The use of Dutch governmental reference architecture in the public/private healthcare domain

The design and evaluation of solution architecture for a healthcare platform in the public/private domain

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Abstract

In the last decade, there has been an increase in connectivity between private and public healthcare organisations. This increase is facilitated by technology developments, new legislations in healthcare, decentralization of healthcare and new market developments. Solutions are designed in the area of healthcare ICT.

However, there is a problem with the design of these solutions; there is a lack of knowledge on how reference architecture can be used to resolve tensions between public and private healthcare organisations. The main research question was therefore: *"How effective is the Dutch governmental reference architecture (NORA) for private organisations that want to connect to the public domain?"* To determine the effectiveness of the NORA two methods were used. The first method was to find out what tensions often arrive between public and private organisations when they collaborate and second if all parts of the NORA are actually usable for private organisations. To do this the following research objective was devised: *"Design and evaluate a private domain solution architecture for a matchmaking platform based on governmental reference architecture to investigate NORA's effectiveness in private architecture"*. There are differences between public and private architecture because of the difference in legislation, guidelines and standards. Connecting public and private organisations is therefore inherently difficult.

A solution was investigated through the use of reference architecture because It was assumed that when different organisations follow the same reference architecture, the tensions can be solved. A single design case study was used to investigate this assumption. A private matchmaking platform is being developed to connect private and public healthcare organisations in the Netherlands for the benefit of the aging population. The public reference architecture used in the Dutch government is the NORA and was used during the design of a project start architecture which was further developed to a solution architecture for an online matchmaking platform that supports elderly to live longer independently.

Using literature in the field of design theory, project start architecture, reference architecture, governmental architecture and solution architecture, this thesis will expand the literature on the inherent tensions between public and private organisations by applying Dutch governmental reference architecture in a solution architecture that facilitates information exchange within the public/private healthcare domain.

The results generated from the design, interviews and a questionnaire showed that the NORA might be useful as a basic framework but the NORA is not ready to use by private organisations. Many parts are not applicable for private organisations and the resulting architecture needs to be enhanced with domain architecture.

The tensions found were split in two domains. The healthcare tensions were healthcare standards, design requirements in healthcare, laws which need to be complied with, privacy concerns and a high level security. As well as the tensions between the public and private domain; attention must be paid to the different guidelines and regulations used by both, the effect of politics on the goals of each organisations, the availability of usable data for both, a different timeline and different concerns steered by society or the market. The first showcase of the usability of public reference architecture in private organisations makes a unique contribution to the area of public/private architecture. However, it can be concluded that the NORA is not ready to be used as a reference architecture for private organisations and as such does not solve all tensions in public/private collaborations. However, the NORA can provide a common language between public and private architects, which makes collaboration easier. The NORA consists of principles, standards and building blocks of which 6 principles cannot be used, the standards cannot be used except the open standards and the building blocks cannot be used since they are designed for public only organisations. As of now the NORA is too abstract, not adjusted and takes too much time to inspire and attract private organisations.

This study can be used as a first case in a multiple case study in this area of research. Future research should be conducted on the use of NORA within the Dutch government and the possible uses and adaption of the NORA for private organisations. This can then be combined into a new reference architecture or adjusted NORA for public/private collaborations.

Keywords: Reference architecture, solution architecture, public/private healthcare collaboration, NORA.

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Contents

Terminology

This section is written to explain business jargon before explaining the standards and formats used during the design.

Table 1:Terminology explanations

PSA	Project Start Architecture
SA	Solution Architecture
SAD	Software Architecture Description
PID	Project Initiation Document
PED	Project Exclusive Design
GDI	Generic Digital Infrastructure
NORA	Dutch Governmental Reference Architecture
ISO/IEC/IEEE 42010	International Architecture Description Standard for Systems and Software
Semantic data model	A semantic data model is an abstraction that defines how the stored symbols (the instance data) relate to the real world
TOGAF	The Open Group Architectural Framework Version 9

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Chapter 1 - Introduction

In this chapter a general overview of the problem statement will be given. After reading the introduction, the reader will have an understanding of the practical problem, the scientific problem, the research objective and the research questions.

