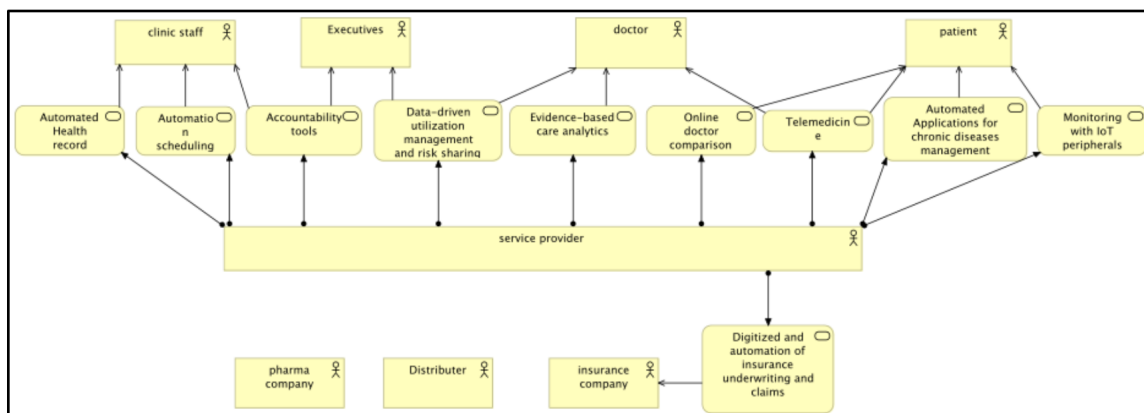


Figure 5.6: ArchiMate model for services provided by and used by actors

derived ArchiMate models. Then we propose some notes to support completeness of the requirements and goals based on the ARM analysis. We do not assume knowledge about the digitization of the Indian digital health care system, and we take the case merely as presented and described in the report. After presenting the ARM approach based on the landscape schema shown in the report in [63], we noticed the omission or the underemphasis of possibly vital actors, their roles, services, and their motives. The omissions are divided into:

- Missing actors in the landscape schema and their importance based on the report itself.
- Omissions in existing actors in the schema and the report.

5.6.1 Missing actors in the landscape schema and their importance according to the report itself

The case study addresses and mentions patients as consumers and doctors, clinical staff, distributors, pharma companies, and Insurance companies as providers; however, it does not address executives, service providers, diagnostic labs, specialists, hospitals (or health care facility as super-entity) and pharmacies. Based on the report's rationale, we argue that the report should consider other vital actors in their initial landscape schema, including the healthcare facilities as super-entities, executives, and service provider.

The report mentions the lack of chief executives engaged in digital initiatives (only 40% of chief executives at digital leaders) and how they should seize the benefits of digitization by correctly adapting their companies. In order to do so, the report should mention executives and legislators in more detail. While the schema and models presented show the digital means to achieve connection, automation, and analysis using digital platforms, it does not value the role of executives and their

vital involvement with distributor, pharma company and insurance companies and most importantly with relevant influencers, for their decisions about issues such as patient feedback. For this reason, the report should also provide a landscape of the proposed digitized healthcare system.

By looking at the ARM, the health care responses involved with the distributor, pharma company, and insurance company should be communicated to executives while patient feedback should reach executives directly. There is also a need to address the role of service providers in general. The report talked about different types of service providers, such as internet and mobile service providers, electronic health record providers, and health care providers. One of the goals of the digital health care system mentioned in the report is to achieve a new paradigm that will encourage integration between providers to personalize uniform health solutions; these providers are not mentioned in the schema to recognize dependencies, motives, and goals.

5.6.2 Omissions in existing actors in the schema and the report

The schema clearly shows the pharma company relationship with the distributor, physician, patient data ecosystem, insurance, and a patient-facing digital application. However, while creating the ArchiMate model from the ARM, we also noticed a missing mechanism for medication dispensing. In the report's redefinition of the primary health care model, the medication is dispensed directly from the clinic.

Also, the elements of concern to the pharma company are not clear such as their interest and expectation and their specific services to and from other actors such as doctors, clinical staff, and the insurance company. Other omissions include the insurance company concerns and expectations and their specific services to and from other vital actors; the report mentions the need to reduce insurance cost, but no

general analysis has been performed to achieve that goal. Finally, the distributors' goals and their specific services to and from other actors were also omitted from the general analysis.

5.7 Suggestions on achieving a digital transformation

The report's effort is to solve the main problems in the Indian health care sector, which, according to the report, is related to access, quality, and patients experience. The report also suggests that the solution is digitizing the system to remove the boundaries between the healthcare sector in order to create a more patient-centric health care system. The report explored some digital applications related to the tasks of automation, connection, and analysis.

In this section, we propose importing some system design enhancements and the technologies associated with addressing some of the related problems in the healthcare system mentioned in the report. We emphasize the aim of the report to achieve an integrated, personalized patient experience.

An e-health architecture is necessary to support the e-health services and to achieve the goals of the Indian healthcare system. The results from the survey presented in [69] show the importance of e-health strategies, organizational change, and appropriate technological infrastructure. It also shows that there is a rapid shift towards the development of the entire health system based on them.

