A HEALTHY ARCHITECTURE FOR MUNICIPAL CARE

Creating a reference architecture for municipal care in the Netherlands

THESIS META-INFORMATION

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ABSTRACT

Municipal care organizations in the Netherlands each take care of public health in one of 28 regions. Currently these organizations are incapable of providing a seamless customer experience due to the lack of interoperability. The problem of interoperability is not unique for the care sector and occurs in many contexts. Research shows that the problems that need to be tackled to achieve interoperability have to do with semantics and business-IT alignment. This research aims to provide a reference architecture that ensures interoperability within municipal care organizations. This is achieved by implementing enterprise architecture at a single municipal care organization which will be the unit of analysis. From the lessons learned in this context the problem is cast onto the problem class of chain computerization. A reference architecture is created by bringing the problems described in literature together with the solutions applied in the research context. This reference architecture provides normative principles for implementing enterprise architecture at municipal care organizations. Applying these principles will help the organization formalize the internal processes and information flow. The service oriented nature of enterprise architecture will then enable the identification and realization of possible interfaces between organizations and organizational units. By identifying the information objects used throughout the organization and modeling these in a corporate concept data model (CCDM) redundancy can be reduced while reusability of information increases. This eventually leads to central concepts such as “customer” which is the same throughout the organization. Services for such a customer now share this concept so that they become uniform and customer centric. Other concepts and their attributes can then be related and traced back to each other so that interoperability between processes and their resulting services may be achieved, increasing efficiency, information integrity and a better customer experience.

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CONTENTS

1 INTRODUCTION

In this introduction the organizational context is described after which the problem occurring in this context is defined. Once the problem statement is given the research question which aims to alleviate this problem is formulated. In order to answer the research question in a structured manner a research method is adopted. The chosen research method is action design research (ADR), which aims at co-creating an artifact from interaction of the researcher with his environment. This method will be followed throughout this document and will be elaborated upon after the research question is formulated. The rest of this document is structured according to the stages described in the research method, starting with a chapter on related literature, followed by the research results, the conclusion and finally the discussion of this research.

1.1 MUNICIPAL CARE

Municipal care organizations in the Netherlands carry out the tasks specified by the Public Health Act. All 28 municipal care organizations are obligated to deliver the following services described by this act:

- Child health care
- Environmental health
- Socio-medical advice
- Periodic sanitary inspections
- Public health for asylum seekers
- Medical screening
- Epidemiology
- Health education
- Community mental health

The main goal of municipal care is to prevent and protect the health of the civilians in their region (GGD Nederland). There are currently 28 such regions throughout the Netherlands, they are depicted in Figure 1. Local government of municipalities is responsible for the continuity and coherence of the public health care. The local government may formulate their own public health policy which may require additional public health services for the civilians living in the municipality. Because of this there is not only a differentiation between the different municipal care organizations in the services they provide, but also from municipality to municipality within the region of a single municipal care organization. The local policies are also shaped by input from municipal care organizations. For instance, in an area where obesity has high prevalence counter measures may become part of the local policy. Measurements on which such high prevalence is based may also come from municipal care organization's monitoring activities. These monitoring features incorporate epidemiologic research and information from other services such as child health care. Based on these measurements municipal care organizations shape their prevention policy, help shape the policy of the local government and benchmark between different areas. Of course different environmental factors also influence the local policies and thus the service of municipal care organizations.

FIGURE 1: REGIONS PER MUNICIPAL CARE ORGANIZATION (RIVM, 2012)

Along with the services described above the municipal care organizations also play an important role in the case of crises, disasters or fires. In these situations the municipal care organizations play a coordinating role in which they work closely with the police and fire department. These chain partners are organized in 25 safety regions. To achieve congruence between the municipal care organizations and the safety regions a change of the Public Health Act force the number of municipal care organizations down to 25. This means that 3 mergers of municipal care organizations must take place, integrating their services into a single organization. The close collaboration with chain partners in the case of extraordinary events also demands that processes and information can cross organizational boundaries. Because the municipal care organization has the coordinating role in this chain, they are also responsible for the implementation of plans and processes which allow for seamless cooperation among chain partners.

While each municipal care organization provides services in a certain geographic area, some measurements must be aggregated to provide insight about the status of nationwide health. This means that information must flow from individual municipal care organizations to nationwide (governmental) institutions. An example is the information generated by municipal care organizations that provide sex education and test for sexually transmitted diseases (STDs). The number of people seen and the percentage of positive test results are aggregated to get a nation-wide view on sexual health. These measurements can once again, just like on a local level, be used to formulate national policy and benchmark between areas.

This illustrates that the responsibilities of municipal care organizations are diverse and require information across organizations and organizational units on different abstraction levels. The information generated by providing a service to the individual may also be required to create an entirely different service for the local municipal government. This use and reuse of information by the organization leads to complexities which will be illustrated in the following section.

1.2 PROBLEM DEFINITION

Municipal care offers a wide range of care services/products (the terms product and service are used interchangeably in this thesis) for the local population and (local) chain partners. While the same customer or patient may obtain multiple products from the diverse focus areas of the municipal care provider, these patient/product combinations usually are and remain in a vacuum on their own. In other words, each product that requires patient information relies on its own information system with its own instance of the particular information required. Not only does the process rely on its own system for storing information, the process itself is also "unique" for most products. The result is that interoperability of information and generic processes are not implemented for use within the municipal care sector. This means that the information of a single customer or patient resides in multiple isolated systems. A complete view of the information is therefore impossible, information stored redundant in multiple systems. The customer may be asked for the same information for each service he or she receives while it is not updated for the other services due to the disparate nature of the information systems. But also on a regional or nation-wide view the different information cannot be aggregated to provide a current status of public health in the area.

The urgency of reformation towards a more versatile and efficient care sector is largely due to governmental changes. The most important change for the municipal care sector in the Netherlands is that local governments will get more responsibilities whilst their budgets do not grow in tandem with these responsibilities. This means that the same or more work has to be done with less money. To achieve the same results with less money efficiency must be improved; eliminating redundant and isolated information islands may be a starting point. By eliminating information islands the right information should be available for the professional providing a certain service in a timely manner. An example of the growing responsibility of municipal care organizations is the role they play in the case of crises, disaster and fire. In such an event the municipal care organization should be able to coordinate the care and security chain and the organizations involved. To do so information must be made available between organizations cooperating in these extraordinary events. Another trigger is a recent report which concludes that information technology that has been applied by the care sector in previous years did not yield the desired effects (Inspectie Gezondheidszorg (IGZ), 2011). According to Detmer, many shortcomings resulting in poor quality of care are due to inaccessible data, information, and knowledge (Detmer, 2003). An example of such a shortcoming in the Dutch care market is the current integration of medicine registration information systems within the primary care, which did not prevent potentially lethal medication errors (Visser, 2011). Interoperability on a business level is not yet realized and seems mandatory for successful integration of care. Without this, lives may be lost due to errors resulting from this sub-optimal care chain.

In short, the problem can be stated as follows: Current use of information sources in municipal care organizations is lacking interoperability which leads to inefficiency and difficulties accessing the right information in a timely manner.

1.3 Research Question

In order to alleviate the lack of interoperability causing inefficient processes and incompatible information flow in municipal care organizations, a solution needs to be constructed. This solution will be an artifact that must deal with the integration of processes and information within the organization, after which information flow across the boundaries of the organization may be addressed as well. The created artifact will be a reference architecture. This reference architecture refers to the best practices and lessons learned of successful enterprise architecture in a municipal care organization. To create this artifact the following research question needs to be answered:

What does the reference architecture of a chain-integrated care provider look like?

Chain-integrated is used here instead of interoperability because interoperability can be viewed as a means and the chain-integrated organization as an end. The idea here is that a chain-integrated municipal care organization will be able to perform more efficient because the information islands are eliminated and incorporated in the value chain. This way information required by the professional to provide high quality service should be made available in a timely manner. To create this reference architecture of a chain-integrated care provider a research method is used which will be described in the following section.

1.4 Research Method

The method adopted for this research is the relatively new Action Design Research (ADR) (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). ADR is a type of Design Research (DR) which focusses on delivering an artifact; a construct, a model, a method, or an instantiation (Hevner & Chatterjee, 2010). The reference architecture this research aims to develop can be viewed as the artifact which is the object to be conceived in both ADR and DR. One of the most important differences of ADR compared to Hevners Design Research is the integration of the relevance and design cycle as shown in **Figure 2**. Because creating a reference architecture for the different care domains is an iterative process where the researcher co-operates with the organization, building, intervening and evaluating it concurrently, ADR is more suitable than DR.

1.4.1 The stages of Action Design Research

The ADR method consists of four stages. These stages are followed as prescribed by the method and will form the outline of this research. In this section the four stages and their interrelation are described, including the tasks that have to be carried out in each separate stage.

1.4.1.1 Stage one

The first stage is the Problem Formulation. In this stage the research opportunity is identified and conceptualized. It should be kept in mind that the problem encountered is an instance of a class of problems. From this perspective it should be understood that a solution for the specific problem should hold abstract content which addresses the broader class of problems. But this does not mean that the specific problem has to be solved. The entire enterprise should be considered a knowledge-creation opportunity. The different tasks in the first stage can be formulated as follows:

- Identify and conceptualize the research opportunity
- Formulate initial research questions

- Cast the problem as an instance of a class of problems
- Identify contributing theoretical bases and prior technology advances
- Secure long-term organizational commitment
- Set up roles and responsibilities

1.4.1.2 STAGE TWO

The second stage is Building, Intervention, and Evaluation(BIE). This stage contains cycles that iterate the development of the artifact. This means that different versions of the artifact are evaluated together with the practitioners and end-users, which provides feedback for the following iteration. During these iterations the researcher can adopt a more high-level view or a low-level approach and use these different perspectives to reflect on the artifact. The different tasks in the BIE stage can be formulated as follows:

- Discover initial knowledge-creation target
- Select or customize BIE form
- Execute BIE cycle(s)
- Assess need for additional cycles, repeat

1.4.1.3 STAGE THREE

The third stage, Reflection and Learning, is a continuous process in which the researcher uses the learning and solutions of the specific problem to conceptualize how they can be applied to a broader class of problems. This incorporates insights from the theory-ingrained artifact of stage one, as well as the insights from organizational use and evolution from stage two. The different tasks in the Reflection and Learning stage can be formulated as follows:

- Reflect on the design and redesign during the project
- Evaluate adherence to principles
- Analyze intervention results according to stated goals

1.4.1.4 STAGE FOUR

The fourth and final stage is Formalization of Learning. This is where the insights are translated into general solution concepts for the class of problems. The accomplishments of the artifact in the organizational context are described to formalize the learning. The different tasks in this final stage can be formulated as follows:

- Abstract the learning into concepts for a class of field problems
- Share outcomes and assessment with practitioners
- Articulate outcomes as design principles
- Articulate learning in light of theories selected

- Formalize results for dissemination

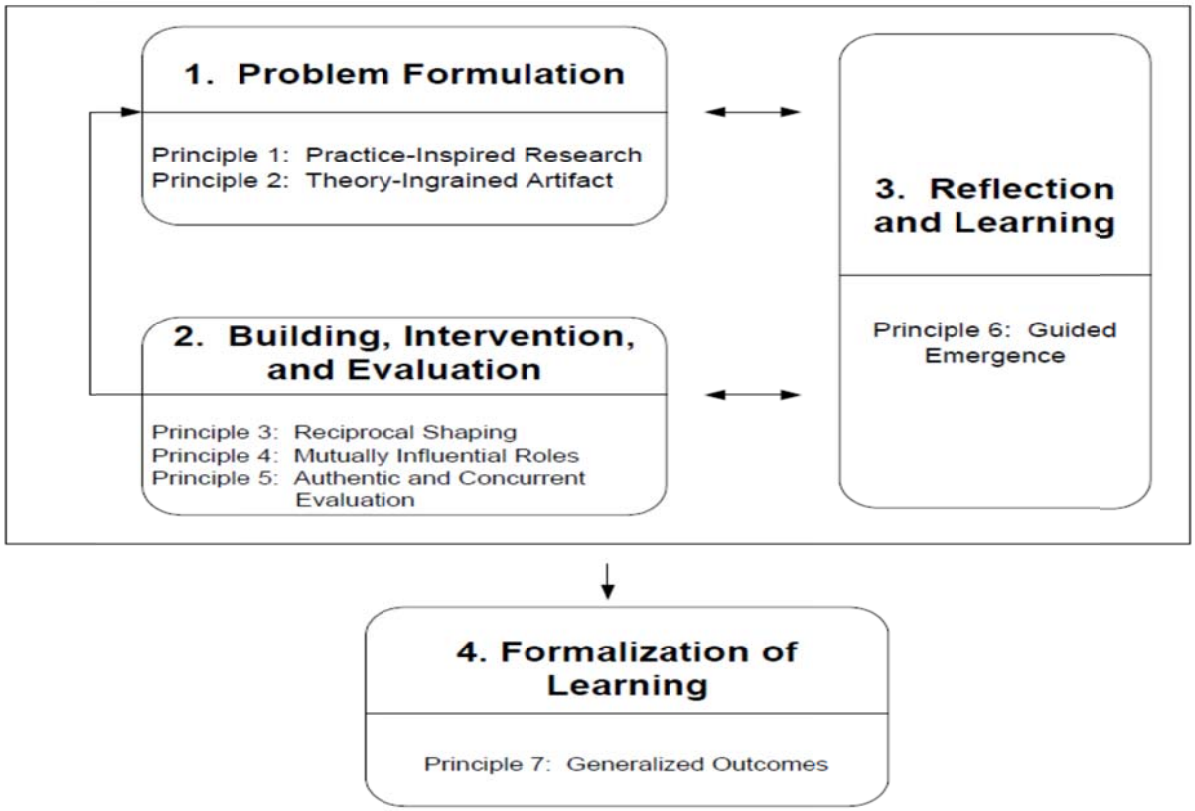


Figure 2: Action design research: stages and principles

Now that the first tasks of the stage one are executed in 1.2 and 1.3, we will continue with the tasks "Cast the problem as an instance of a class of problems" and "Identify contributing theoretical bases and prior technology advances" in the following chapter.