1.1 - Practical problem

In this section, the practical problem of this thesis is explained. The practical problem is derived from several topics which show parts of the problem. The conclusion shows the final problem to which a solution should be found.

Healthcare - The world population is expanding at an increasing rate. Secondly, the world's population it is also aging because people live longer and the fertility rate is declining (Population Reference Bureau, 2016). This has a number of consequences. The healthcare facilities must be expanded, current healthcare institutions have to be more efficient to cope with this increase of possible healthcare users and these developments place stress on the current institutes and therefore also on the end-users of the healthcare.

Government rules and legislation - In addition to the aging problem, the Dutch government has put its hope in deinstitutionalization and the decentralization of Dutch healthcare to save costs in the healthcare system to cope with the increasing and aging population. As an example, Finland is ahead in this process of deinstitutionalization: "*Deinstitutionalization is an important trend in the redesign of long-term eldercare in Finland. It refers to a process where traditional institutional care is partly replaced by home care services and the creation of homelike housing units"* (Anttonen, 2016). The concept of placing long-term eldercare in the hands of the community is in line with developments in Dutch legalisation. The Dutch government is shifting responsibilities from a national level to the municipalities (Rijksoverheid, 2016) because of the financing problems that arose because of the aging population and to improve healthcare quality by getting healthcare closer to the user.

One of the groups of care users are the elderly. Before the decentralization, the elderly would move to a care home when living at home was no longer possible. Within the new legislation, the municipalities want to support the elderly at living longer independently. The Elderly have to adjust their home incorporating smart living technologies. Smart living consists of developments that interconnect hardware and applications within the home to ensure that functional and non-functional requirements concerning home design come together. This is supported by the concept internet of things (IoT). Smart Living services are related to the Internet of Things (IOT) which is interpreted as "*a worldwide network of interconnected objects uniquely addressable, based on standard protocols*". Next to that, smart living services can be seen as mediator between providers and customers in the process of value creation (Keijzer-Broers, Florez-Atehortua, & De Reuver, 2015a).

Technology - Smart living products and internet of things concepts are the result of technological improvements of the last century which follow up on each other at an increasing pace. These technologies are also being developed in the area of information and communication technology (ICT). ICT often forms the basis of new IT developments and the challenge lies in how to manage those developments (Ba, 2015).

One of the technological advancements this century is the increased level of connectivity. Connectivity describes the amount of information shared between organisations in all areas of the world. The increasing amount of connectivity brings new knowledge to areas previously un-serviced and is facilitated by ICT developments which increase the level of ease in which end-users can connect to each other acquiring information. High-speed internet especially increases the way companies do business and exchange information. This connectivity is also interrelated with the increase of the world population, because bigger populations place higher demands on information exchange (Vetter, 2008).

In the domain of smart living, healthcare providers (supply side) want to help their end-users (demand side) more efficiently. End-users consist of elderly, informal caretakers and care-users according to Keijzer-Broers (2013). The healthcare providers want to offer their end-users optimal solutions, but there are multiple problems that are unresolved. For instance, supply and demand are not aligned writes Keijzer-Broers (2013). Keijzer-Broers has determined that "*Service providers find it difficult to create awareness among end-users about smart living. In practice end-users are often unaware of how technology can help them and (healthcare) providers are unaware of the specific needs of end-users*"

(Keijzer-Broers, De Reuver, & Guldemond, 2013). The matchmaking of demand and supply is done through connecting suppliers and end-users by providing information. This is necessary because the available information is scattered. This is exemplified by the many websites available concerning smart living (Smartliving, 2015) (Amsterdamsmartcity, 2016) (electrostyling.nl, 2016).

To resolve this mismatch, healthcare providers need to be connected in an efficient manner with their end-users. The providers of healthcare services and –products can enhance their quality when they can offer integrated and comprehensive solutions. To offer integrated solutions these healthcare providers need more detailed information about their end users. Such information can consist of personal data including medical records. Personal and medical data can be wide spread across multiple institutes but should be available as a whole to deliver optimal services. A problem often occurring is that medical data is not easily reachable and stored at different public organisations such as hospitals and general practitioners.