Health care information systems could be classified as enterprise information systems because of their size and complexity. Therefore the design of frameworks and enterprise architecture can be used to reduce complexity and increase the adaptability and resilience of the information systems. With the continuous change surrounding systems such as social, political, and technology advances, there is a need to keep

up with the transformations in a consistent manner for a more resilient system [70]. That is why we suggest the use of customized application of enterprise architecture frameworks such as TOGAF ADM. The benefits can be observed in the successful cases of application of the TOGAF EA framework in healthcare systems in Australia and Canada [71]. A suitable application of the EA could be the adaptive integrated digital architecture (AIDAF) by Masuda et al.[72], which was proposed and verified in their case study where adaptive EA is aligned with IT strategy supporting mobile cloud, mobile IT and digital IT. There are also several efforts to achieve efficient IoT digital platforms at the middleware and application layer in the healthcare industry, such as in the “Open Healthcare Platform 2030 – OHP2030” (OHP2030) [73]. In the initiative of the open platform for healthcare-related IoT services, an AIDAF based model is proposed to achieve secure and efficient layer interoperability. Inter-operations occur when several systems are collaborating, where one system provides operations to the other to perform services and achieve goals. In healthcare systems, the collaboration should also be taken into consideration to achieve the important characteristic of enterprise interoperability [74].

Cloud computing infrastructure should be discussed to achieve the goals of the report of data management and accessibility and to address the issues presented in electronic health care systems such as data management and interoperability, [75].

There is also a need to address IoT based architecture to acquire and manage sensor data on the cloud. Some research could be referred to address efficiency in the cloud environment for a centralized architecture for the integration of IoT in healthcare systems such as the use of FOG computing [76]. Fog computing is proposed in [77] to ensure security and privacy for patients’ medical data.

We also propose a high-level design for the health information system to address previous issues. The high-level design of health care infrastructure and the ecosystem should be in a holistic and patient-centric manner where all the patient’s life stages

are taken into consideration in a lifelong healthcare system and a clear life cycle.

5.8 Summary

In this chapter, we reviewed the report on the proposal of digitization of the Indian Health care system. We extracted the elements of the business model ASOMG to perform the ARM analysis and then construct the ArchiMate model. The use of the resulting ARM facilitated the assessment of the completeness of the requirements. The report on the Indian health care system was created to inform about the current situation of the health system in India. The report proposed a brief plan to enhance and create a unified system focusing on the patient and using the contemporary technologies currently in use by the system. Our review showed some missing elements and requirements which could serve the goals of the report and an open opportunity to apply more system design enhancements and technologies such as Adaptive enterprise architecture frameworks.

Chapter 6

Thesis Summary and future work

We believe that the key to successful adaptive information systems is the improvement of business and operational models from the early stages of architecture and consistently over the system's growth. For this reason, we mainly consider the changes in operations and business models of enterprises in our research.

In this dissertation, we evaluate and review the EA adaptability features and elements and classification categories to gain some insight into and create our definition of adaptive EA. The evaluation is also useful in choosing the appropriate adaptive framework/s. The system must examine its requirements and goals against the elements and features in the evaluation to benefit from the evaluation adequately. Our definition of adaptive EA included general characteristics (key features) of the adaptive EA and the categories and elements of the chosen point of view or the point of view of interest (digital transformation in our case). In future work, we wish to create a more comprehensive definition for adaptive enterprise architecture to properly enable adaptation and to improve the adaptive capacity.

Based on our belief that certain natural language documents could be a factor in improving the adaptive EA, we found out that the ConOps is the ideal document for the basis of our research for many viable reasons. The main reason is its ability

to support EA because ConOps can play an essential role in bridging the current status where we want to move from to the desired status. Another reason is that ConOps clauses were easily mapped to ArchiMate elements. To understand ConOps we extracted its concepts and created a meta-model based on the IEEE 1362-1998 ConOps standard to base our mapping on and suggested the integration of TOGAF ADM iteration cycles and ConOps elements. To further improve the understanding of the relationship between ConOps and ArchiMate and to establish some facts about their relationship, we investigated and explained the relationship between ArchiMate concepts and ConOps levels and elements. Creating a ConOps document itself can be challenging because there is no exact technique to collect and analyze data. For this reason, we suggest using ArchiMate as a tool for analysis and communication.

On the same subject, we presented a mapping table between the concepts of ArchiMate and ConOps clauses based on the ontology definition. However, there is still a need for a complete definition of concepts found in domain-specific ConOps documents. We also presented a method to create ConOps based on ArchiMate by showing an example. Also, by using an experiment, we proved that using ArchiMate to represent ConOps increased accuracy and reduced difficulty.

To show that ConOps produced from ArchiMate is efficient (ease of communication), we introduced a case study where we create a new “man-hour management system” by creating the ArchiMate model first, then the ConOps clauses. The specifications of the system were communicated and specified quickly and smoothly.

Healthcare systems and e-health services are among the most critical sectors in information systems. In this dissertation, we presented a case study to highlight the role of the ARM in improving health care information systems. The healthcare system is regarded as an enterprise system because of its size and complexity.

We mainly addressed the complexity by analyzing the completeness of healthcare requirements, and we were able to review the report about the proposal of digitization

of the Indian Health care system in [63] successfully. The use of ARM facilitated the assessment of the completeness of the requirements; first, we extracted the elements of the business model ASOMG for the ARM analysis, and then an ArchiMate model was constructed. The report proposed a brief plan to enhance and create a unified system, focusing on patients and using the technologies currently in use by the system. Our review showed some missing elements and requirements which could serve the goals of the report better. The review also showed an open opportunity to apply more system design enhancements such as adaptive enterprise architecture frameworks.

There is still a need to propose rules and describe ArchiMate models from the ARM table. We hope to carry out more reviews and address extended issues concerning healthcare information systems using more adaptive EA methods and techniques.