2 RELATED LITERATURE

In this chapter the main concepts for the problem domain and how these concepts are related shall be described. This is the result of the activities “Cast the problem as an instance of a class of problems” and “Identify contributing theoretical bases and prior technology advances” from stage one of the research method (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). In order to place the problem in a scientific background a conceptual position has to be formulated. For this purpose Google Scholar will be used to search for relevant literature on the different concepts. Because the concepts are not always clear cut and standardized semantics of describing the problem are few and far between, a constrained snowball sampling search procedure shall be followed. The nature of Action Design Science is focused on iteration and dynamic insight development so this shall be reflected in the literary study as well. As a starting point we will search for the “integrated care” challenge and the problems identified in this context. References in the documents and the documents referencing to the literature may be included. From there on an abstraction of the identified problems shall be formulated as generic as possible. This generic problem formulation can be used to identify how it may be addressed in different contexts, such as the care sector. Moreover, this generic problem formulation defines the class of problems from which the case study should be an instance. During the process of gathering literature it is important to keep track of the variables that seem to play a role specifically in the healthcare context so that once a generic solution has been formulated it can be tailored according to these specifics. Once the same challenges and solutions start to appear over and again in the literature theoretical saturation is reached and no new literature needs to be included.

This chapter is structured from most abstract concepts to more concrete concepts. The class problem identified which corresponds to the integrated care challenged is value chain integration. Integrated care is the chain integration of the care value chain. While integration of a value chain should improve the service delivery to the market the main inhibitor of this integration is the problem of interoperability. Investigating this problem led to the concept of business-IT alignment which is another prerequisite for creating successful chain integration. This concept can be seen in the context of this research as a challenge that needs to be addressed to achieve interoperability on the organizational level. It is thus more concrete than the chain integration concept because it is a part thereof. A concept that addresses issues of business-IT alignment and chain integration, such as standardization, is the use of reference models. After this concept is elaborated on a type of modeling called enterprise architecture is described. The concept of enterprise architecture is the last and most concrete concept described in this chapter. The relation of the concepts is illustrated in Figure 3 where it is shown how solutions from one concept can be applied to the more abstract context of a more generic problem domain in the context of integrated care. However, this does not mean that this hierarchy of concepts is meaningful for every context. For instance, enterprise architectures may also be applied to problems outside the domain of chain computerization.

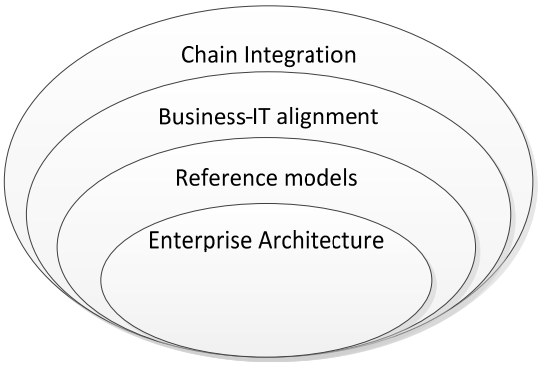


FIGURE 3: RELATION OF CONCEPTS

2.1 CHAIN INTEGRATION

The integrated care problem, which was the starting point of the literature study, is an instance of the class problem chain integration. Chain integration is identified as the abstract problem of getting the right information, on the right place and the right time in a value chain. Taking such a high level perspective on the problem makes it a generic question about disseminating information among key stakeholders, which is not unique for the care sector but can be applied to any value chain. The approach in literature to questions about computerized information dissemination within a value chain is considered chain integration. From a software perspective such initiatives are called system integration which in turn focuses on the autonomy, heterogeneity and distribution of information systems (Hasselbring, 2000). The use of information by multiple systems, users or contexts is considered interoperability of that information. Interoperability is not just limited to technology if we consider it in the context of chain integration. To prevent the narrow information technology interpretation of "interoperability", we adopt the following definition by Legner and Wende: "the organizational and operational ability of an enterprise to cooperate with its business partners and to efficiently establish, conduct and develop IT-supported business relationships with the objective to create value" (Legner & Wende, 2006). Such interoperability requires compatibility at the business level (Yang & Papazoglou, 2000). Because of this the problem of system integration cannot be seen separate from the business view of the problem which is chain integration. Even though many have attempted to solve this problem in the United States alone no organization was found that achieved the robust clinical date exchange (Adler-Milstein, Bates, & JHA Ashish, 2011). While some initiatives for the integrated care challenge even adopted software from a single vendor, problems persisted. One of the major causes for these issues is the lack of universal standards for vocabulary. So while the systems can exchange information packets the meaning of this information is not standardized at the semantic level. Separating the system implementation from workflow design would also lead to adoption failure (Goroli, Simon, Tripathi, Ascenzo, & Bates, 2009). This leads to the conclusion that all the technical standards for health information exchange such as the Integrated Healthcare Enterprise(IHE) (IHE, 2012) or the ISO standard requirements for an electronic health record architecture (International Organization for Standardization, 2011) fail to address the entire scope of the chain integration problem by focusing on technology. A survey of electronic healthcare record standards leads to the conclusion that semantic interoperability, understanding information with formally defined domain concepts, will be the best bet to achieve interoperability on the long run (Eichelberg, Aden, Riesmeier, Dogac, & Laleci, 2005). This interoperability requirement is not unique for the healthcare domain except that the effect may be context specific because information can save lives here. A few example cases where information could save lives in the Dutch care sector include, but are not limited to, the acute medical chain, diabetic care and Cerebro Vasculair Accident (CVA) care (Grijpink & Plomp, 2009). In these contexts medical professionals have to make decisions based on the information at hand. Providing these professionals with the right information in a timely manner could enable them to make better decisions.

2.2 BUSINESS-IT ALIGNMENT

The different solutions for enabling chain computerization and interoperability are not likely to succeed if approached from either solely a business view or an information technology perspective.

To tackle this problem both the business and the information technology need to be aligned. The concept which addresses such solutions is called business-IT alignment. Alignment can be described as the application of Information Technology (IT) in an appropriate and timely way, in harmony with business strategies, goals and needs. In order to position this problem of business-IT alignment for the healthcare domain we start by illustrating the general problem, and then look into the specific literature of this problem in the care domain.

For eight consecutive years the IT and business alignment problem has been in the top 3 of IT management concerns, from 2003 through 2010 (Luftman & Ben-Zvi, 2010). Four reasons why business-IT alignment is and remains elusive are mentioned (Luftman & Ben-Zvi, 2010). The first problem is that there is no single solution, many different components need to be addressed. All aspects of the organization will have to be taken into consideration. The second problem is that the question "How is IT aligned with business" is wrong. The real question is how IT and business are aligned to each other. The third problem is that organizations need to focus on more than just IT infrastructure. This is also shown in the more generic research on chain integration: creating technological solutions in a vacuum, not considering the business view, are unlikely to be viable projects. The last problem is that the debate on the alignment problem is clouded with different buzzwords. This problem with semantics is also visible in the literature where a myriad of terms are used to describe problems of the same class. To address the problems of business-IT alignment the modeling of all the generic information in an enterprise-wide information model is proposed. Such enterprise-wide information model approaches are common in the practice of tackling the business-IT problems of organizations (Chan & Reich, 2007) (Baets, 1992).

Searching Google Scholar for the combination "business-it alignment" and "healthcare" yields only 363 results since 2008. This does not show that it is not a problem in this domain, just that it hasn't received a lot of specific attention. Within healthcare alignment is considered a significant issue in care organizations. Different managers use different approaches to keep IT aligned with the overall strategy and goals of the care organization (Bush, Lederer, Li, Palmisano, & Rao, 2009). An example of a successful region wide network for chain integrated care in Lombardy implies the importance of involving the business first (Barbarito, Pinciroli, Mason, Marceglia, Mazzola, & Bonacina, 2012). In this project, Barbarito et al. specifically addressed important business problems like unifying specific processes, compatible with a generic workflow. Another decision which shows that they had the interest of the business in mind is the choice for a middleware solution. Instead of implementing new technology that would completely meet the technical requirements for interoperable information sharing they decide against this because it would be too disruptive for the business. This shows how the business view thumps a technological solution with arguments that could not have come to mind if it was solely a technological approach. Although Pascot et al. are not explicitly mentioning business-IT alignment; their solution is similar to the modeling of enterprise-wide information models found outside the healthcare domain. This is done using a central concept model that is linked to the business processes which ultimately realize products/service in a care context (Pascot, Bouslama, & Mellouli, 2011). Their positive research result prove that such efforts of central information models are promising for alignment purposes in the care context.

2.3 Reference Models

In order to tackle the problem of business-IT alignment models may be used to map these two domains to each other. Models can be used on different abstraction levels so that they may apply in a broad context if they are very abstract or in a very specific context if they are more concrete. Initiatives to support the re-use of reference data and process models to advance standardization have led to the creation of reference models for specific industries (Peristeras & Tarabanis, 2000). These reference architectures are abstractions from standard models. They can be used as meta-models, where instantiating the reference model helps the specific organization to create a standard model within its own business context. In order to meet the interoperability requirements described in the previous sections, reference architectures and methods should be researched and created accordingly (Legner & Lebreton, 2007). Such models can then be used by multiple organizations in an industry which should be more efficient than letting everyone invent the wheel on his own. Another advantage is that by using a common model for the generic processes and information will normalize them, thus providing a basis for interoperability. The practice of creating reference models, specifically using enterprise architecture (EA), to support standardization and integration has been adopted by public administration in the Netherlands (Binnenlandse Zaken). The result is a set of reference architectures for domains such as government(NORA), municipalities(GEMMA), provinces(PETRA) or the water authority(WILMA). These reference architectures for public administration provide principles which support each separate administration to do their own implementation of enterprise architecture. Because they use the same principles a common ground is reached among those different administrations, which ensures a certain degree of compatibility among the users of these principles. Public administration struggle with a highly fragmented information system landscape (Hjort-Madsen, 2006) and so do care providers (Monteiro, 2003). Integration of information systems should enable different processes to actively use the same information and deliver homogenous service to the customer. Not only should this help care providers to meet the growing demands of the customer, recent budget cuts force the care sector to operate more cost effectively. Even though standardization is an important issue in the field of integrated care (Winthereik & Vikkelsø, 2005), the development of reference architecture within this domain has hitherto largely been ignored.

2.4 Enterprise Architecture

Enterprise architecture in this research can be seen as a sub-domain of the reference model concept. Where reference models are abstractions which can be used to instantiate models, enterprise architecture is used to create holistic models of enterprises. Lessons learned and guiding principles of such holistic models may be used as a reference to develop new instances. Enterprise architecture is explored because of its service oriented models and its holistic capabilities which may be used to enable interoperability.

2.4.1 The field of Enterprise Architecture

Enterprise Architecture (EA) came into being when the financial and conceptual limitations for large and complex information systems began to fade. The implication of technology being applied in enterprise-oriented ways, next to the traditional approach of creating local and smaller systems, was that some kind of structure would be required. It is because of this that the concept of information system architecture was no longer optional but mandatory. Zachman described this problem and

suggested an approach to this problem which he calls the “information systems architectural framework” (Zachman, 1987). His framework was soon renamed to “the Zachman framework for enterprise architecture” and has sparked the attention and development of Enterprise Architecture as a field of research and practice. While Zachmans framework emphasizes the view of information systems and information technology this focus has shifted so that it also includes the business perspective. This shift of focus has led to the realization that a model can only have meaning in a certain context and that this context is related to a viewpoint (Iyer & Gottlieb, 2004). Unfortunately in the past 25 years the term “enterprise architecture” has not yet consolidated all these viewpoints. Some define architecture just for software and system architectures (Hilliard, 2000) while others focus on organizational structures (Wognum & Fan, 2007). A review of 126 publications on enterprise architecture show that 42 give a proprietary definition with no further reference, while 44 use enterprise architecture without defining it at all. Only 33 use a definition by reference while 7 use a proprietary definition based on a definition they reference to (Schöenherr, 2009). This shows how problematic it is to capture the full definition of Enterprise Architecture. The following definition of enterprise architecture is adopted in this thesis: ” (Lankhorst, 2009): “The enterprise architecture is a coherent whole of principles, methods, and models that are used in the design and realization of an enterprise’s organizational structure, business processes, information systems and infrastructure.” This definition is adopted because it covers the aim of the tool in the entire complexity of the care domain. The credibility of adopting this definition is backed by the fact that it is part of the result of the ArchiMate project, which produced the initial version of the enterprise architecture modeling language that is now an international standard (The Open Group, 2009).

2.4.2 Application of Enterprise Architecture

Reference models can help organizations tackle their chain integration problems in contexts of the value networks they do business in. To address the complexity of business-IT alignment a model, or reference model for that matter, should contain both the business view and the software perspective. One of the important challenges in the field of business interoperability is defined as the design of internal and cross-organizational process and system architectures (Legner & Lebreton, 2007). For this purpose enterprise architecture models provide exactly these different perspectives and how they make up a coherent whole. The field of enterprise architecture has been gaining momentum for the last decade. By providing a holistic view of the enterprise it aims to eliminate local problems that reduce the flexibility and adaptivity of the organization as a whole (Lankhorst, 2009). It is recognized that a shared method and language to model the architecture is important, so that it can be applied on multiple organizational levels (Johnson, Lagerström, Närman, & Simonsson, 2007; Iyer & Gottlieb, 2004). To do this a shared language is chosen. For the purpose of this research the language should not matter for its contents in so much as writing this thesis in English rather than Dutch should not affect its content. An example of a widely adopted standard language for enterprise architecture is ArchiMate (The Open Group, 2009). The method for creating such an architecture does make a difference. Especially in the area of interoperable health information systems current frameworks lack an architectural development process (Lopez & Blobel, 2009). It is because of this that frameworks are successful in addressing interoperability and chain integration but the problems they encounter are with respect to the implementation (Pascot, Bouslama, & Mellouli, 2011).