Platforms - Platforms can be used to facilitate the information transfer mentioned above. Especially mobile platforms are emerging as *"The single most powerful way to extend economic opportunities and key services to millions of people in the world"* (Zhen-Wei Qiang, C, 2016). The concept of information transfer through platforms is especially related to the concept of matchmaking. This research defines matchmaking as the service that connects two pieces of data based on search definitions given. Matchmaking through platforms is often seen through internet based services that match the information request of an end-user with a supplier in the business. Healthcare providers, are recently using platforms to increase their reach within The Netherlands (Accenture, 2016). These projects are unusually complex because of all the interrelated organisations, scattered information and sensitive data. Examples of this in the healthcare domain are https://www.zorginnovatie.nl/, and http://dichtbijzorg.org/.

The design of such a matchmaking platform in the public/private healthcare domain is hindered through several problems. Public and private organisations must cooperate more through new regulations within the Dutch healthcare sector. Within the healthcare sector, public organisations are leading and therefore, private organisations must adjust to public guidelines to deliver the requested interoperability and connectivity. Additionally, the regulations in the healthcare sector that puts constrains on the data of end-users is also something to take into account concerning information matchmaking.

Conclusion - There is an increasing need of information exchange concerning healthcare products in the smart living area for care users. Care-users want to know what developments and products are available and healthcare providers are in need of support to cope with the increasing workload and stress caused by the aging, increasing population and because of new regulations in the Dutch healthcare. On top of this healthcare providers, have a need for a platform to deliver their products and services. All these problems are made more difficult since must be solved in the public/private domain.

1.2 - Scientific problem

Section 1.1 introduces multiple topics which present the practical problem: How can private healthcare organisations exchange information with governmental organisations and civilians to solve a mismatch between demand and supply in the smart living domain. A matchmaking platform might provide the solution and operates on the border of public and private healthcare. This is because Dutch healthcare is partly in hands of the government (hospitals) and of private organisations (home care). The data kept by both organisations are protected by strict security requirements. This places constrains on the possibility to exchange information.

Tensions between private and public organisations and how those organisations exchange information with each other through ICT are the main obstacles. These tensions can be explained through comparing both organisations. When comparing private and public organisations there are differences in rules and legislations, standards used, blocks of codes available for re-use, available data registers, different actors and constant reform or pressure from management. These differences make interoperability between public and private organisations difficult. A common set of solutions to those differences might solve the mentioned problems.

A possible solution is found in how ICT systems are designed. The design of a ICT platform can be done in two ways. Ad hoc programming and design the ICT system beforehand. One method of ICT design is working under architecture. The first method is often used by start-ups and the latter is used by bigger companies and public organisations. ICT architecture prescribes how to design something and resolves many problems, normally found during development. Examples of such problems are preventing

unnecessary coding, realising how much security is necessary, what rules and legislation are applicable and what types of data will be used. This reduces development time, costs and provides a communication tool for the developers and users.

There are many different types of architecture. The concept of ICT architecture is relatively old and can be defined as *"a coherent set of principles, rules, guidelines and standards that are used in the design and the construction of information systems and the information supply as a whole"* (Rijsenbrij, 1999). Many factors influence what type of architecture is needed for a specific design problem. The main types of architecture are: Start architecture, Solution architecture, Enterprise architecture, software architecture and reference architecture.

Information exchange is done through hardware and software; however, knowing beforehand what hardware and software is needed, what standards and regulations are necessary, and how architectures relate to each other can solve many problems. Without guidelines this means starting from scratch each time and is very resource intensive. One way to solve this problem, is using reference architecture. Reference architecture provides a set of guidelines and rules within a certain domain. Several organisations define reference architecture differently. For example, Reed (2002) and Rouse (2012) state that "*reference architecture is a resource containing a consistent set of architectural best practices for use by all the teams in your organisation*" (Reed, 2002), (Rouse, 2012). On the other hand, Lankhorst (2014) defines "*Reference architectures are standardized architectures that provide a frame of reference for a particular domain, sector or field of interest*" (Lankhorst, 2014). As seen from the two statements above a reference architecture can include many things such as 'best practises', standards, design principles, building blocks and practical implications. When multiple companies within a domain use the same reference architecture, information exchange is increased if these companies will use the same standards, building blocks as well as the same semantics and information descriptions.