To further ease communication and to achieve a better connection between ConOps and ArchiMate, we hope to create an accurate definition for the most used concepts defined by the ConOps document guidelines and a specific domain ontology and map them to ArchiMate concepts. There is also an opportunity to create a tool based on our definitions. The tool should aid in the process of creating a consistent ConOps document and automate the process of identifying concepts based on a set of rules using natural language processing and domain ontology to derive and generate the corresponding ArchiMate models. The recognition of lead words in ConOps could assist in automating the process in the future by creating domain ontologies from textual documents [14].

Appendix A

Questionnaire 1 for Problem 1

Group 1 (NL)

1. Name:-----

Date:23/5/2017

ConOps部1

5.3.4 インジェスト

インジェストは、Submission Information Package (SIP)

を受け取り、コンテンツ処理のためのSIPを準備する機能です。

主要なシステムコンポーネントと高位の相互接続:

Ingestは、SIPをAIPおよびACPに変換し、コンテンツパッケージをコンテンツ処理に転送します。将来のデジタルシステムの機能、機能、および特長:

- 適合するSIPを受け入れ、不適合なSIPを拒否しコンテンツが攝取されなかったことをGPO コンテンツエバリュエータに通知します。
- SIP メタデータが最小提出レベル要件を満たしていることを検証する。
- 一意のIDを受け入れるか割り当てます。
- メタデータを作成します。
- SIPをAIPに変換し、AIPをストレージに渡します
- SIPをACPに変換し、ACPをストレージに渡します

Q.1不適合SIP拒否なら通知されるのは誰ですか?

- ACPコンテンツ作成者
- GPOコンテンツマネージャ
- GPOコンテンツエバリュエーター

[English]

5.3.4 INGEST

Ingest is the function that accepts the Submission Information Package (SIP) and prepares the SIP for Content Processing. **Major System Components and High-Level Interconnection** Ingest transforms SIPs into AIPs and ACPs and transfers the Content Packages to Content Processing. **Capabilities, Functions and Features of the Future Digital System:**

- Accepts conforming SIPs, rejects non-conforming SIPs and notifies GPO Content Evaluator that content was not ingested.
- Validates that SIP metadata meets minimum submission level requirements.
- Accepts or assigns a Unique ID.
- Creates metadata.
- Transforms SIP into AIP and passes the AIP to storage.
- Transforms SIP into ACP and passes the ACP to storage.

Q.1 Who is notified in case of "Reject non-conforming SIP"?

- ACP Content Originator
- GPO Content Manager
- GPO Content Evaluator

ConOps部2

1.3 システム概要 将来のデジタルシステムは、GPOがコンテンツのインGEST 込み、管理、保存、およびアクセスを可能にするために必要な技術とビジネスプラクティスで構成されます。GPOは、電子コンテンツと非電子コンテンツの両方の管理が、ユーザーに最大の効率と価値を提供する統合プロセスでなければならないと考えています。GPOの顧客は、ハードコピーの出版物を入手できます。

Q.2 最大効率を実現するという目標を実現する原則は何ですか？

- 意味のある情報の場所と説明を含む、関連性が高く、有用で詳細な結果リストが作成されなければなりません。
- コンテンツの管理は統合されたプロセスでなければならない
- 将来のデジタルシステムは、検索と検索技術の業界標準を満たすか、それを超えなければなりません。

1.3 SYSTEM OVERVIEW

The Future Digital System will be composed of the necessary technology and business practices that will enable GPO to ingest, manage, preserve, and provide access to content. GPO believes that management of both electronic and non-electronic content should be an integrated process that provides maximum efficiency and value for users, GPO customers will be able to obtain hard copy publications...

Q.2 What's the principle that realizes the goal of providing maximum efficiency?

- Technology should produce a highly relevant, usable, and detailed results list that includes the location and description of meaningful information.
- Management of content should be integrated process
- Future digital system should meet or exceed industry standards for search and retrieval technology.

ConOps 部3

4.1変更の正当性 2004年6月のGAO（General Accounting Office）報告書で繰り返し議論された2つの重大な弱点は、「新製品とサービスの提示」と「顧客ニーズへの対応」であり、現在および将来の多くの要件がGPOで満たされていないことを示しています。代理店が直面する問題の1つは、これらのサービスやその他のサービスがよく知られておらず、その結果、フュージティブ（一時的な）・ドキュメントが作成されるということです。GPOは現在のテクノロジーに追いつくことができませんでした。

ConOps Portion 3

4.1 JUSTIFICATION FOR CHANGES Two significant weaknesses repeatedly mentioned in the General Accounting Office (GAO) report to Congressional Addressees of June 2004 are “presentation of new products and services” and “responsiveness to customer needs,” indicating that many current and future requirements are not being satisfied by GPO. One of the problems facing the agency is that these and other services are not well known, with the result that fugitive documents are created. GPO has been unable to keep pace with current technologies.

Q3:なぜフュージティブ（一時的な）・ドキュメントが発生するのですか

- A. GPOが顧客のニーズに対応できない
- B. 顧客ニーズへの対応に問題がある
- C. GPO がサービスを認知させることに失敗している
- D. GPOが現在の技術に追いついていない
- E. GPOが顧客のニーズをよく知ることができていない

Q3:Why do fugitive documents occur?

- A. Because of GPO unable to keep up with customer needs
- B. Because of the problem with responsiveness to customer need
- C. Because of GPO failure to make services known
- D. Because of GPO unable to keep pace with current technology
- E. Because of GPO failure to make customer need well known

Q.4タスクはどれくらい難しいですか？次の中から選んでください。(How difficult was the task?)