Within this research the ArchiMate language is used as the modeling language for the Enterprise Architecture. We elaborate on this language a little more to create a basic understanding of its

concepts and their relations. The concepts used in the language are divided in three different layers; the Business layer, Application layer and Technology layer. On the business layer reside the products and services which are available to customers and are realized by processes performed by business actors. On the application layer reside the application services which are realized by applications. On the technology layer reside the infrastructural concepts such as storage and communication services which are required to run the applications. Each layer contains three different concept types; Information concepts, Behavioral concepts and Structural concepts. An overview of all concepts on the business and application layer is available in Appendix A: ArchiMate Concepts. In Figure 4 an example is given of the main concepts on each layer and their relations. Note that from a behavioral perspective the architecture is service oriented. Each layer realizes a service which is available to the following layer. It is important to note that for different views some relations are derived so that concepts lying between two other concepts are not necessarily depicted. In the business layer reside the business wide objects and services which are made available in the outside world. The concepts in this layer make use of the concepts in the application layer. As can be seen in Figure 4, artifacts realize (depicted by the arrow) data objects, and data object realize business objects. Mapping these objects from layer to layer will provide insight in dependency of service to the outside world on internal processes, applications, software and even devices. Such a complete picture of the business and the IT should provide the right tool for achieving business-IT alignment due to its holistic nature of mapping the enterprise as a whole as can be seen in the picture where concepts from each domain are pictured and their relations are mapped.

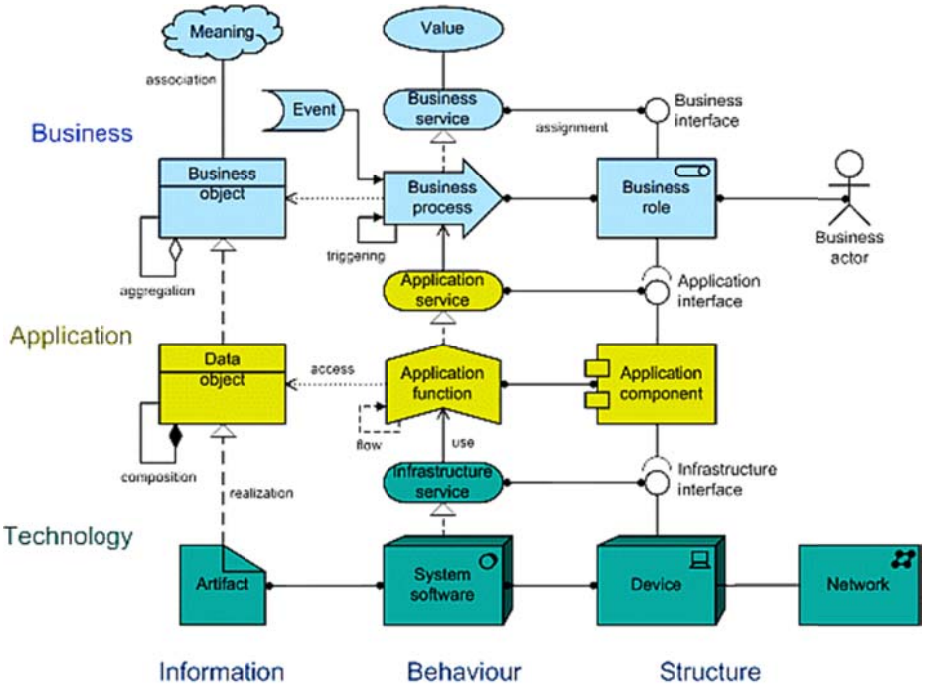


FIGURE 4: EXAMPLE OF CONCEPTS AND THEIR RELATIONS IN ARCHIMATE (THE OPEN GROUP)

3 RESULTS

In this chapter the results of stage 1, stage 2, and stage 3 are described. The "theory-ingrained artifact" which is one of the results of stage 1 will be the basis for the incremental artifact development during stage 2. Important artifact increments will be documented in the section on results of stage 2 while the relevant rationale associated with these increments will be the results of stage 3. The rationale associated with the increments will be captured together with the evolved design principles; together they will ultimately provide the reference architecture for end-users in the (municipal) care domain. In this chapter, architectural principles that are a result of the research or derived from the research results will be stated in italics after the context which led to these principles.

3.1 STAGE 1: PROBLEM FORMULATION

The first phase of this research is the problem formulation. This is done on two levels, in theory and in practice. The tasks "Identify and conceptualize the research opportunity", "Formulate initial research question", "Cast the problem as an instance of a class of problems" and "Identify contributing theoretical bases and prior technology advances" from this stage will be done with a literature study. The results of these tasks are the previous chapters on the introduction and the literary background. In order to cast the problem as an instance of a class of problems not only scientific literature will be reviewed but also reports on care in the public domain and the existing reference architectures used in the public sector (which are not for care but for government institutions). In order to identify the problem at the municipal care organization of northern north-holland the ICT manager and the director will provide their view. Based on their views and the management reports of previous years, the problem and strategy are formulated. Once this problem is cast onto the class of problems defined in the literature, which can be found in the chapter Related Literature, the initial artifact will be created. This artifact is the starting point for the following phase in which incremental work on the artifact will be performed with a group of key stakeholders. These key stakeholders are identified in the first phase and will be the participants for the main iterative group sessions with the artifact. They will also be working with the researcher to apply and improve the artifact during interviews with the professionals in each domain. But before we can do this the task "Secure long-term organizational commitment" must be performed. This commitment is ensured due to the fact that the organization intends to use enterprise architecture for their strategic goals. To realize these strategic goals a budget and time of employees is made available to implement enterprise architecture. The researcher will be part of this program so that he is guaranteed to be directly involved and ensured of the organizations commitment.

It is important to note that the goal of implementing and using enterprise architecture is twofold in the organization, although both uses of the enterprise architecture are related. The first approach is more abstract and can be viewed as top-down because it focuses on abstract customers and services. The second approach is more concrete and works bottom-up with the professionals to get a detailed view of the information requirements of every single process step. The first and most prevalent goal is to reorganize in the business side in order to achieve a more external oriented organization, promote and improve internal collaboration, leverage the professional and his autonomy, steer on business and improve results, and last but not least to achieve cutback targets. The second goal is to promote efficiency and effectiveness of the IT portfolio. This means that from an IT perspective the

application portfolio should be reduced if possible and any hand-made information transformations with the use external tools (such as excel) should be automated or dissolved. Even though both sides of the motivation to work with enterprise architecture are interrelated it is important to see that the different stakeholders do not necessarily see this connection at the start of the project. This gives a good impression of the starting point of the action design research and the views the researcher has to deal with. The fact that different stakeholders aim to achieve something with the implementation of enterprise architecture is important to secure long-term organizational commitment.

The adoption and understanding of the language used, ArchiMate (The Open Group, 2009), is an important point which will be done with the key stakeholders (mostly end-users) during stage 1 but has to be done with the groups of practitioners as well. During interviews with these key stakeholders the initial knowledge-creation target is established. This initial knowledge-creation target is to get an inventory of the services and their processes, mapped to the customers of these services using ArchiMate. Along with this inventory there should be an understanding where which expertise resides so that it may be leveraged by the organization for its strategic goals. This is however a target that is outside the scope of this research and will not be discussed in depth. Interviews with the practitioners will be used to formulate concrete implementations mapped on the architectural concepts. This initial mapping of the expertise of the interviewees to the concepts of the architecture will be done by the researcher. Once this mapping is in place the exit point for the following interviews will be this mapped architecture. This way the researcher and practitioners will collaborate on the shaping of the artifacts. The end user will also collaborate on the interviews and will perform workshops where they apply the artifact. These workshops will contain a combination of practitioners, end-users and the researcher. The main goal of these workshops with groups of end-users is to design a new organizational structure based on the reference architecture.

3.1.1 THEORY INGRAINED ARTIFACT

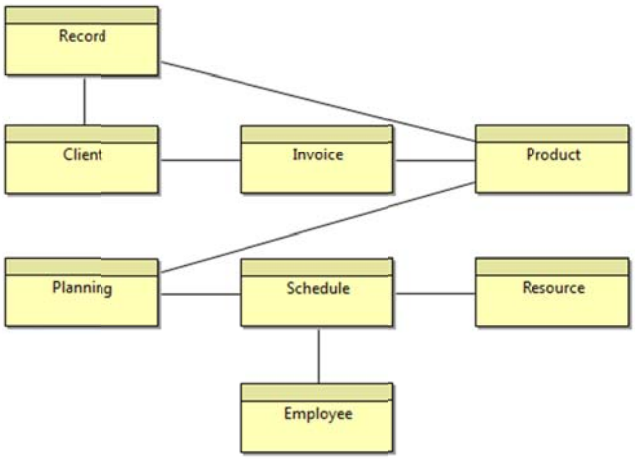
Now that all the tasks of the first stage are performed an initial version of the artifact this research aims to establish is conceived. This initial conception is called the “theory-ingrained artifact” which is the second principle of ADR (Sein, Henfridsson, Purao, Rossi, & Lindgren, 2011). This artifact is based on the existing theories on the structure of the problem, the solution possibilities, and the design guidance.

Based on the research and the literary background addressed in the previous sections, an initial version of the reference architecture will be created. This theory ingrained artifact shall be used as a starting point for the incremental design research which will be described in further depth in the following chapter.

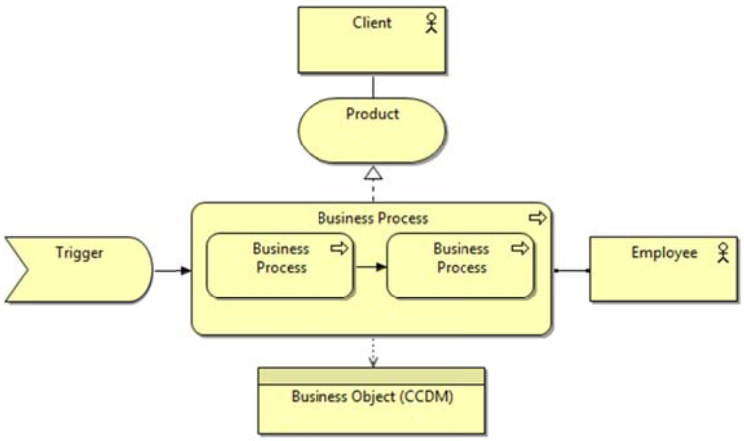
The starting point for our artifact will be a corporate concept data model (CCDM) which describes all vital data in the organization (Pascot, Bouslama, & Mellouli, 2011). This model contains the abstract uniquely defined objects for enterprise wide use for the municipal care organization. In order to manage the size of the model it may apply to two different levels, dividing the model in two subsets. The first subset is the common subset which applies to almost all domains of the enterprise. The second subset is the context dependent subset. Within this second subset the nature of the object is likely to be limited to specific contexts, which will result in specific concept instances that do not recur anywhere else in the organization. These subsets may be used and developed in specific projects or context in the organization. Every such local element must be matched to a global

element in the generic model. If no such element is found or no specialization from a generic object can be found its use and definition must be evaluated so that it can either be added or coupled in the CCDM. For the initial artifact we will focus on the most abstract and generic objects first so that context specifics may be added during the iterations with the end-users and practitioners. These contextual subsets will mostly reside in the application layer of our model while the most abstract parts of the corporate concept data model will be modeled in the business layer of the enterprise architecture model (The Open Group, 2009).

The result is an initial CCDM for the business objects of the municipal care organization which is depicted in Figure 5. This shows that a client may have a record which can be seen as his health record. But in order to grasp the entire history of a client the products/service he has acquired are also relevant. The generic products can be linked to a client with an invoice. But not every product can invoiced because they are commissioned and paid for by the municipality as a standard responsibility of the municipal care organization. For the internal organization a planning is required so that resources may be scheduled in order to deliver the product or service. The planning contains the timeline for the production of a product incorporating the required resources while the schedule contains the availability of such resources and of employees. Planning is abstract and only couples a kind of employee and a kind of resource in a timeframe for the production of a product. The schedule in turn provides the specific employee of this kind that is available in a timely manner. With this conceptual model of the business objects used in the organization all required information should be captured and map-able to the model.



The second step is defining the business processes. For this purpose we adapt the approach of the "Field Actions" so that it complies with the ArchiMate Approach. The Field actions are the reusable building blocks for any business process representing non-contextual information and mutations (Pascot, Bouslama, & Mellouli, 2011). For brevity sake, and to comply to ArchiMate, we use the information concept for the informational part of field actions and processes for the actions (The Open Group, 2009). This way a business process can affect business objects in the business layer and adaptations of the data object can be done in the application layer by application functions.



In order to map the business processes, or information creating and mutating “Field Actions”, to our CCDM we need to take a look at how clients access products via these processes. This should result in a mapping between products and clients and show how the process is triggered. The given diagram in Figure 6 is not an actual piece of the architecture but a reference architecture which shows what line of reasoning is employed viz. the client triggers a process in order to get a product. The ultimate goal is to create an effective design of the enterprise architecture that uses objects of the organizational domain, using its contextual knowledge and reality (Pascot, Bouslama, & Mellouli, 2011). The resulting business processes need to meet three criteria defined by Pascot for effective use in the healthcare domain:

1. They must generate or modify information that is relevant for the clinical or social service
2. They must be persistent in such a way that they can be registered
3. They must represent reality of the healthcare organization and not an ICT perspective

The criteria above make clear that not all processes have to be interoperable. For instance the schedule and the processes which use this business object may be of administrative purposes only and are not relevant to the care provider or the client per se. However, in order to provide a holistic view of the enterprise it may be necessary to include not directly health related process steps in the model. Their relation on client related information will then show whether it is likely that they should be interoperable with the outside world. Moreover, by synchronizing administrative processes with the governmental administration the person object can be uniquely identified among different organizations and organizational units (Barbarito, Pinciroli, Mason, Marceglia, Mazzola, & Bonacina, 2012).

In order to create a meaningful mapping of clients to products via business processes we need to specify the clients and the products in a little more detail. This is especially important so that the specific information requirements for the different stakeholders become clear. On the level of a single civilian other information may be relevant than for the purpose of public health, for which the information of all individual civilians can be pooled for research (Detmer, 2003). By standardizing and integrating these information flows in the business processes local repositories can be reduced (Barbarito, Pinciroli, Mason, Marceglia, Mazzola, & Bonacina, 2012). To do so the local information silos need to be mapped to the different processes. If this is done for all processes we can deduce from the model exactly which stakeholder requires what information for each product.

For the initial enterprise architecture some generic principles are formulated based on the strategic targets of the organization, which include process interoperability. These principles will evolve during the project so that they capture the required rationale required to effectively support the strategic goals of the organization. The content of these principles reflect the current strategy of the municipal care organization and the lessons learned from current literature. When working with enterprise architecture these principles are used as normative rules to which the enterprise architecture should ideally conform.