Using a reference architecture is no certain solution. This is because there are many different reference architectures, for example: DYA (Sogetti, 2011) (R. Wagter, 2005), NORA (NORA-ICTU, 2015), NICTIZ Healthcare (NICTIZ, Paginas/Informatiestandaarden.aspx, 2016), PURA Dutch mental health services (J. Murk ten Cate, 2013), GEMMA for municipalities (KING, 2016), ROSA (OC&W, 2015), HORA (NIVO, 2016). This present an inherent problem: Making a choice between all these formats, documents and reference architectures and applying them. This makes cooperation between organisations of different domains problematic, since both would use different reference architecture. Additionally, public organisations have to comply with public reference architectures but there is no legislation stating that private organisations must do so with either public or private reference architecture. It is also uncertain if a private organisation can use all components of the public reference architecture.

The matchmaking platform discussed in section 1.1 would connect organisations from the public and private healthcare and in addition store or use medical information. This provides an inherent problem when designing such a platform. *Currently there is no reference architecture that would address all these domains (public, private and healthcare) at the same time.*

The Dutch government as the main public organisation in The Netherlands has one main reference architecture, the Dutch Government Reference Architecture (NORA). On the other hand, private organisations have many different reference architecture; within an organisation itself or between a (small) number of companies. If a private organisation wants to design the matchmaking platform in the healthcare domain, it seems easier for the private organisation to comply with one national reference architecture instead of the other way around; one national organisation complying with many small reference architectures. To do this, the context of the problem should be sketched in the project start architecture and the design is made in a solution architecture. A solution architecture is described as the expansion of the high level architecture of the project start architecture into a more detailed description in the solution architecture. The open group, which is an organisation many architects support, defines solution architecture as "A description of a discrete and focused business operation or activity and how IS/IT supports that operation. A solution architecture typically applies to a single project or project release, assisting in the translation of requirements into a solution vision, high-level business and/or IT system specifications, and a portfolio of implementation tasks" (The Open Group, 2011).

Conclusion - Currently, it is unknown how tensions can be solved between public/private organisations. A possible solution might be found in the usage of the same reference architecture, but it is unknown what the effectiveness is when public reference architecture is used within the private sector. There are

no known companies operating in the public/private domain that have used Dutch governmental reference architecture.

The practical problem and the scientific problem both lead to the research objective (1.3) and the research question (1.4) so that a solution to these problems can be found. The approach on how to do this is written in section 1.5.

1.3 - Research objective

The objective that the research aims to fulfil is to **"Design and evaluate a private domain solution architecture for a matchmaking platform based on governmental reference architecture to investigate NORA's effectiveness in private architecture".**

1.4 - Research question

Based on the knowledge gap, the research objective and the practical problem the research question is as follows:

"**How effective is the Dutch governmental reference architecture (NORA) for private organisations that want to connect to the public domain?"**

Sub questions are devised to help answer the main research question. The first sub question is necessary to make sure that the design methodology is done according to the proper standards and theory. Sub question one will solve the problem of choosing the right format as discussed in the section 1.2. The project start architecture and the solution architecture should also be evaluated. This knowledge will be derived from the literature review.

The first step in the research will be collecting the necessary information to construct the artefact. To generate this data, the first sub question is devised:

Sub question 1: "What architectural knowledge is needed to design solution architectures?"

It is important to find define the architecture concepts necessary, because as stated in the introduction many different formats are used within architecture design. A literature review is done to make sure that the concepts concerning the architecture inform the architect. Goldkuhl (2010) states that the literature research should inform the researcher so that the design decisions concerning the solution architecture are sufficiently grounded in abstract knowledge (Goldkuhl, 2010).

The main topics are project start architecture, enterprise architecture, reference architecture, governmental architecture and combining the previous topics into the solution architecture. An in-depth analysis of the NORA is shown within the section of reference architecture.

When this sub question is answered and the solution architecture is constructed, the solution architecture must be evaluated. Therefore, the literature will inform the architect on evaluation:

Sub question 2: "What methods are available to evaluate solution architectures and what possible evaluation criteria can be found in the literature?"