- 非常に簡単/very easy
- 簡単/easy
- 難しい/difficult
- 非常に難しい/very difficult

Q.5どのConOpsの例の部分が混乱していましたか？混乱した例の記号に○をつけてください(Which ConOps portion example was most confusing?)

- Q1
- Q2
- Q3

Appendix B

Questionnaire 2 for Problem 1

Group 2 (ML)

Group 1. Name:-----

Date:23/5/2017

ConOps部3

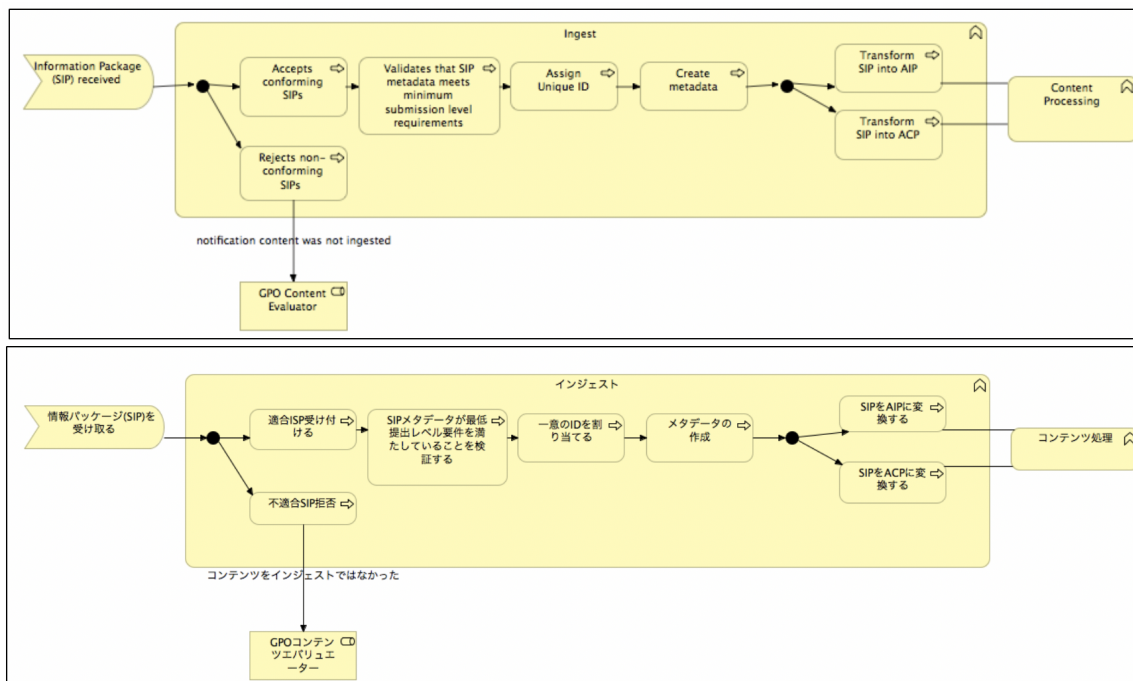


Figure B.1: (5.3.4):Ingest business process

Q.1不適合SIP拒否なら通知されるのは誰ですか？

- ACPコンテンツ作成者
- GPOコンテンツマネージャ
- GPOコンテンツエバリエーター

Q.1Who is notified incase non-conforming SIP is rejected?

- ACP Content Originator
- GPO Content Manager
- GPO Content Evaluator

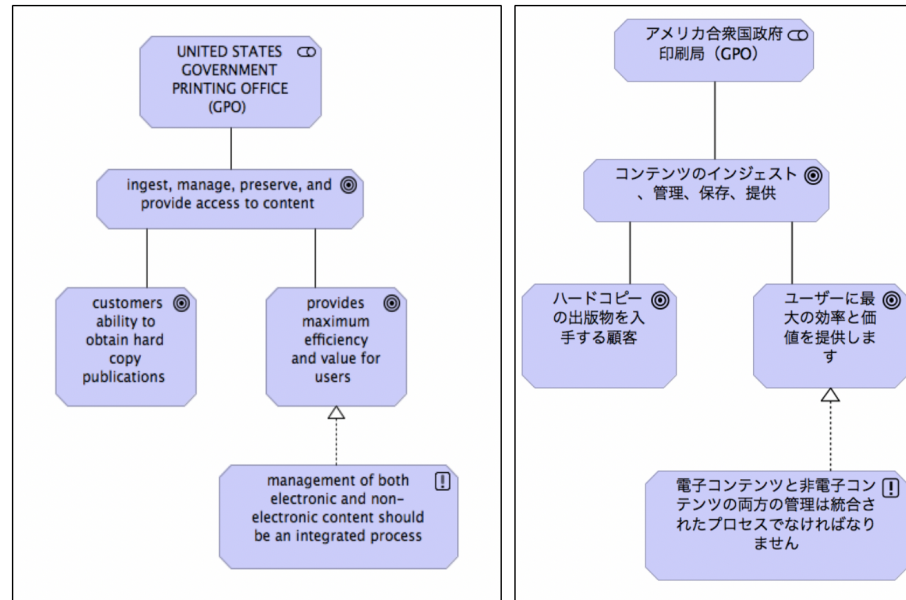


Figure B.2: (1.3) System Overview

Q.2最大効率を実現するという目標を実現する原則は何ですか？

- 意味のある情報の場所と説明を含む、関連性が高く、有用で詳細な結果リストが作成されなければなりません。
- コンテンツの管理は統合されたプロセスでなければならない
- 将来のデジタルシステムは、検索と検索技術の業界標準を満たすか、それを超えなければなりません

Q.2What's the principle that realizes the goal of providing maximum efficiency?