The CCDM is evolving and should be maintained so that concepts can be mapped to it at all times

Harmonize administrative processes and align them with corresponding regional or nationwide repositories

Map different customer contexts to a single customer in the CCDM

Standardize processes and information for reuse throughout the organization

Uniform service measurements and performance indicators

Reduce application portfolio and information silos

Reduce the administrative information mutations by professionals

3.2 Stage 2: Building, Intervention, and Evaluation

This is by far be the most complex and intensive stage of this research. The starting point for this phase is the artifact created in the previous stage based on the literature. There will be two abstraction levels used in this phase. The most abstract being the interventions with the stakeholders responsible for the actual formation of a new organization. With these stakeholders different interventions are planned which will be the main evaluation moments for the entire artifact. These stakeholders are all responsible for a subdomain of the inventory of products and processes for the municipal care organization. The process of mapping these processes and products in relation to the processes of other domains and customers is supported by the researcher. Within this abstraction level the main target is to use the artifact to achieve the strategic goals as formulated in the previous section. Evaluation sessions with all five stakeholders are planned to take place with intervals of about a month. Between these sessions the artifact is re-iterated, based on insights from the previous session but also from interviews with professionals who work on products within one of the five domains, depending on the stakeholder who is responsible. The main approach used by the five stakeholders to create the inventory of products and processes was already mentioned shortly in the section Theory ingrained artifact. The aim is to start by creating an inventory of customers which can be mapped to products. Once we have this picture we can ask how the customer obtains the product, in other words, what triggers the organization to do something and how do we do this. This results in the process and the process trigger. When describing the process it is important to see every step as a transformation which requires input information and generates output information. These information chunks can be seen as semi-finished products which should be map-able to the corporate concept data model (CCDM). This level of detail is however not the first concern for the stakeholders so that this mapping is done by the researcher together with the professionals and information specialists of the municipal care organization. We will call this part of the research the top-down approach because it starts at the highest abstraction level and works its way down if more details are required.

The concrete level used will focus on operational issues which should be addressed by parts of the artifact. These can be seen as the bottom-up approach which in turn can be used to complement or adapt the abstract artifact (Pascot, Bouslama, & Mellouli, 2011). On this abstraction level the role of ICT is much more visible since it deals with the interoperability issues the professionals encounter in their daily work. Here the ICT department aims to provide solutions within specific processes which will provide very detailed insight on the information sources required for these processes. This will be added to the inventory of the more abstract results from the five stakeholders so that the artifact is complemented with the application view of the organization. The researcher will perform information analysis based on problems stated by the professional to see which information is used,

generated and aggregated. These local interventions not only serve as a proof of concept of the artifact but also show the organization benefits resulting from the interventions. Some of these operational problems deal with interoperability within the organization while other deal with the interoperability among external parties. The last sort of problem is especially interesting since this is a candidate for the full complexity of inter-organizational chain computerization. Because the operational issues in the municipal care organization are myriad and the researcher can't actively participate in all of them there will be weekly meetings so that the entire team and the researcher are always up to date. In these meetings the CCDM will be an important part of the artifact that is evaluated in the way it is used to solve the operational problems.

The nature of the aforementioned intervention requires reflection from practitioners with different perspectives on the envisioned artifact. In order to have informed discussions about the reference architecture a formalized notation is used. This notation is the ArchiMate language version 1.0 which in recent years has become a world wide open standard (The Open Group, 2009). During stage 1, when the long-term organizational commitment is secured the importance of such formalization was established.

3.2.1 TOP-DOWN

This section will cluster the results from the top-down approach with the end-users of the architecture. They are responsible for the creation of a new organization on the most abstract level. The organizational goals of his group are to be supported by the enterprise architecture. As stated in the section Theory ingrained artifact the minimal requirement of the architecture is that it maps all the different processes, products and customers to each other. Based on this inventory similar processes and products should be grouped together while internal cooperation and interoperability are enhanced. This should result in a more efficient, more customer centric organization in which the professional can do what he or she is good at.

3.2.1.1 PRIMARY SERVICES AND CUSTOMERS

The starting point for the top-down enterprise architecture will be to map the customer to the services the municipal care organization delivers. Before we can do this we need to identify the clientele of the municipal care organization. The clientele of a municipal care organization can be split in two categories. Such categorization of concepts is essential for an informed decision on which concepts can be mapped together in the CCDM and ensure their interoperability. In the case of categorizing and identifying the clientele, the criteria were already given and accepted in the organization. Nevertheless, a great number of client definitions existed that did not comply with the categorization, especially for the individual clients. The first category in the categorization of the clientele is the civilian to which the municipal care organization provides care, either individually or in groups. The second category is made up of other organizations such as municipalities or educational institutions. This second category can be split up into four parts based on the following characteristics: commissioning parties, chain partners, internal customers or indirect customers. Commissioning parties are paying for products they wish to receive themselves or that should be provided to civilians in a certain area. Typically these would be local governmental institutions such as municipalities. Chain partners are the organizations municipal care works closely with to realize their products. Since one of the responsibilities of all municipal care organizations in the Netherlands is to take care of people who typically avoid care or fall outside regular care for some reason. To do so municipal care works together closely with other organizations to see if the patient may be known

there or if his treatment can be brought under control of these regular care organizations. Internal customers are members of the municipal care organization who, in order to realize their service, require support from other internal services. These internal services may for instance be supporting services such as the financial administration which may be invoked to take care of invoicing of services throughout the organization. Indirect customers are organizations that receive something as a side effect of another service for a commissioning party. An example would be a nursery which is inspected on commission of the local government. As can be seen from this example, a too fine grained categorization will lead to a great deal of abstraction levels very fast. For the client we now have the upper category which makes for the most generic concept used enterprise wide as the "Customer". After this two more specializations of these concepts are given on a lower level, which in turn are split into six other even lower concepts as depicted in Figure 7. Unfortunately in many a case, new specializations were identified for these six low level concepts which would lead to even more levels. To prevent adding infinite levels of specialization, the categorization criteria should always include the constraint that the added is required only on a lower level and would interfere with the use of the concept if added on a higher level.

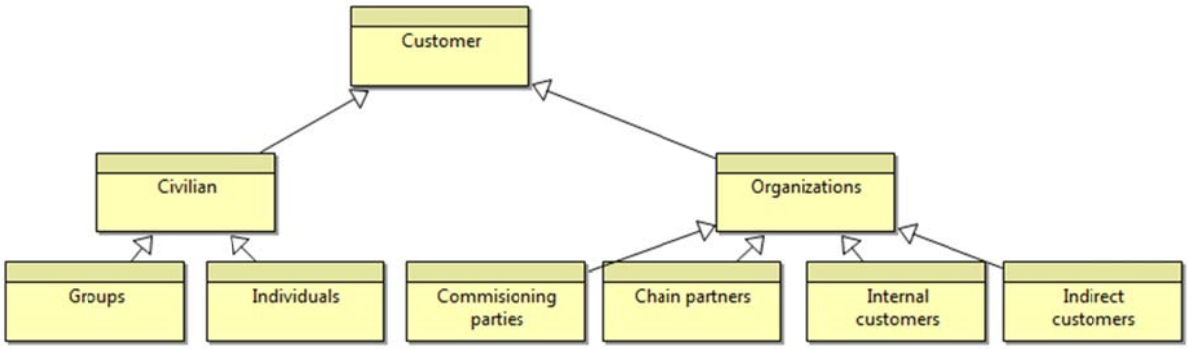


FIGURE 7: CUSTOMER CONCEPT AND ITS SPECIALIZATIONS

During the first interviews with professionals it became clear that formulating who the customer is for a certain service was not a straightforward exercise for them. This was due to semantic problems and abstraction problems, even though the categorization described above was already formulated and accepted by the organization. The combination of abstraction and semantic problems make it hard for an enterprise architect to correctly map the concepts to the CCDM, because it remains unclear if it is applicable to the organization wide highest abstraction level or if it is strictly contextual. If this problem remains unaddressed, overlapping services, processes and actor definitions are defined as unique concepts, disregarding their overlap and thus resulting in redundancy. To overcome this problem a more detailed categorization of customers is suggested which maps actors with specific characteristics to the objects present in the abstract CCDM concepts. This categorization led to the distinguishing characteristic of directly receiving a product from a single process and the party paying for one or more of these processes. So now the categorization not only incorporates attributes of the client but also of the required process and the resulting service and generated information. An example is for instance the vaccination of children. It is the child who receives the vaccine, but it is the government who commission and pay for the vaccination of an X amount of children within the region. To further clarify such distinctions we differentiate between products that require a link to an individual and products that do not need this link. The case of a vaccination for a particular child requires that we know that this specific child is vaccinated while the

product and thus this link needs to be in place and this information has to be communicated with the national government. For a product such as “healthy schools”, where a plan is created and implemented to get children from a school to live more healthy lives, we do not necessarily need to know which individuals are reached exactly with such a project.

To tackle the problems described above three architectural principles are added to the reference architecture to help the further implementation at the municipal care organization. These principles are added because they proved their value in the discussions resulting from these specific problems. The use of categorization led to a better understanding of the relation between concepts based on their differences and similarities. Such categorization can also be made using the information requirements of processes which proved to be insightful. Therefore the principle of mapping services based on the information requirement is added. A clear advantage of doing so is that the connection of business and IT becomes very clear once the information requirement is translated in the software in which it is used. To deal with the second order services it should be recognized that some services rely solely on the execution of other services. The information generated from these individual services make up for a new service altogether which in essence brings together existing information for new purposes. The difference in service and customer levels should therefore be recognized and its dependencies mapped in the model.

Use categorization to reduce complexity if necessary, formulate and agree on the decision tree for this categorization.

Map services to customers according to the information generated and required.

Difficulties with service to customer mapping may imply new services of a second order: services which rely on the information generated by delivering another service multiple times in a given period. Make this distinction if it is appropriate.

But the strict separation of products in relation to customers, on individual and on group levels, leads to the discussion if we should not try to always capture the link to the individual. The municipal care organization is required to monitor and intervene over the entire scope of public health. From this perspective it could be beneficial to see if certain interventions on a group level show significant change in the individual and perhaps to be able to create personal interventions based on this. However, such detail of administrative data is not always possible so an alternative may be sought. This leads to the creation of group concepts on which individuals are recognized as groups based on the value of a certain attribute. This may be cohorts of age, location or those persons attending a certain educational institution. Mapping people to such cohorts will enable the organization to trace interventions to the individual based on these attributes matching the person and the cohort, but also to share information on cohorts while keeping the individuals anonymous for the outside world. This mapping is done using the CCDM high level abstract concepts which are mapped to the contextual more concrete concepts of certain products. In order to do such tracing the low level concepts *must* be coupled to the CCDM on an organization wide level.

Mapping contextual concepts to high level concepts in the organization wide CCDM may enable adding information by derivation, especially with second order services.

Another problem that occurs when talking about individuals as customers is the context that can make a potential difference. To map these contextual instances of the individual there is a concept "role" available in ArchiMate. Discussions on the categorization of customers led to the realization that an employee can also be a customer for his own organization. This way we would require redundant information so that we can recognize this person as a customer and as an employee. This sparked the discussion on specialization. Can we still identify a generic concept of which extra attributes are used to provide a specification of the generic concept in a certain context, and if we do so, will this improve interoperability? The ICT department took a special interest in this discussion because it puts relationship management in a new perspective. Classical relationship management is aimed specifically at customers with customer relationship management(CRM) systems. The conclusion was that an individual person is specialized as employee, because then all we require is more attributes. Of course the employee object is related to some contract which provides more information about his or her role in the organization. The concept of a relation is then a person linked to a context. So one person can occur in multiple relations, each with its own context. An example would be a man who is also an employee but who comes as the father of his child to receive a parent related training. In another context this person is not a father but part of a group who are going to travel abroad and require vaccination. In Figure 8 we see an example of how this was modeled by the ICT department. Implementing the person concept as the most generic instance in the CCDM ensures that we will never ask the same person for information we already know about him or her. This can also be used to ensure privacy of the person because information linked to the person in specific contexts may be made inaccessible. This level of modeling is however far too technical for the users of the enterprise architecture. For the purpose of our model the Actor-Role distinction available in ArchiMate is sufficient. Implementing this on an application level will result in the necessity of an extra concept to dynamically connect groups of people together. This necessity was recognized during the interviews with professionals and is exemplified in the section Indirect services and customers.

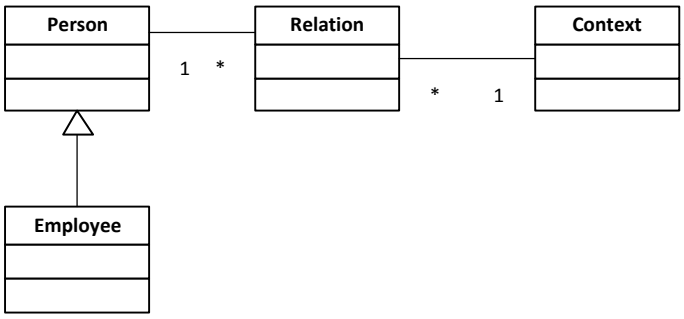


FIGURE 8: EXAMPLE OF THE PERSON CONCEPT AND ITS RELATIONS

3.2.1.1.1 NAMING

Another much more practical problem is how to name products and services in such a way that they are intelligible throughout the organization and that categorization will be obvious. We adopt a naming scheme where, in case the name consists of multiple terms, the greatest common factor is the first part of a name. This way the first part of the name is more generic than what follows. This results in a sorting mechanism based on names where concepts of the same class are grouped together. Such a naming scheme can be compared to a date notation which uses YYYY-MM-DD, years being the biggest most general thing and thus the starting point. A month cannot contain a year,

such a restriction based of can or cannot contain may be another usable approach for the naming convention.

Adhere to a strict naming scheme for concepts which make it clear to what generic concept it belongs for categorization purposes

3.2.1.1.2 INTEROPERABILITY AND GENERIC PROCESSES

One of the goals for the municipal care organization is to organize centrally what can be organized centrally. Using the strict naming convention with generics first directly shows if a product or service occurs often. Unfortunately there are many synonyms for some concepts and semantics often lead to endless discussions. To resolve these semantic issues of synonyms the architect must ultimately decide on a name on the highest level in the CCDM. The synonyms should then only occur in certain contextual settings for which the lower level concepts are used. Because these concepts are mapped to each other semantic confusion should be eliminated.