The topics generated from this part of the literature review are necessary to evaluate the artefact. The research starts out defining the architecture concepts, providing a literature review of current works, and how the subjects are related to the solution architecture.

Sub question 3: "What are tensions occurring between organisations in the public/private healthcare domain?"

This sub question places the main research question in its domain and needs to be answered to find out what influence this has on the end result. Are there any inherent problems that make the NORA inherently inapplicable? This investigation of tensions allows a more efficient design, which already incorporates a number of solution to common pitfalls and steers the questionnaire and the interviews to evaluate the NORA.

Sub question 4: "How is a solution architecture for the public private healthcare domain designed?"

To construct the solution architecture a selection must be made from the different methodologies and methods. There are many different formats and frameworks and choosing between the formats can be difficult and the choices made have a profound effect on the solution architecture.

The design of the solution architecture is expanded from the project start architecture. The project start architecture follows from the enterprise architecture as a source for important design principles and models based on the current enterprise (if available). A reference architecture is also used that also supplies architecture principles and models in collaboration with the enterprise architecture. The use of reference architecture is an alternative since this project has no enterprise architecture

Sub question 5: "What parts of the NORA can be used by private organisations and does using the NORA makes connecting to public organisations easier?"

The reflection on the iterative design process together with the evaluation of the solution architecture and its applied reference architecture will answer the main research question.

1.5 - Theoretical relevance

The use of reference architecture within design is not very new. However, knowledge about the effectiveness of governmental reference architecture in the private domain is limited. Decentralization causes the need for private organisations to be interoperable with governmental organisations because of the data and information stored in governmental ICT systems. A critical view on the application of public reference architecture in private architecture design can be useful for all private organisations in the public/private domain. This will expand the scientific literature in the domain of ICT architecture. The results of this research might increase future information exchange between public and private organisations and show if the available reference architecture can facilitate this. This research can also show solutions to the tensions between public and private organisations and possible how to solve them through architecture.

1.6 - The research approach

A project start architecture and a solution architecture in the public/private healthcare domain will be designed with the help of a governmental reference architecture. This is done because there is no available case to study this. Therefore, the design is made and consequently analysed. The requirements and input for such a design research are taken from a design case study.

Design case - The design case study would consist of a private healthcare organisation that wants to connect and exchange information with governmental organisations. The reference architecture from that government will then be applied during the design process and the resulting solution architecture will be evaluated. The design requirements will come from a design case, a literature study, documents and interviews with the actors connected to the design case.

The evaluation process will provide two kind of answers: Is the solution architecture made according to the reference architecture and what the implications are of the governmental reference architecture for private organisations. The solution architecture is evaluated with the help of public and private architects.

Interviews are hold during the design process to iteratively develop the solution architecture and additional interviews were to elaborate on the answers of the architects.

1.7 - Thesis Overview

The thesis chapters are built up in the following manner:

Introduction phase

1. Introduction: Practical problem 1.1, scientific problem 1.2, research objective 1.3, research question 1.4, the research approach 1.5 and the thesis structure 1.6)
2. The literature study: design research, project start architecture, reference architecture, solution architecture, evaluation protocol and the evaluation criteria. *(The first and second sub research question)*
3. The research domain: Healthcare *(The third sub research question)*
4. The design methodology: architecture concepts and the case study
   This chapter lays the groundwork for chapter 6 and partly answers sub research question 4.
5. The research methodology: Interviews, questionnaire and follow-up interviews.

The design and evaluation phase

6. The design of the solution architecture: Iterative steps *((The fourth sub research question)*
7. The evaluation and discussion of the solution architecture: The used protocol and results of the questionnaire and interviews. *(The fifth sub research question)*

The reflection and learning phase

8. The conclusion: The answers to the research questions and the conclusions. *(main research question)*

Chapter 2 - Literature review

2.1 - Introduction

The literature research will give basic definitions of important topics, explain why the subject is of interest, which research already has been undertaken and how their claims support this research. The literature research is done to gain a broad understanding of the topic of interest: The solution architecture.