- Technology should produce a highly relevant, usable, and detailed results list that includes the location and description of meaningful information.
- Management of content should be integrated process
- Future digital system should meet or exceed industry standards for search and retrieval technology.

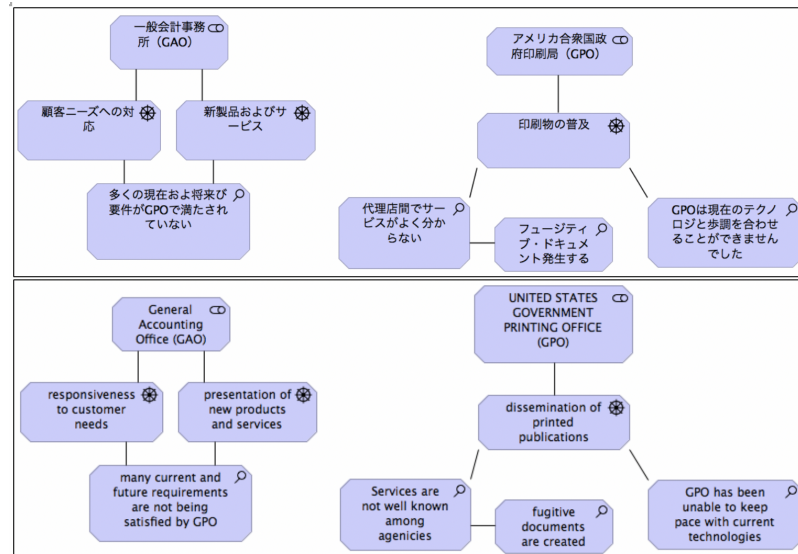


Figure B.3: (4.1) Justification for changes

Q3.なぜフュージティブ（一時的な）ドキュメントが発生するのですか？

- GPOが顧客のニーズに対応できない
- 顧客ニーズへの対応に問題がある
- GPO がサービスを認知させることに失敗している
- GPOが現在の技術に追いついていない
- GPOが顧客のニーズをよく知ることができていない

Q3.Why do fugitive documents occur?

- Because of GPO unable to keep up with customer needs
- Because of the problem with responsiveness to customer need
- Because of GPO failure to make services known
- Because of GPO unable to keep pace with current technology
- Because of GPO failure to make customer need well known

Q.4 タスクはどれくらい難しいですか？次の中から選んでください(How difficult was the task?)

- 非常に簡単/very easy
- 簡単/easy
- 難しい/difficult
- 非常に難しい/very difficult

Q.5 どのConOpsの 例の部分が混乱していましたか？混乱した例の記号に○をつけてください(Which ConOps portion example was most confusing?)

- Q 1
- Q 2
- Q 3

Appendix C

Questionnaire 3 for Problem 2

Group 1 (ML)

Group 1. Name:-----

Date:23/5/2017

Q.1 次のページのArchiMateモデルを見て、各図を適切なConOps要素 (ConOpsの文書IEEE Std 1362™-1998) と照合してください。各ConOpsドキュメント要素を表す数字を1つ選んでください: (Match each ConOps element in the table below to the appropriate figure)

ConOps要素 Element	図 picture
Q.1 4.1正当化と変更理由: a) ユーザーのニーズの新しい側面または変更された側面を要約します 4.1 Justification and reason of changes: a) Brief summaries new or modified aspects of the users needs	
Q2. 5.3提案されたシステム: 機能の記述:この節には、提案されたシステムの記述の主要部分が含まれる d) 提案されたシステムの機能または機能 5.3 Proposed system: description of a function: This sub clause will contain the major portion of the description of the proposed system: d) Capabilities or functions of the proposed system;	
Q.3 1.3システムの概要: このサブクラスには、提案されたシステムまたはサブシステムの目的が簡単に記載されています (主要目標) 1.3 System Overview: This sub clause briefly states the purpose of the proposed system or subsystem to which the ConOps applies (Major Goals)	
Q.4 3.現在のシステムまたは状況: 3.1背景、目的、範囲: このサブセクションは、現在のシステムまたは状況の概要を提供します。このサブセクションでは、現在のシステムの動機付けの概要を説明する必要があります。現在のシステムの目標と動機を記述します。 3.1.1現行システムの分析3.1.2現行システム: 新しいシステムの動機 3.Current system or situation: 3.1 Background, objectives, and scope: This sub clause provides an overview of the current system or situation, this sub clause should provide a brief summary of the motivation for the current system:Goals and motivations of current system. 3.1.1Analysis of current system 3.1.2 Current system: Motivation for new system	
Q.5 3.現在のシステムまたは状況:3.3現在のシステム: 現在のシステムの説明: この節には、現行のシステムまたは状況の説明が記載されています。 a) 運用環境とその特性b) 主要なシステムコンポーネントとそれらのコンポーネント間の相互接続。 3.Current system or situation: 3.3 Current system: Description of current system: This sub clause provides a description of the current system or situation, including the following, as appropriate: a) The operational environment and its characteristics; b) Major system components and the interconnection among those components;	