Discuss and map synonyms and resolve semantic confusion

These discussions tend to focus on the differences between the concepts rather than on the similarities. Because of this it is not easy to group the concepts so that they may be organized centrally based on categorization as discussed earlier. The parts of a process on which is easily agreed upon by the professionals tend to be the administrative steps before and after the steps which really require their professional expertise. Using the input and output data from these administrative processes we can look for similarities within the domains of the experts. Eliciting these similarities together with the differences we can now decide if the categorization should be based on the differences, i.e. if the concepts are really different or based on the similarities, in which case the differences just make up exceptions on the generic concept. A pitfall in this approach is that the discussion takes place on different abstraction levels. For instance, a service which is commissioned and paid for by the municipal government may be a second order service. This service may require the municipal care organization to perform a vaccination on a number of patients. In such a case the administrative in- and output may be very different from another service which is directly paid for and delivered to a single patient. But if we look at both processes on a patient level, and ignore for a moment the second order service for the municipal government, we can see more similarities than differences. The second order service is, after this, only an extra administrative step that follows once the service is delivered to the designated number of patients. So instead of taking the abstraction level of the second order service, focusing on the steps required on the more concrete level may show the right abstraction level. In this case it shows that the process for the second order service is simply a repetition of the process for a single service to an individual with the extra administrative step of making some abstraction of the administrative figures.

Focus on similarities first, and then discuss the differences

Once the generic concepts are defined and mapped to their contextual counterparts there should also be a translation to readily available semantics outside the organization. Within the Netherlands there are several relevant administrations for the identification of persons or locations (Binnenlandse Zaken). The reference architectures in the public government of the Netherlands dictate that these administrations should be used whenever possible. For some care products of the municipal care organizations the use of the municipal administration for person information is mandatory. Patients

are identified based on their social security number (in Dutch, the burger service nummer(BSN)), before they may receive care. Communication with this central person repository also makes it possible to retrieve information about the nationality, date of birth and all sorts of other information on the patient by providing the unique identifier (in this case the social security number). It is therefore important to have unique identifiers for concepts in use by the organization and if possible to copy these identifiers from readily available sources. The public administrations in the Netherlands use 13 central repositories ranging from persons, to addresses and geographical information. Adhering to these repositories when possible will be a great improvement of the interoperability of information. This is also true for the internal organization in which it should be clear who is responsible for the central repository. Because there are so many applications in which this information may reside, one application or database should be chosen as the central one. In order not to disrupt the business too much, a middleware solution can be used for this purpose. This middleware solution will be the central administration on top of the existing application portfolio which maps all the concepts together and enforces the unique identifier organization wide. In some cases this middleware solution may not be necessary if the unique identifier chosen for the concept is supported and implemented in all processes and systems making use of the given concept.

An important note on unique identifier is that they should only be used to link objects to each other. The identifier should therefore have no meaning. Many applications use some formula to come up with an identifier so that it has some meaning. The problem with these meanings is that they are prone to cause redundancy, because the same codified information is often already captured in a dedicated attribute of the object. The other problem is that these codifications require decoding which makes interoperability more complex. This would mean that the identifier has to be decomposed for each instantiation so that the information required can be decoded which in turn requires additional functionality or skill of the user. Most of such codes are only machine readable because of the required decoding, it is therefore not desirable to have information important for human processing in these codifications. Moreover the semantic incompatibility of such codification clouds the discussion on mapping these semantics among concepts. Such codes can be anything and can mean anything so that incompatible mappings may arise because the meaning of different codes can be interpreted in any possible way. This risk is lower when discrete variables are used to store information and the identifier is kept purely for identification purposes of the collection of variables.

With no middleware and no adherence to the CCDM the concept of a customer is not defined centrally. Chances are every single product uses its own concept of the customer and the information object of this customer resides in a dedicated system. Further customer information resides in the customer record. This record may contain medical information but can also contain the product history the customer has with the organization. An example of this situation is given in Figure 9. This picture shows the processes accessing the different customer objects, each in isolation so that differences may occur and if in reality this consumer is the same he may have to provide the same information for every single product again.

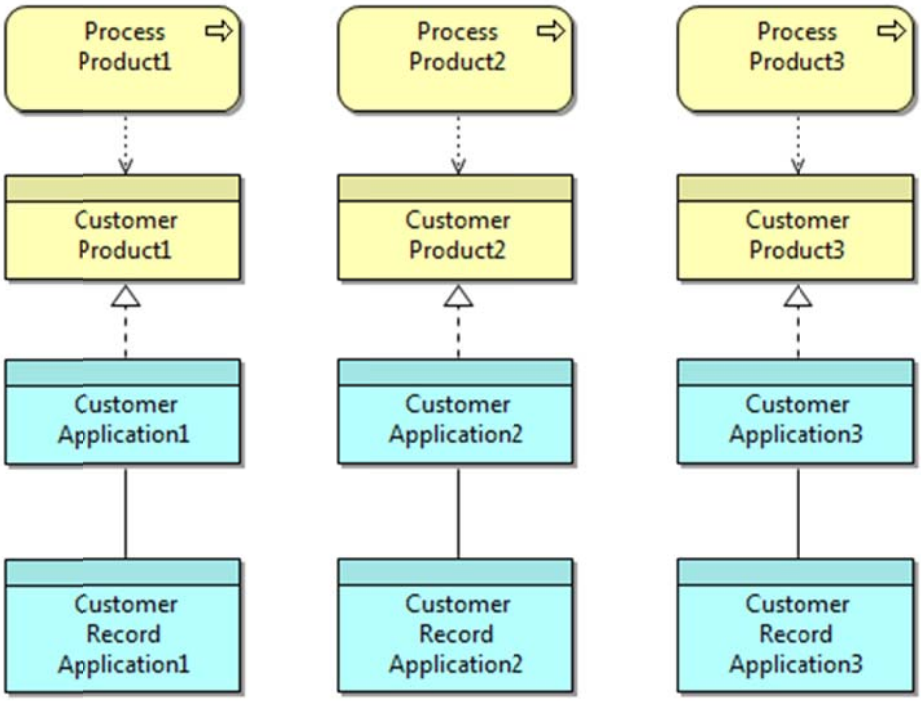


FIGURE 9: CURRENT SITUATION WHERE DIFFERENT PROCESSES USE DIFFERENT CUSTOMER CONCEPTS USING OBJECTS FROM DIFFERENT SOURCES

The middleware solution is used to implement the mapping of the different instances of the customer concept in a single middleware object. This object is the direct instantiation of the customer concept as defined in the CCDM. It is not required that the object itself carries information on its own as it may all be available in the underlying application objects. The middleware object then only contains a leading unique identifier and the identifier used in each of the underlying objects. This way the middleware solution service as a mapping between the different instantiations of the concepts but does not prevent them from being different from each other per se. To do so some intelligence must be implemented in the middleware layer that makes it possible to mutate the concepts that are now mapped each in their respective sources so that no differences among instances can occur. But it is also possible to define one instance of the customer object in one of the applications as corresponding completely to the CCDM. In this case no new unique identifier for the object should be created in the middleware layer. Instead the middleware solution should point at the object in the application which will now be used as the central repository. An example of the middleware situation is given in Figure 10. In this situation the separate instances of the customer record could be aggregated to one via the centralized customer object. This sparks the discussion on the content of the customer record. Even though they may be used in specific professional contexts, it is possible that they contain information that is relevant outside this context.

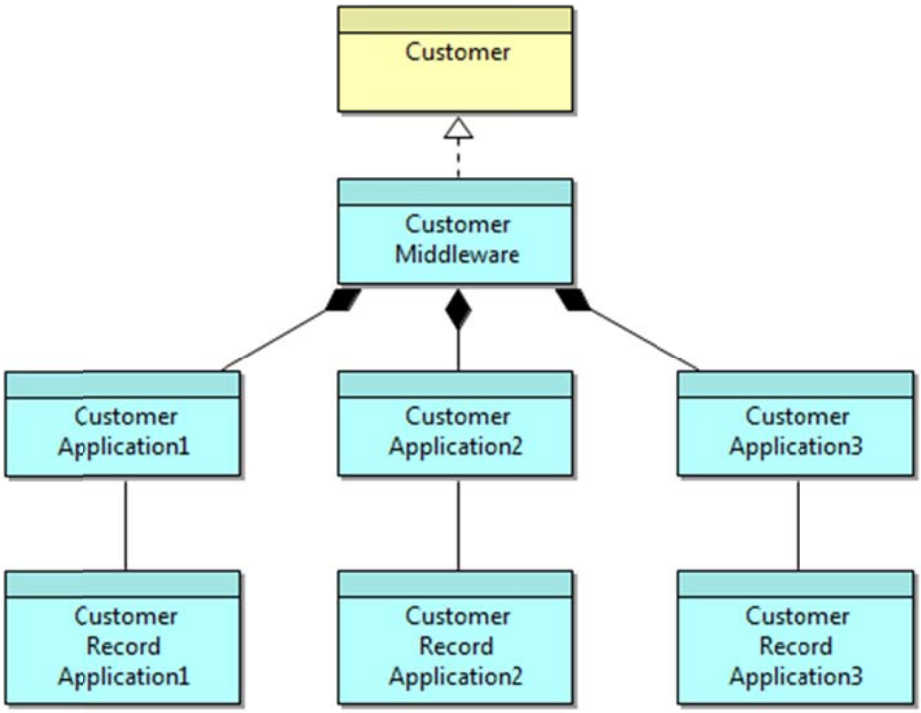


FIGURE 10: MIDDLEWARE SOLUTION MAPPING THE DIFFERENT CUSTOMER OBJECTS TOGETHER

When evolving to standardized repositories for instances of the concepts defined in the CCDM it may also be possible to create a single repository which is used by all applications. This means that throughout the organization the customer object is always taken from a single application. The upside is not only that interoperability of the customer object is ensured; it also makes the step towards the complete customer record shorter.

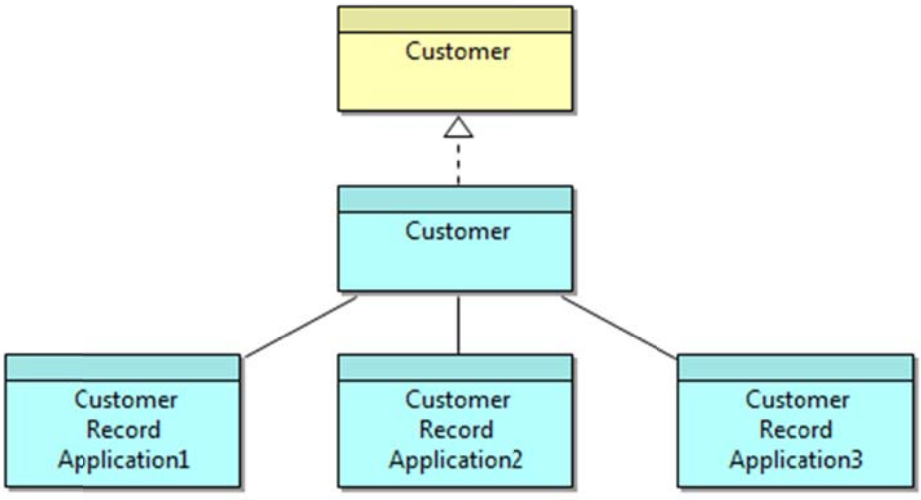


FIGURE 11: IDEAL SITUATION WITH ONE SINGLE REPOSITORY FOR THE CUSTOMER OBJECT

While Pascot et al. suggest that enterprise architecture in a care setting should focus on concepts that are exclusively relevant for the care context (Pascot, Bouslama, & Mellouli, 2011), this may not be true for municipal care organizations. Because of the second order services the municipal care organization may have responsibilities on a patient level as well as on a more administrative level to

the municipal government. The responsibilities of the second order services can only be performed if the process and data of the first order service is interoperable with the second order service. For some services, such as sexual health consultation, there is also a nationwide system which keeps track of the second order data. This data is used to keep track of how many first order services the municipal care organization performed and which should be reimbursed. So to be reimbursed for the services provided to individual patients, the administrative data should not only be interoperable to the local administrative function of the municipal care organization, but also with the nationwide application. This shows that seemingly administrative data is crucial for reimbursement of the municipal care organization. But the performance indicators such as the amount of sexually transmitted diseases(STD) diagnosed may as well be used to find anomalies in the sexual behavior in a certain area. On the administrative level such information may primarily be intended for reimbursement by the government, while at the same time providing crucial medically relevant insights. Due to the reimbursement requirements the municipal care organization must account for the services provided on the individual level so that the financial administration cannot be seen separately from the care context. But in order to fully account for the cost and thus reimbursement by the local government for certain products we also need to know how much effort from non-care services are involved. It may be that facilities of the internal organization are required to realize a product. This proves that due to reimbursement requirements and accountability the holistic view of the enterprise is essential in municipal care, including the non-care context services. This means that the initial criteria about the mapped processes which should “generate or modify information that is relevant for the clinical or social service”, dictated by Pascot et al., encompasses much more processes than may initially seem clinically relevant. More on the intertwining and cross dependencies of service will be addressed in the following section.

3.2.1.2 INDIRECT SERVICES AND CUSTOMERS

Next to the products and services to the outside world there is also a myriad of less visible services to the internal organization. The current organization has separated organizational units with separated responsibilities. These units are not only divided by separate management and organization but also by location. Of course some organization wide units such as the financial department are used by all other units, this is however not standardized. The relation of primary products to these supportive and internal services is not clear and the information flow required for these processes invisible. A mapping is required of the internal services provided by the supporting units to the primary services which are delivered to the outside world. It became clear that the professional often spends a lot of time to tailor the information provided or required from these supporting services. In some cases this results in the professional taking over some or all administrative services, which leads to a segregation of information and processes.