The goals - In the literature review the first two sub questions need to be answered:

Sub question 1: "What architectural knowledge is needed to design solution architectures?"

Sub question 2: "What methods are available to evaluate solution architectures and what possible evaluation criteria can be found in the literature?"

These two research questions should be answered before the design of the solution architecture. The review shows how the concepts are interrelated and why they are of importance. The individual concepts will be defined and show what research was done before. This part also helps to inform the choices made in the methodology chapter (Ch. 4).

The second part of the literature review was conducted to evaluate the design in a scientific matter. The review will reveal evaluation methods/frameworks used by other organisations and show what evaluation criteria are used in other design projects.

Literature review method - To efficiently carry out the literature review a number of steps are followed to filter and select papers and topics. The quality of a good literature review is marked by using a systematic literature review that shows up-to-date knowledge, relevant concepts, link those concepts and within a particular research discipline (Hildalgo Landa, 2011). This literature review informs the reader and the researcher about relevant topics useful and necessary for the design of a solution architecture. The researcher has made an important selection criterion regarding concepts in general and applied. New concepts concerning methodology might pass the revue during later cycles that are not incorporated in the first literature review (Kelly, 2008).

Research Semantics – The objective of this research work is to design an artefact and generate data from the design process. Artefacts can be defined as: "*something observed in a scientific investigation or experiment that is not naturally present but occurs as a result of the preparative or investigative procedure*" (Google, 2016). This explains the nature of this work and how it generates data; The artefact is not found before in its environment. This research also distinguishes between concepts, methods and models. Concepts are defined as "The reasoning behind an idea, strategy, or proposal", methods are defined as "a set of steps (an algorithm or guideline) to perform a task" and models are defined as "Graphical, mathematical (symbolic), physical, or verbal representation or simplified version of a concept, phenomenon, relationship, structure, system, or an aspect of the real world" (BusinessDictionairy, 2016). These terms are readily used throughout the research and will be used within the definitions described above.

An additional problem concerning this body of research is the definitions used within the field of ICT architecture. Most architecture is based on the ISO420-10, which is an architecture standard on which many architecture documents are based, but from this broadly defined standard, most architecture documents are very different from each other. This is due to organisation processes and standards and how the architecture itself defines his or her work. What one architect calls a solution architecture may be different for each other institution and how to propose to fill the document (iso-architecture, 2015). The ISO42010 standard grants the architect design freedom. This is important to take into account since the literature contains research papers, which define their documents differently.

Keywords - During the review, the following keywords were used in the search engines "Science direct", "Google Scholar" and "Google":

Project start architecture, solution architecture, enterprise architecture, platform design, design research, architecture design, evaluation criteria, design variable, design issues, NORA (Dutch governmental reference architecture) 2.0 & 3.0 & online, reference architecture.

The concepts used in the introduction and the research questions have served as the starting point of the literature research. Based on the definition problems, English and Dutch literature is used. Much practical knowledge about architecture is not academic but very useful for this thesis. Additional research is found through intensified searching in current literature found on basis of the keywords. This is done according to the snowball method. This means that from the original keywords literature is found. The references used within this literature are used to find additional work.

2.2 - Architecture of information systems

This section will answer the first sub question:

Sub question 1: "What architectural knowledge is needed to design solution architectures?"

The reference architecture NORA stands central in this research. A problem, briefly mentioned above is defining what a solution architecture is. *An additional problem is who names which product what*. This is important to take into consideration since the systematic review of the literature is hindered by un-clarity about keywords, no consistent use of terms and what is actually included in an artefact such as a project start architecture or a solution architecture.

So what is architecture in itself? Meneklis (2009) has given an interesting viewpoint on architecture namely, "*It provides a blueprint (architecture as blueprint metaphor) for the implementation and a practical and detailed guide of the steps to be made in order to develop it. Architecture as a blueprint metaphor can be helpful to software engineers, programmers, or network architects. On other occasions, the architecture is used as a common communication vehicle for stakeholders with different backgrounds (architecture as language metaphor)"* (Meneklis, 2009). This metaphor of architecture as a language which key-stakeholders use to communicate to each other is the starting point for this literature review.