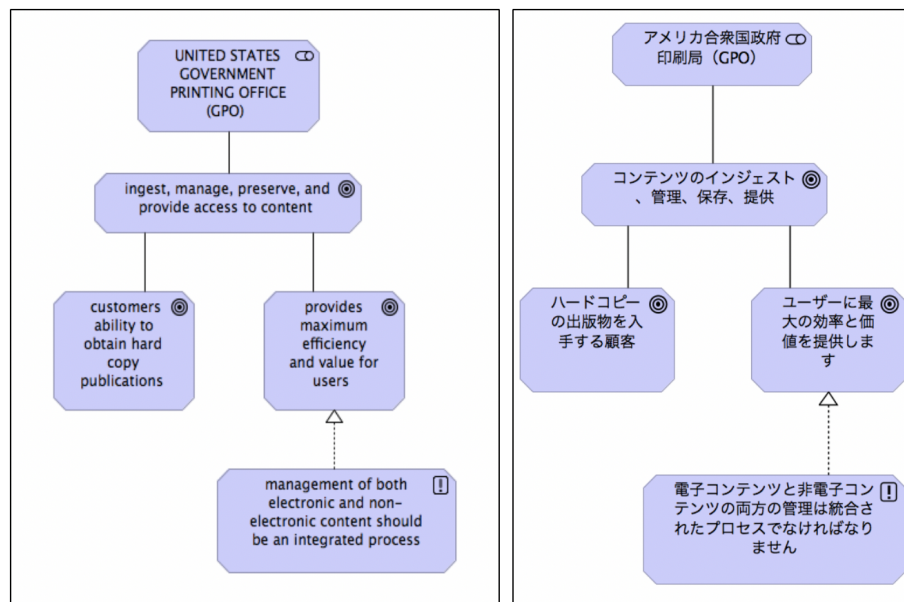


Figure C.1: Figure 1

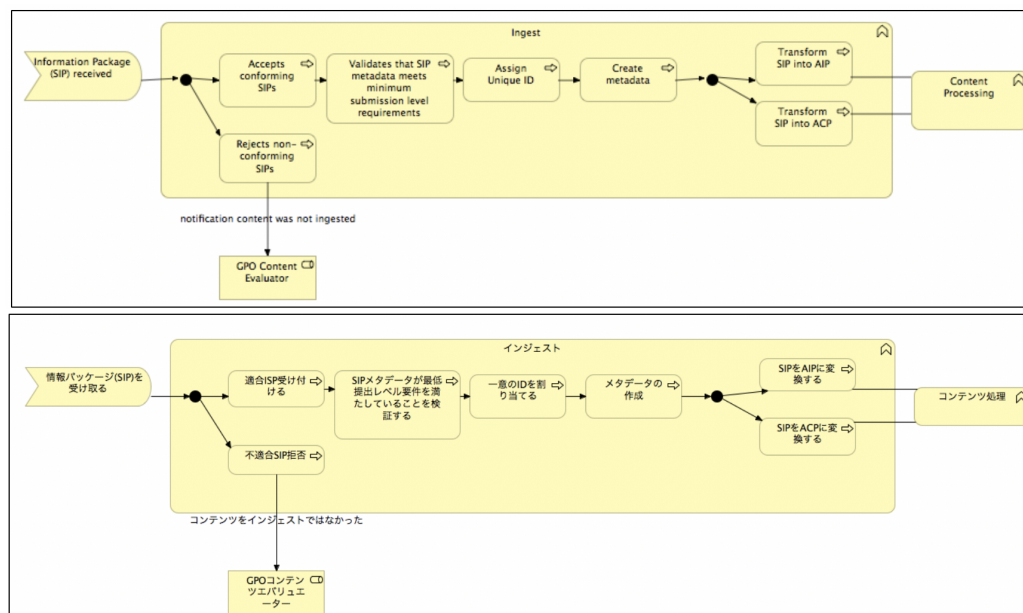


Figure C.2: Figure 2

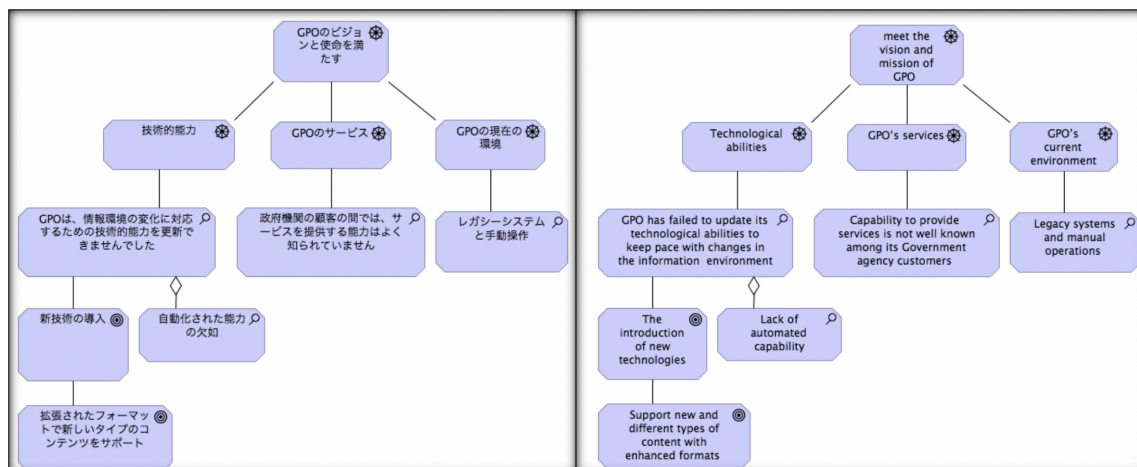


Figure C.3: Figure 3

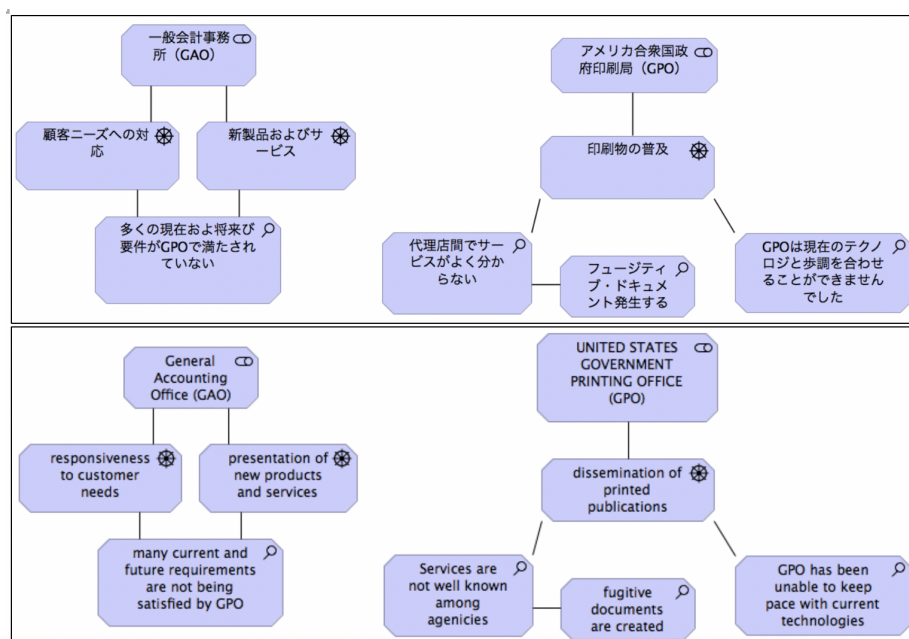


Figure C.4: Figure 4

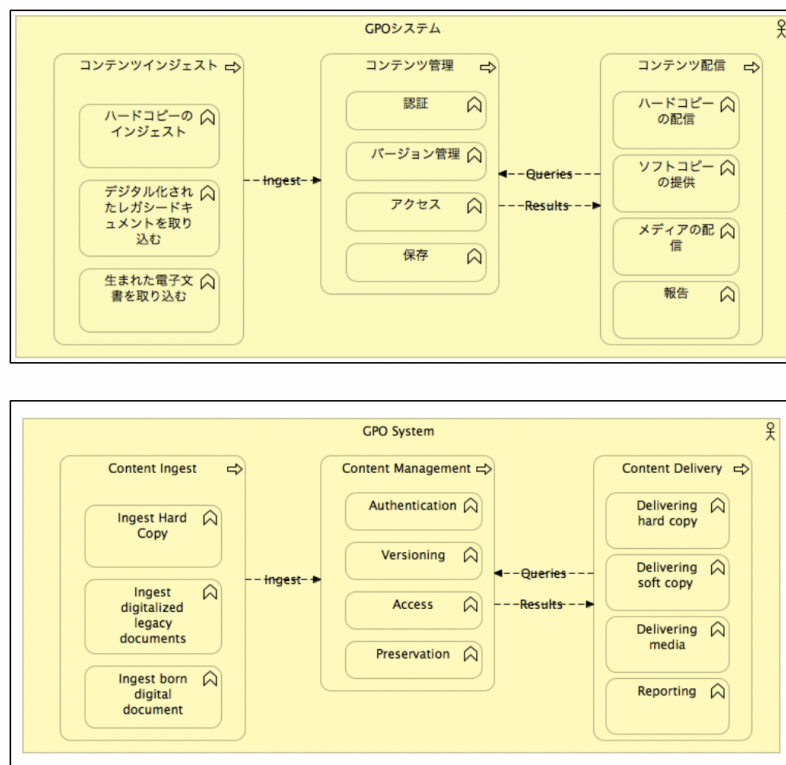


Figure C.5: Figure 5

Q.6 タスクはどれくらい難しいですか？次の中から選んでください(How difficult was the task?)

●非常に簡単/very easy ●簡単/easy ●難しい/difficult ●非常に難しい/very difficult

Q.7 どの ConOpsの要素が混乱していましたか(Which ConOps element was most confusing?)

● Q1 ● Q2 ● Q3 ● Q4 ● Q5

Appendix D

Questionnaire 4 for Problem 2

Group 2 (NL)

Q1. ConOpsはIEEE Std 1362TM-1998を文書化しています。ConOps要素に合うように、表2の例に対する記号（AE）から選んで、表1の記号欄に記入してくださいPlease match the following ConOps elements to the appropriate ConOps portion to the best of your knowledge. 表1