Along with the administrative services, there are also the services required to create the second order services. It is possible that these cross current organizational boundaries. This means that administrative information of a service in unit A is the required information for a primary service in unit B. Awareness of these dependencies is scarce and the effort required to tailor the information generated by unit A for unit B tedious and often performed by the professional. As a result, professionals tend to work a lot with excel to transform and mutate information so that it suits the needs for their service to the outside world. This is a very clear problem where interoperability is lacking within the organization. As mentioned in the previous chapter, such interoperability must first be achieved with the organization before it can be achieved beyond the organization. To ensure

interoperable processes which reproduce information in a standardized way the following principle is introduced:

Information gathered for specific processes should be standardized so that every time the process is executed the resulting information is the same

Another problem with these disparate processes and information silos is that working together for innovative service using the expertise of multiple organizational units is inhibited. It turned out from the interviews that different units work in the same context to provide services to a certain customer group. Examples of such a context are festivals where multiple services are provided. There is the preventive work of the sexual health experts, the inspection of hygiene conditions, the youth care activities to teach people about drugs and the milieu experts who can inspect the volume levels against hearing damage. All these services take place at the same time but only the youth care and the sexual health education work together on this. This exemplifies how the mapping of services to customer and customer roles in certain contexts visualizes the problems of such discrepancies. But it also inhibits working together on future products where the expertise of multiple units could be leveraged. The expertise of preventive measures lies with the professionals active in these unit while the expertise of getting it across to a certain target group may reside in another unit. Realizing this led to the conclusion that in order to leverage this expertise to enable innovation of services, the new organization model has to take this into account.

To tackle this problem a standardization of all administrative processes and services is proposed. This is done by coupling all administrative information to the CCDM. A customer that is identified and used during a primary product must be identifiable via the CCDM so that administrative processes such as finance have the same person information. A complete inventory of the second order products and the cross unit services proved hard to achieve. To facilitate this, the professionals are asked how, why and where they get what they require and to think about what they feel they do for others. This way both the supply and the demand should become visible and can be mapped to each other. The result is a lot of perceived discrepancy between supply and demand which requires in depth analysis. By focusing again on the similarities instead of discrepancies and using categorization to structure these information in- and output this perceived discrepancy can be solved.

3.2.1.2.1 Secondary services

Like any other organization the municipal care organization has supportive units that are required for the operation of the primary services. These units provide secondary services which are separated from the care context such as the ICT department or the financial department. Due to the nature of reimbursement by the government the calculation for cost based pricing is important. An introduction to this phenomenon was illustrated in the section Interoperability and generic processes. Apart from this cost calculation for which the interdependency of services needs to be mapped there is also the dependency of information. This may not be directly visible because in the administrative context a concept may be information while in another context it may be an actor. An example is the personnel which is an information concept in the human resource management context. But in the context of the primary process this concept is an actor responsible for certain actions. The fact that actors need to be identified and that information is necessary in the diverse contexts of municipal care leads to the realization that relationship management is important. From an architectural point of view this means that an actor can never exist in an informational vacuum,

there should be a corresponding business object linkable to the actor. Doing so makes new parts of the interdependency among secondary and primary services insightful.

The result of mapping the primary services based on the information flow shows that there are administrative services which serve as starting points for the client to receive some primary service. This leads to the categorization of front-office and back-office for administrative services. The front-office services are all available to the outside world as a contact point. In order to capture all customer information in a central place the current front-office and back-office services will be grouped. Currently these services are spread throughout the organizations primary units so that the front-office for a youth care service is different than that of the traveler vaccination services. By organizing the front-office in a generic manner for the entire product portfolio of the municipal care organization a higher level of customer centric service can be provided. But the advantage of this is not only the experience of the customer but also the standardized administration of generic information of object residing in the CCDM. This makes it possible for the administrative services, both in the front- and back-office, to reduce the use of local repositories and manual conversions of information. Another aim is to reduce the amount of time a customer has to provide the same information. This aim corresponds with the aim stated in the reference architecture for municipal government(GEMMA) (KING, 2009). To achieve further advantage the central repositories should be used to exchange information on concepts from the CCDM. Doing so will make the patient or consumer object interoperable with any organization making use of the identifiers in the central repository. In a patient-centric approach of the chain integration problem this is the first step towards interoperability of care. An example of this is the “verwijsindex risicojongeren(VIR)” (Binnenlandse Zaken), this is an index in which persons who received youth care can be registered. In essence all this index stores is a person identifier (based on the social security number) and the name of the organization that knows more about this. If a care organization perceives a youth is at risk, they can check if there are colleagues with whom the individual is known. Further information exchange should be performed by the organizations themselves but could in the future be facilitated with digital information exchange. To ensure this interoperability within the organization the following principle was added to the artifact:

Information gathered about the customer, or related to the customer, should always be mapped to the unique object in the instantiated CCDM

As mentioned earlier accountability is important for the inter-organizational reimbursement that takes place in the public care sector in which municipal care organizations act. Centralizing the administrative services not only provides a way to communicate primary services in an organized manner. It also facilitates managerial control by creating singular measurement points. The performance of products is measured more easily if the same and single entity of a customer is used throughout the organization. Production figures of different products become comparable because the unit of analysis can now be the same. Such performance measures are necessary for the accountability towards the commissioning and paying municipal government. Measuring performance can only be done if the required variables are available and compatible with the measuring instrument. This means that if we want for instance to compare the personnel required to realize a certain product we cannot compare a headcount with man-hours. Standardizing these measurement variables in the same way as with other concepts in the CCDM makes it possible to compare these and even calculate product cost based on the people required. To further facilitate

this control function and comparison of measurement a single repository of performance indicators was introduced. This repository extracts and calculates indicators from the source systems directly or via import-export functionality. The exact operational details of extracting these values from different sources will, as far as it relates to the architecture, be described in the section Bottom-up. Formalizing organization wide measurements using a central repository and making these numbers available for the managers of different sectors does spark new discussions on grouping personnel and processes. Categorization within concepts in the CCDM such as personnel makes the reorganization easier as administrative staff is categorized as such, making it visible for the different managers how disparately it is organized. But the more important effect is the discussion on the sub categorization of medical personnel. In this process many different sub categories of "nurse" were named. Again, focusing on the similarities instead of the differences made it insightful how much overlap there is.

3.2.2 BOTTOM-UP

This section describes the result from the bottom-up approach where context specific problems are addressed and related to the enterprise architecture. The results in this section have a closer relation to the application layer than those in the previous section. This is in part a result of the ad-hoc solutions that are provided based on the implemented architecture by the ICT department at the municipal care organization. Due to a few country wide information systems, which are used at nearly all municipal care organizations in the Netherlands, some solutions touch the interorganizational interoperability issue. From these cases we not only learned that other municipal care organizations encounter the exact same problem, but also that our solution is applicable over multiple settings.

3.2.2.1 NURSERY INSPECTION

In the Netherlands, municipal care organizations are responsible for inspecting nursery organization. Based on the location of the nursery organization it falls in the working area of a specific municipal care organization. The nursery organizations are registered in a central repository, Landelijke Registratie Kinderopvang(LRK), in which their unique identification code is given. This administration is not accessible directly for the municipal care organization so that they are forced to create their own administration of nursery organizations. To facilitate the reporting of inspection from municipal care to the municipal governments a nationwide application was launched. In this application the municipal care organization can register findings of inspections and create reports. To be reimbursed for these inspections the municipal care organizations are required to send invoices to the municipal government. On these invoices the inspected nursery organization must be identified along with the performed inspection type. This information resides in the central application and cannot be exported to the municipal care organization. In order to make invoicing and business intelligence possible without creating a new and redundant administration of this information an export function is required.

This concrete project identifies a new central repository which should be used for the identification of the nursery organization concept. It also shows that there is another kind of secondary degree service based on production data which is the monitoring of business performance. In order to keep track of the performance indicators for the municipal care organization business intelligence is applied to collect measurement data. Mapping these information sources of the nationwide application to our CCDM showed the lack of information exchange. This lack of information

interoperability from the nationwide repository to the individual municipal care organization is not unique to the municipal care of northern north-holland. After it was identified at northern north-holland it was put on the agenda of the user group of the nationwide application. The problem was generic and the developer of the nationwide application is now working on a solution which should enable interoperability of information for the nursery inspection product. While this is still a work in progress the aim is to provide exports of the central repository with weekly mutations for the local municipal care administration. Along with this information operational information such as performed inspections will be provided to support invoicing but also other second degree services.

3.2.2.2 NEWBORN CARE

One of the many responsibilities of municipal care in the Netherlands is to screen newborn children for certain defects. This screening should take place within the first week after the child is born. For this purpose the municipal care gets a list of all the newborn children from the municipal government's repository, which is part of the nationwide standardized repositories for person administration. The central repository, and thus the information delivered to the municipal care, contains the information required to contact the mother and arrange for the screening so that it may take place within the one week timeframe. But before the governmental repository contains the required information and gives such an update a few days may have already passed. There are circumstances where the child will not be known in the central repository in time and thus no notification will reach the municipal care organization via this route in a timely manner. Because of these exceptions there are informal ways in which the municipal care organization is contacted by other care providers to inform about the newborn child. These exceptions have implications for the applications used to store customer information because if the child is not known by the government repository yet, it doesn't have a social security number either. So it is required that we can create temporary identifiers which should later be mapped to the definitive identifier. This example shows how a relation between two consumer instances is sometimes required in a certain care context. In this case the mother is linked to the child so that it can be located and the screening can take place. The enterprise architecture was used to map this process and its exceptions after which the discussion about "relations" was sparked in the ICT department. It is clear that concepts can appear in certain contexts in certain configurations which add information. So can multiple customer instances be a family together which is important for the youth care context, while some of the actors in this family may be part of a traveler company which is in turn relevant for the traveler care service. This shows the importance of the difference between natural persons and the roles they may play in each different context. Mapping all these roles to the natural persons and their generic characteristics sheds more light on the complexity of mapping services and customers together because the categorical mistake of thinking of a person while talking about a role happens easily.

3.3 STAGE 3: REFLECTION AND LEARNING

The reflection and learning stage takes place during the stage two activities of building, intervention and evaluation. Where the evaluation of stage 2 comprises the effectiveness of the practical problem at the municipal care organization this stage focusses on how it relates to the class of problems. The issues and solutions found in the case study will be mapped to the ones found in the literature. Because of this the literature study can possibly expand due to new insights. By abstracting the stage 2 results in stage 3 generalization of the outcome and validity is ensured. These abstractions take place after each intervention in stage 2 so that the generic artifact is created with the same

increments as the practical artifact. In this stage it is also important for the researcher to put considerations used to alter the practical artifact in an independent perspective so that their influence is correctly taken into consideration for the class problem.

This section describes the abstraction of the results from stage 2 and contains the architectural principles and rationale applied in this research. Architectural principles are the prescriptive notions which need to be taken into account in order to achieve the strategic goals for which enterprise architecture is applied. In the abstract problem of chain care this goal is seamless integration of care towards the patient. Each individual organization should first and foremost be able to provide such care as one after which this experience can be extended to the chain partners (Barbarito, Pinciroli, Mason, Marceglia, Mazzola, & Bonacina, 2012). Examples of such integration have been given in the previous sections, illustrated by cases of both the inter- and intra-organizational problems.

3.3.1 PRINCIPLES

In this section the architectural principles are described that were conceived during the stage 2 interventions. These principles should be considered as normative to ensure interoperability. Of course the list of principles is not exhaustive and should be used dynamic within organizations so that new principles may be added to address the organizational strategy.

The municipal care provider possesses the means to prevent asking the customer for information that is already known in the organization or available from accessible repositories of chain partners.

Mutations of information are done in and via the central repositories

It is clear who the owner of information is and in which central repository it resides

There should be no copies of information from the instantiated CCDM which are not coupled to their source

In case of erroneous information appropriate action should be taken to fix this in all repositories and notify the involved actors

Information exchange with chain partners is done according to agreements and with respect for the privacy and confidentiality of the information

Information gathered for specific processes should be standardized so that every time the process is executed the resulting information is the same

Information gathered about the customer, or related to the customer, should always be mapped to the unique object in the instantiated CCDM

Mapping information to the most abstract concepts in the instantiated CCDM should always be done in the shortest way possible

Applications which make the most direct mapping to the instantiated CCDM or incorporation of the instantiated CCDM directly are preferred over solutions which require more steps

Applications should support services that enable them to broadcast or receive mutations from and to the central repositories

The CCDM and the instantiation thereof should both be updated so that they correspond with each other at all time

Front-office services should be made available without human intervention as much as possible

3.3.2 RATIONALE

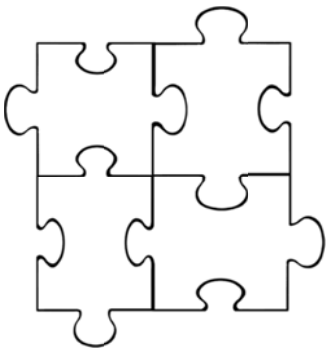
In this section the rationale that played an important role for the iterations of the artifact. Along with the architectural principles this rationale should provide guidance while instantiating the reference architecture in an organization.

3.3.2.1 THE PLATYPUS PROBLEM

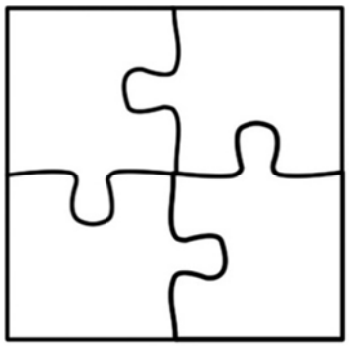
As discussed in the section on Primary services and customers, categorization can and should be used to decrease complexity. The criteria used to decide if a concept belongs in a certain group can however create new problems because some concept is found which would include it in multiple groups or worse, exclude it from all groups. The result may be new discussions about whether the criteria should be revised altogether so that this new concept fits in one category exclusively. Creating such fine grained criteria is tedious and increases the risk of finding more of such problematic concepts. A certain degree of pragmatism should be used to counter this. During the top down approach workshops this problem was addressed as "the platypus problem". The platypus is a creature in the animal kingdom which is categorized as a mammal, but shows a lot of characteristics of both reptiles and birds (Warren, et al., 2008). By recognizing the complexity of making categorizations using this illustration we were able to sidestep some semantic discussion. In many cases it was sufficient to ask the question if the concept that didn't fit was really one concept or if it should be decomposed into other concepts. This turns out to be a recurring problem because of the many second order services the municipal care organization delivers.

3.3.2.2 THE PUZZLE PROBLEM

A challenge of applying enterprise architecture is that you do not know what you don't know. Professionals may skip steps in describing the process or may not even recognize some output of their work as products. Completeness can only be verified dynamically based on the relationships amongst the different objects. Creating a centralized front- and back-office alleviates this problem somewhat by creating clear entry and end points for every single service and underlying processes.



NO KNOWN



KNOWN

But the problem still persists, especially for services of the second degree. This problem can best be illustrated by comparing it to a jigsaw puzzle. If you have one single piece of a jigsaw puzzle

(assuming there is no print) you will not know how many pieces you need for the complete puzzle. This problem is depicted in Figure 13 where even though some parts fit together we know nothing of the total. Gathering more pieces and being able to put them together provide a context for the initial piece and eventually should create a coherent structure. But for this structure nothing can still be said about its completeness, we may assume that it goes on forever. The connectors of the puzzle pieces are analogous to the relationships in the enterprise architecture. These may be formed by the information flow between processes and can be seen on the output side as supply and on the receiving side as demand as was illustrated earlier in the section on Indirect services and customers. Central organization of administrative processes can be leveraged to create "edges" in the enterprise architecture. These make it easier to say something about the completeness of the inventory of concepts and objects, like edge pieces in a jigsaw puzzle can be used to delimit the outline of the entire thing. An example of such known end pieces is depicted in Figure 12. Once we have the edges in place we can look at completeness from an informational point of view. If there is a discrepancy in the information sources and the information use of the process there may be some steps or sources missing or obsolete. The biggest problem encountered here is that such discrepancies are not always visible. If we have "Process A" and "Process B" where the A provides input for B this may appear like a good fit. But in truths on many occasions this fit is deceiving. In processes where step A is done by a certain actor and B by another actor it is often the case that the actor for process B has some extra conversion on the information it receives. This is illustrated in Figure 14 which shows the seamless process on the left but the reality decomposed on the right. In order to perform process B there is a conversion of the Output A required which also adds infromation from another source "Pooldata B". This decomposition illustrates that there are still gaps if we take a close look while at first glance the "puzzle" seems complete. To get a grip on this problem another "edge" can be used, which is the mapping of all information sources to all processes. This requires a lot more work because the professional has to state all the information and be able to recognize that the transformation illustrated results in another source. The architectural picture is discussed with the professional including such examples of decomposition. While initially this seems pretty straightforward, because the ICT depratment is aware of most applications, the use of Microsoft Excel by the professionals makes this mapping a lot more complex.

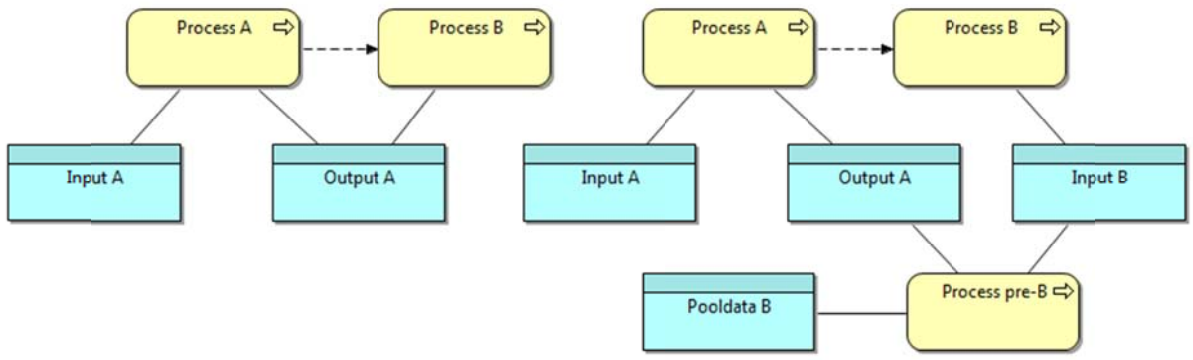


FIGURE 14: SEAMLESS PROCESS DECOMPOSED

The analogy of the puzzle along with the enterprise architecture model was used in discussions with professionals which helped them grasp the extent of information use in their process. Raising awareness within the organization led to numerous operational fixes of which some are illustrated in

the earlier section Bottom-up. Awareness on this level is especially important for the tractability of second-order services. It is also important to note that a complete picture in one context is incomplete in another. If the input and output of processes A and B are complete and mapped or instances of the CCDM the sub process may not be relevant at all for the rest of the organization. In this case contextual concepts used for “Process pre-B” should not be part of the organization wide view and the completeness based on the edges may still be assumed on this level. Considering “Output A” as an edge piece for “Process B” may in turn show the discrepancy which requires the “Process pre-B”. This shows that the analogy of the puzzle is striking if we consider it regressive. In other words, a piece may be an edge, but built from other pieces that are not necessary edges. To prevent models with endless regression it is of vital importance that we only include the level of detail that is necessary for achieving our architectural or business goals. This corresponds to the principle of the dynamic architecture(DYA) framework which states that architecture must be developed “just enough, just in time” (Wagter, Berg, Luijpers, & Steenbergen, 2005).

4 CONCLUSION

This chapter describes the final conclusions from implementing architecture at a municipal care organization in the Netherlands. The abstracted learning from this project is presented here as a reference architecture which captures all the rationale and principles required for successful and interoperable enterprise architecture. This chapter is the product of the final stage of the ADR method: Formalization of Learning. Its focus is on generalization of the outcomes of the situated research. We do this by moving from the specific-and-unique to the generic-and-abstract on three levels:

- Generalization of the problem instance
- Generalization of the solution instance
- Derivation of design principles from the research outcomes

The outcome of these generalization moves will each be described in separate sections within this chapter.

4.1 GENERALIZATION OF THE PROBLEM INSTANCE

The problem statement specific for the municipal care organization in this research was as follows: Current use of information sources in municipal care organizations is lacking interoperability which leads to inefficiency and difficulties aggregating the right information in a timely manner. In short we can call this problem the lack of integrated care. Looking at the more generic problem we are dealing with information interoperability in a value chain. In a generic context this problem is the problem of chain computerization. The integrated care problem is thus an instance of chain computerization in a care context. This care context may differ from other sectors in that increased effectiveness may save lives and improve (public) health. Achieving interoperability in the care value chain increase the chains value even though this may be harder to measure with monetary values as would be done in commercial value chains. The problem of integrated care is thus the same as chain computerization but the context offers some differences which must be taken into account when applying traditional solutions to chain computerization.

4.2 GENERALIZATION OF THE SOLUTION INSTANCE

In this step we move from the enterprise architecture implementation to the rationale of the reference model, so that the organization specific features are abstracted. This final artifact aims to provide a means to solve chain computerization problems within the municipal care organizations in general. The relevant rationale used during the evolution of the theory ingrained artifact to the final version is abstracted so that it applies to a broader context. Decision factors that were specific to the context of northern north-holland will be mapped to abstract factors or be dismissed as not applicable to a generic context. Once this abstraction is finished and the generic rationale is captured it will be presented to the end-users and practitioners at the municipal care organization. This will provide the researcher with final feedback and pointers on the abstract artifact after which it will be finalized along with the documentation of the lessons learned and the threats to validity to which the research is subject. At this point the results will be evaluated against the literary background to place it in a scientific context.

4.2.1 INTEROPERABILITY: INTERNAL VERSUS EXTERNAL

The main target of this thesis was to create a reference model for interoperability in the municipal care sector. However, at this point in time the municipal care organization is not entirely capable to provide interoperability between the different internal organizational units. This should be addressed first so that the organization can reap the benefits of unified processes and measurements. Of course the application of enterprise architecture to achieve interoperability for the internal organization does not exclude its efficacy on an external level. This was proved with the nursery inspection case in section 3.2.2.1; sometimes interoperability with external organizations is a prerequisite to prevent implementing new redundant information silos. Readily available external repositories which harbor concepts required for the internal organization should in such cases be preferred over internal solutions. Doing so makes the step towards interoperability with other organizations smaller because there is already a common and interoperable concept in use.

4.2.2 GENERIC CONCEPTS

The use of a generic concepts in the CCDM proved to successfully alleviate interoperability problems. Central concept models such as the CCDM are easily modeled using enterprise architecture which supports all the required concepts to address all aspects of business-it aligment. This way not only the generic information but also its underlying processes and systems are logically addressed. Its effectiveness depends on the amount of context based abstraction levels remain in the organization. As we have seen if there are more specializations available of a certain concept, the information linked to this objects remain scattered. The first step is to map the scattered objects to the central concepts before interventions can be designed and implemented. Each intervention can be targeted to further comply with the principles of the reference architecture so that communicating about the concepts on the highest level of the CCDM facilitates access to the information mapped to these concepts.

Another very important aspect of the use of a CCDM which maps all information concepts together is its effect on communication. By focusing on the similarities of concepts and mapping these to central concepts professionals identify the possibilities of reusing the same concepts over different processes. If minor attributes suggest a separation of concepts this can most of the times be fixed by using specializations. This way the central concept remains in use while the extra attributes for the specific context reside in the specific instantiation of the concept. Interoperability on the generic context is ensured while the specifics remain intact so that professionals can easily identify themselves with the concept and its instances. Sometimes semantic discussions arise where the name given to a concept in a different context is essential for its use. In such cases a central concept should be chosen to which these synonyms can be mapped. An example of adding information to a concept can be understood by looking at the analogy of the planet Venus. Venus is sometimes referred to as the morning star or evening star. In both cases they refer to the same object, Venus. But there is a subtle difference in the name which relates to the context in which it is used. This context has to do with the position of Venus on her orbit around the sun which makes it either visible from earth in the morning or in the evening. So unless we want to create separate concepts for the times on which Venus is visible, we may accept the synonym names which only for those with the knowledge of Venus's orbit include extra information which is not explicitly captured. This should of course only be done if the implicit information of the synonym is only relevant in an isolated context while the generic term should suffice organization wide.

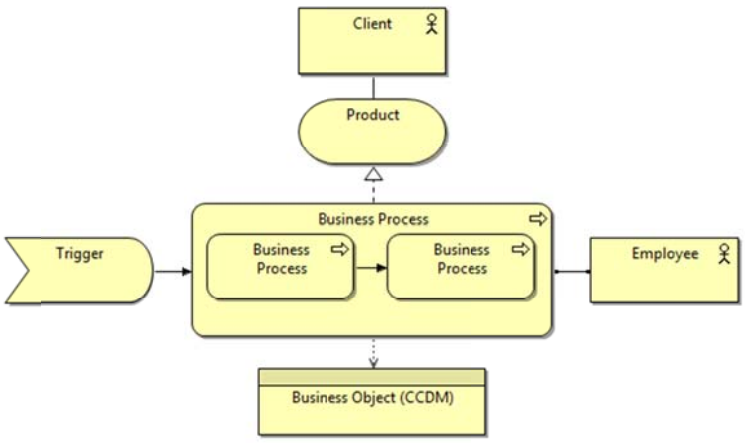
While the use of generic concepts proved very powerful it also proved very difficult to achieve this. Categorization is used to group concepts based on similarities or to exclude them from groups based on certain characteristics. Sometimes the similarities of different concepts can be placed in the model on a higher abstraction level so that the differentiating characteristics are merely used as specializations of these abstract concepts. An example is when we take the similarities between male and female and put these in a model as a new concept which we name human. We then proceed to create two specializations of this human concept, one for male and one for female. This way the generic concept can be used in all processes where only the generic information of the concept is required while ensuring compatibility with processes that require more detail. Of course making categorizations is often complex and certain characteristics may seem impossible to align with the established categorization criteria. The risk is that the process hampers due to unresolvable discussions on semantic problems. To sidestep these discussions it should be recognized that adding more detail also increases complexity so the level of detail should be kept to the level that is required for organization wide use. Recognizing the complexity of making fine grained categorization, which we call the "platypus problem", helps getting acceptance from professionals to choose more pragmatic categorizations.

4.3 DERIVATION OF DESIGN PRINCIPLES FROM THE RESEARCH OUTCOMES

In this section the design principles which are the result of the reflection and learning stage will be re-iterated. The goal is to capture all knowledge of creating the instance of the solution so that it may be applied for other instances that belong to the class problem viz. chain computerization in the care value chain. This is a re-iteration of the principles found in the results of stage 3 together with the required rationale. These principles along with their rationale and illustrations are the final artifact: a reference model for municipal care.

4.3.1 THE ARTIFACT

The goal of this reference architecture is not to prescribe a complete method for the implementation of enterprise architecture. For this purpose there are suitable existing methods such as the open group architecture framework (TOGAF, 2005). The goal of this reference architecture is to create a common ground among municipal care organizations who implement enterprise architecture and to help them tackle their interoperability problems within the organization. The focus is on creating a service oriented view of the organization, where services are what the organization delivers to its environment. This orientation ensures that the organization knows which services are available so that it can be communicated to their customers (internal and external) and chain partners.



To create a service oriented architecture it is important to choose a level of granularity on which these will be mapped. The main goal will be to make insightful how services are delivered to the customer so that interoperability of these services and processes may be achieved. To create

the inventory of these services a line of thinking must be used to illicit this information for the model. A good starting point is to ask who receives which services, followed by mapping how this is done. This is illustrated in Figure 15. The question how should be answered with a trigger which starts a business process with possible sub-processes, executed by employees and making use of information of business objects. The chosen level of granularity must correspond to the strategic goals for the purpose of implementing enterprise architecture. This may also mean that multiple levels of abstraction or granularity are used. Operational problems which occur in a few specific processes may be addressed with much more detail than the question if such and such service belongs to a certain organizational unit. While the operational problem may require a detailed view of information and process flow, the positioning of a service may not require this level of detail. Both approaches are part of the same enterprise architecture but use a different view in which the level of detail is determined by the organizational goal for which it is employed.

Principle 1	*Using a central concept model*
Goal	Use of a central concept model to which each instance of its occurrence can be mapped is required to share information among such instances
Example	The use of a concept “customer” of which the concrete uses “child” and “patient” are instantiations make it possible to identify the “child” via customer once it becomes a “patient” in another context.
Principle 2	*Mutations of information are done in and via central repositories*
Goal	To eliminate information silos and redundancy. This also gives a central identifier for the concept which can be used throughout the organization, making it interoperable for multiple processes.
Example	For the identification of persons the municipal government has a central repository available in which persons are identified by their social security number.
Principle 3	*It is clear who the owner of information is and in which central repository it resides*
Goal	To create a sense of ownership and make it clear where the leading information resides. This leading information should result in a reliable source for the concept of which information is required
Example	The municipal government owns and mutates the central repository for the administration of persons. All organizations using this repository know that they can find a certain set of variables in this repository using the social security number.
Principle 4	*There should be no copies of information from the instantiated CCDM which are not coupled to their source*
Goal	To prevent an instantiation to keep on existing apart from its source which would result in redundancy and discrepancies of the central concept
Example	Once the information from the repository of the central government is downloaded in a certain application, the acquired variables should not be mutated apart from the repository. If the repository is incorrect it should be mutated there and not only in the instance used in a certain context.
Principle 5	*In case of erroneous information appropriate action should be taken to fix*

this in all repositories and notify the involved actors.