ConOps要素 Element	記号 Portion
Q1. 4.1正当化と変更理由： a) ユーザーのニーズの新しい側面または変更された側面を要約します 4.1 Justification and reason of changes: a) Brief summaries new or modified aspects of the users needs	
Q2. 5.3提案されたシステム: 機能の記述:この節には、提案されたシステムの記述の主要部分が含まれる d) 提案されたシステムの機能または機能5 3 Proposed system: description of a function: This sub clause will contain the major portion of the description of the proposed system: d) Capabilities or functions of the proposed system;	
Q3. 1.3システムの概要：このサブクラスには、提案されたシステムまたはサブシステムの目的が簡単に記載されています（主要目標） 1.3 System Overview: This sub clause briefly states the purpose of the proposed system or subsystem to which the ConOps applies (Major Goals)	
Q4. 3.現在のシステムまたは状況：3.1背景、目的、範囲：このサブセクションは、現在のシステムまたは状況の概要を提供します。 このサブセクションでは、現在のシステムの動機付けの概要を説明する必要があります。現在のシステムの目標と動機を記述します。 3.1.1現行システムの分析3.1.2現行システム： 新しいシステムの動機 3.Current system or situation: 3.1 Background, objectives, and scope: This sub clause provides an overview of the current system or situation, this sub clause should provide a brief summary of the motivation for the current system:Goals and motivations of current system. 3.1.1Analysis of current system 3.1.2 Current system: Motivation for new system	
Q5. 3.現在のシステムまたは状況：3.3現在のシステム： 現在のシステムの説明：この節には、現行のシステムまたは状況の説明が記載されています。 a) 運用環境とその特性b) 主要なシステムコンポーネントとそれらのコンポーネント間の相互接続。 3.Current system or situation: 3.3 Current system: Description of current system: This sub clause provides a description of the current system or situation, including the following, as appropriate: Ex: a) The operational environment and its characteristics; b) Major system components and the interconnection among those components;	

記号	ConOps例の説明 Portion
A	<p>将来のデジタルシステムは、GPOがコンテンツの摂取、管理、保存、およびアクセスを可能にするために必要な技術とビジネスプラクティスから構成されます。 GPOは、電子コンテンツと非電子コンテンツの両方の管理が、ユーザーに最大の効率と価値を提供する統合プロセスでなければならないと考えています。 GPOの顧客は、ハードコピーの出版物を入手できます“The Future Digital System will be composed of the necessary technology and business practices that will enable GPO to ingest, manage, preserve, and provide access to content. GPO believes that management of both electronic and non-electronic content should be an integrated process that provides maximum efficiency and value for users. GPO customers will be able to obtain hard copy publications...”</p>
B	<p>現在の環境の説明：</p> <ul style="list-style-type: none"> ●コンテンツ取り込み：ハードコピー、デジタル化レガシードキュメント、生まれたデジタルドキュメント。 ●コンテンツ管理：認証、バージョン管理、アクセス、および保存 ●コンテンツ配信：ハードコピー、ソフトコピー、およびメディア <p>“Description of current environment”: Content ingest:</p> <ul style="list-style-type: none"> ●hard copy, digitized legacy documents, born digital document. ●Content management: Authentication, versioning, access, and preservation ●Content delivery: hard copy, soft copy, and media”
C	<p>GPOのサービスを提供する能力は、その顧客の間ではよく知られていません。さらに、GPOは、変化に対応するために技術的能力を更新することができず、その結果、ニーズに対処するためにテクノロジーを更新する必要があります。GPOの現在の環境は、レガシーシステムと手動操作で構成されています。拡張されたフォーマットで新しいタイプのコンテンツをサポートする新しいテクノロジーの導入が必要です。自動化能力の欠如。</p> <p>“GPO’s capability to provide services is not well known among its customers. Additionally, GPO has failed to update its technological abilities to keep pace with changes and as a result it must update its technology to address the needs. GPO’s current environment consists of legacy systems and manual operations. There should be an Introduction of new technologies that support new and different types of content with enhanced formats; a lack of automated capability”</p>
D	<p>2004年6月のGAO (General Accounting Office) 報告書で繰り返し議論された2つの重大な弱点は、「新製品とサービスの提示」と「顧客ニーズへの対応」であり、現在および将来の多くの要件がGPOで満たされていないことを示しています。代理店が直面する問題の1つは、これらのサービスやその他のサービスがよく知られておらず、その結果、フュージティブ（一時的な）ドキュメントが作成されるということです。 GPOは現在のテクノロジーに追いつくことができませんでした</p> <p>“One of the problems facing the agency is that these and other services are not well known, with the result that fugitive documents are created. GPO has been unable to keep pace with current technologies. Two significant weaknesses repeatedly mentioned in the General Accounting Office (GAO) report to Congressional Addressees of June 2004 are “presentation of new products and services” and “responsiveness to customer needs,” indicating that many current and future requirements are not being satisfied by GPO.”</p>
E	<p>Ingestは、SIPをAIPおよびACPIに変換しコンテンツパッケージをコンテンツ処理に転送します。</p> <p>将来のデジタルシステムの機能、機能、および特長：</p> <ul style="list-style-type: none"> ・適合するSIPを受け入れ、不適合なSIPを拒否し、コンテンツが摂取されなかったことをGPOコンテンツエバリュエータに通知します。 ・SIPメタデータが最小提出レベル要件を満たしていることを検証する。 ・一意のIDを受け入れるか割り当てます。 ・メタデータを作成します。 ・SIPをAIPに変換し、AIPをストレージに渡します。 ・SIPをACPIに変換し、ACPをストレージに渡します <p>“Ingest function:</p> <ul style="list-style-type: none"> ● Accepts conforming SIPs, Rejects non-conforming SIPs and notifies GPO Content Evaluator that content was not ingested. ● Validates that SIP metadata meets minimum submission level requirements ● Accepts or assigns a Unique ID, creates metadata, Transforms SIP into AIP and passes the AIP to storage ● Transforms SIP into ACP and passes the ACP to storage.”

Q.6 タスクはどれくらい難しいですか？次の中から選んでください(How difficult was the task?)

●非常に簡単/very easy ●簡単/easy ●難しい/difficult ●非常に難しい/very difficult

Q.7 どの ConOpsの要素が混乱していましたか.(Which ConOps element was most confusing?)

● Q1 ● Q2 ● Q3 ● Q4 ● Q5

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