Goal To keep the repositories reliable and eliminate a need to keep isolated copies of instantiated concepts.

Example If information about a person is incorrect in the central repository it should be communicated to the responsible organization. In this case the municipal government.

Principle 6 *Information exchange with chain partners is done according to agreements and with respect for the privacy and confidentiality of the information.*

Goal To prevent the achieved interoperability from being used in ways that is not in the best interest of the customer or the organization.

Example Communication of lab results from the hospital to the municipal care organization is done via unique codes so that only the municipal care organization can trace it back to an individual.

Principle 7 *Information gathered for specific processes should be standardized so that every time the process is executed the resulting information is the same.*

Goal To make the process itself interoperable with other organizations or organizational units who have a clear understanding of the information in- and output of the process.

Example The process of vaccinating a child always requires the social security number of the child and the batch number and name of the given vaccination.

Principle 8 *Information gathered about the customer, or related to the customer, should always be mapped to the unique object in the instantiated CCDM*

Goal To have a customer centric approach all his relevant information should be mapped to a single instantiation of the concept so no redundant or isolated information can occur.

Example Once a customer gives some information required for the delivery of a service this information should not be asked for again when he is to obtain another service requiring the same information.

Principle 9 *Mapping information to the most abstract concepts in the instantiated CCDM should always be done in the shortest way possible.*

Goal To prevent long routes for acquiring information about the concept which obfuscate the relation between the abstract concept and its concrete instantiation.

Example The concept customer can be instantiated as patient or child. If this is the case it should be mapped like this in the model. The alternative, which should not be used, is that the central concept is mapped to a process which is then mapped to an application which is mapped to the patient or child.

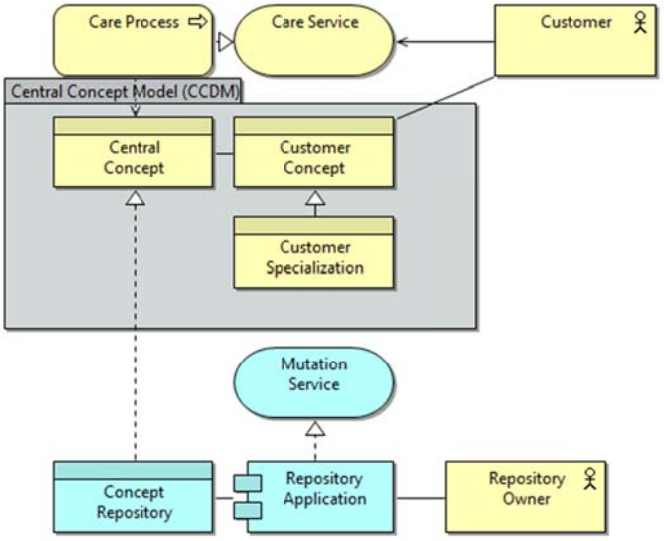
Principle 10 *Applications which make the most direct mapping to the instantiated CCDM or incorporation of the instantiated CCDM directly are preferred over solutions which require more steps*

Goal To prevent long routes for acquiring information about the concept between applications.

Example More than a single middleware layer or transitions between applications are eliminated this way. Thus eliminating redundancy of function and of storage.

Principle 11 *Applications should support services that enable them to broadcast or receive mutations from and to the central repositories*

Goal	Make it technically possible to mutate information centrally so that no instantiation is missed.
Example	The application for traveler vaccination may receive updates on client information which is then also mutated in the central repository and other instances of the customer concept.
Principle 12	*The CCDM and the instantiation thereof should both be updated so that they correspond with each other at all time*
Goal	To keep the CCDM and the objects used by the business synchronized
Example	If a new business object is required it is linked to the central model accordingly.
Principle 13	*Front-office services should be made available without human intervention as much as possible*
Goal	Accessibility of services for the customer is better this way, making it possible to deliver more with less people.
Example	A customer can login on the website of the municipal care organization to schedule a vaccination. The required information can be submitted to the system directly.



When the principles are applied and the central concepts are related to corresponding central repositories the application layer needs to be added to the initial inventory of services which was depicted in Figure 15: Line of reasoning used for mapping the services. Figure 16 illustrates how the central concept model relates to both the processes and the central repositories according to the architecture principles above. The gray box delineates the central concept model. Here the organization wide concepts such as customer or patient record will reside. The "care process" accesses the concept when information is required for the execution of "care service". For each "care service" delivered to a customer, there should be a relation of this customer to the central concept according to principle 8. In this example the customer information is generic enough to be coupled directly to the highest level "customer concept". If more detail is required in the specific context the relation can also be established through a "customer specialization" concept which captures these specifics on a lower level in the central concept model. In order to realize principle 2, *Mutations of information are done in and via central repositories*, the concept should be captured as a data object "concept repository" by the "repository application". This application should have a known owner and a "mutation service" which allows the user of the repository to access mutations in the repository directly, in accord with principles 11 and 12.

5 DISCUSSION

In this chapter the threats to validity and shortcoming of this research are described and suggestions for further research will be sketched.

5.1 GENERALIZABILITY

Because the action design research is only performed by one researcher at one single company it may harm the credibility of applying it on other organizations. The researcher has of course used the last stage of the research to validate the outcomes with the scientific knowledge in literature. This ensures some degree of generalizability. The case of nursery inspection and the adaption of the nation wide application that was triggered by this research is a demonstration of the generalizability. But although this proves that the same concepts are recognized and used in the other municipal care organizations, interoperability requires a shared concept preferably in a central repository. Because this may not be available for all required concepts or worse, multiple semi-central repositories are available, there is no guarantee that this approach is always successful. But this is an implementation problem which should be addressed in future research. The fact that a central and standardized repository for concepts makes interoperability possible still stands. After interoperability is achieved within the different segments of a single organization the next logical step would be to leverage this to the entire municipal care value chain. If more organizations will implement enterprise architecture according to the principles described in this thesis, some common ground will be achieved. The efficacy of such common ground stemming from the interpretation and implementation of a common set of principles must be researched.

5.2 CONTRARY FINDINGS

The findings of this research are different from the literature which states that process interoperability should be limited to those which create or modify clinically relevant information (Pascot, Bouslama, & Mellouli, 2011). The current research did encounter clear instances where creating interoperability for the administrative function enabled interoperability for the clinical function as well. It is not entirely clear how the difference in these results may be caused. Generally it is accepted that while implementing enterprise architecture we should focus on the strategic goals and leave out what is not important for these goals. Of course there is a difference between a concept that only appears in administrative functions and a concept that is shared organization wide. In our case the major advantage was created just because it strengthened the interoperability of the customer concept. Interoperability of the administrative function itself is not required for patient care so this may be what was suggested in earlier research. How this distinction can be made, and how administrative use of clinically relevant concepts can improve standardization and interoperability should be researched from a change management perspective.

5.3 SUB-OPTIMAL SOLUTION

While the results of this research can be used to alleviate the problem of chain-computerization nothing is known about the effectiveness of the proposed solutions. While a positive effect has been observed it is not measured. This means that it is not known how far away from an “optimal solution” the proposed solution is. We must assume that the solution is far from optimal and that it should be improved upon with more iterations of the artifact. Further research should look for

alternative solutions and compare the effectiveness of such solutions with the one proposed in this thesis. That way the feasibility and efficacy of the proposed solution and its development can be established.

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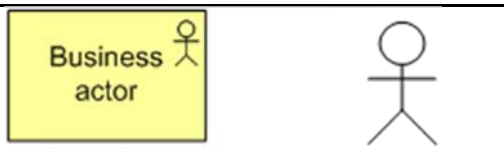
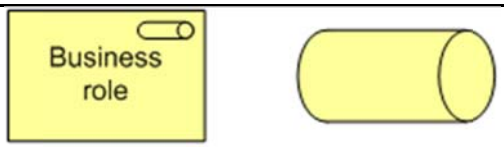
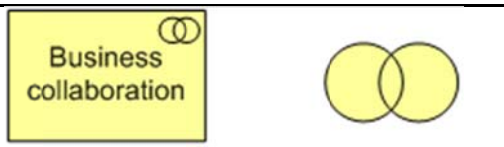
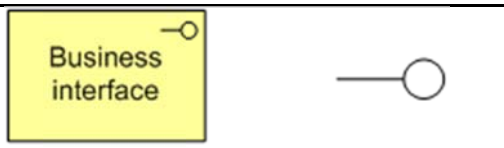
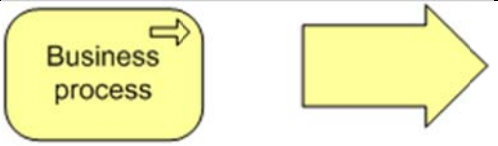
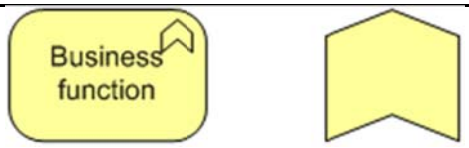
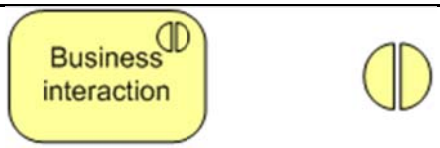
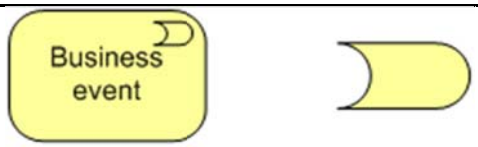
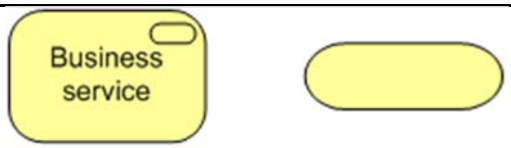
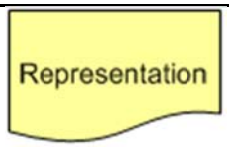
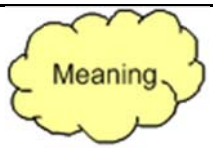
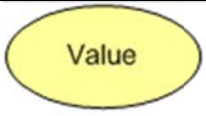
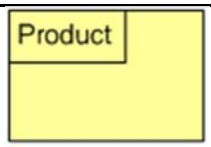
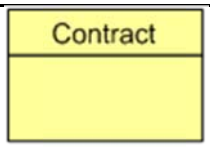
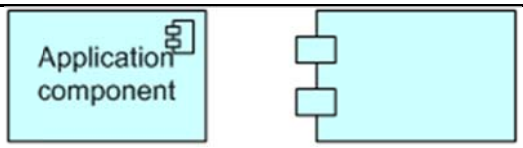
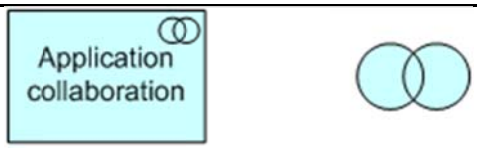
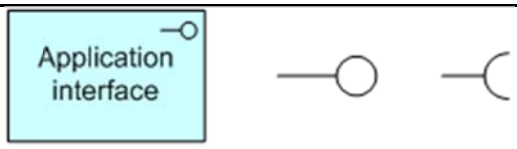
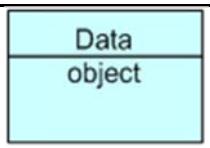
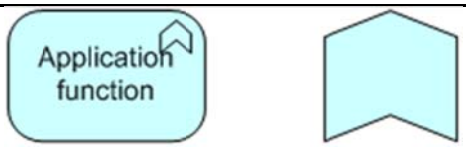
7 APPENDIX A: ARCHIMATE CONCEPTS

A full overview of the ArchiMate 1.0 concepts used in the business and application layer is provided (The Open Group, 2009). The technology layer is not included because it was not used in this research project. The first column gives the name of the concept, the second column a short description and in the third row the notation is depicted. Note that some concepts two different notations are available and that the color is different per layer.

Concept	Description	Notation
Business actor	An organizational entity that is capable of performing behavior.	
Business role	A named specific behavior of a business actor participating in a particular context.	
Business collaboration	A (temporary) configuration of two or more business roles resulting in specific collective behavior in a particular context.	
Business interface	Declares how a business role can connect with its environment.	
Business object	A unit of information that has relevance from a business perspective.	
Business process	A unit of internal behavior or collection of causally related units of internal behavior intended to produce a defined set of products and services.	

Concept	Description	Notation
Business function	A unit of internal behavior that groups behavior according to, for example, required skills, knowledge, resources, etc., and is performed by a single role within the organization.	
Business interaction	A unit of behavior performed as a collaboration of two or more business roles.	
Business event	Something that happens (internally or externally) and influences behavior.	
Business service	An externally visible unit of functionality, which is meaningful to the environment and is provided by a business role.	
Representation	The perceptible form of the information carried by a business object.	
Meaning	The knowledge or expertise present in the representation of a business object, given a particular context.	
Value	That which makes some party appreciate a service or product, possibly in relation to providing it, but more typically to acquiring it.	
Product	A coherent collection of services, accompanied by a contract/set of agreements, which is offered as a whole to (internal or external) customers.	

Concept	Description	Notation
Contract	A formal or informal specification of agreement that specifies the rights and obligations associated with a product.	
Application component	A modular, deployable, and replaceable part of a system that encapsulates its contents and exposes its functionality through a set of interfaces.	
Application collaboration	An application collaboration defines a (temporary) configuration of two or more components that co-operate to jointly perform application interactions.	
Application interface	An application interface declares how a component can connect with its environment.	
Data object	A coherent, self-contained piece of information suitable for automated processing.	
Application function	A coherent group of internal behavior of a component.	
Application interaction	A unit of behavior jointly performed by two or more collaborating components.	

Concept	Description	Notation
Application service	An externally visible unit of functionality, provided by one or more components, exposed through well-defined interfaces, and meaningful to the environment.