Most of the literature used in the review is from Dutch scientists and Dutch architects. This is because in the field of NORA research most of the available data is generated by Dutch scientists. This is enhanced by the keywords used. The term project start architecture is used mainly in The Netherlands. Another reason is that the NORA is purely for the Dutch government and the international version the EIRA is quite different. The literature review below will give the reader a basic understanding of all the concepts needed to understand research in reference architecture and architecture design.

2.2.1 - Project start architecture

The project start architecture serves as a starting point for the development of the solution architecture and sketches possible directions for solutions. According to Van Dijk, there is an increasing amount of companies that use the project start architecture (Van Dijk P. , 2010). The project start architecture describes the context of the solution and considers the solution a black box while the solution architecture describes the black box and transforms it into a white box (solution) (Luijpers, 2009).

The project start architecture and solution architecture built upon each other because the project start architecture is thus the context description of the solution architecture and is thus inherently part of it. A problem arising when designing such artefacts is which guidelines to use. These guidelines are not the same as the requirements described in the solution architecture definition. The requirements are taken from a design case that contains actors, the context and prescribe *how* this platform should be designed. The guidelines describe to what standards and rules the designed solution must comply.

When a project is early in development a start architecture can offer a lot of insights that may help predict problems later on during the development. Not all companies or institutions use architecture as a starting point or use it at all. The main advantage of the project start architecture is that it gives a description of the context of the problem while leaving the solution for what it is. This is called a black box as shown in figure 1. The architect can show which rules and regulations are useful for the project and to what legislation it must adhere. It can additionally show possible solution directions and serve as a project initiation document (PID). A Project Initiation Document often contains the following: Project goals, scope, project, organisation, business case, constraints, stakeholders, risks, project controls, reporting,

frameworks, PID Sign Off and a summary (BizBodz, 2016). This is part of project management. In addition to the PID the project start architecture can also sketch a high level architecture overview and show how reference architecture fit in the context. This means that the project start architecture is the work preparation to start working on the solution architecture and provides the business plan for the solution.

In this section an overview is given about research concerning the project start architecture, how it helps a project and how it relates to the other concepts.

A project start architecture is a type of start architecture when a new project within an enterprise or organisation is started. This does not mean that a project start document is not useful or not possible when there is no enterprise architecture available (Luijpers, 2009). The project start architecture can still offer many benefits. When new projects are started, they should be described within a *"normative restriction of design freedom"* (Van Alst, 2011). This restriction is very good, since the ISO420-10 standards give unlimited design power to the architect. This restriction therefore places restraints on the document itself. This increases the readability through a better-defined scope and a limited size. The project start architecture is constructed for this purpose. It encompasses clear goals and borders in which the project must fit and specifies the context of the project within the greater whole of the entire solution. This also stimulates the design process, the interoperability of different systems (e.g. by using standards), enhances information sharing between different stakeholders and lowers the amount of discussion about design choices (Luijpers, 2009). Project start architecture supports the design in four parts. The first is making an analysis and a description of the borders and prerequisites of the project. This includes the vision and strategy of the platform, the architecture agreements, principles, guidelines and standards & norms that will aim the direction of the solution that the project will realise. This will also suggest possible implications of the architecture. The second is making a sketch of the context of the possible solution and its connection to other existing likewise services and new services. The third part advices the use of an impact analysis of choices made during the architecture design and the last method offers extra guidelines according to the coherence of information streams, the interoperability of that information, the generalizability of the solution offered and lowering the need for administration and control.

The four steps above illustrate the effect the project start architecture has on the entire project. For a project leader this document will then be the starting point for further development and aids by generating insights in possible time and money constraints.

The project start architecture consists of a template that is either complete or is specified to a certain architecture view. An architecture view can be described in two ways. One definition is the description of the business, information & application, technology and security views. The other description of architecture view relates to a certain industry, such as healthcare. Sometimes a general template of a project start architecture is available and specific components of a view (healthcare) are copied in.

There are two main project start architectures: The public format from ICTU (NORA-ICTU, 2015) and the private format developed by DYA (Sogetti, 2011). When a private business stays in that domain it can use the DYA project start architecture. When such a private organisation wants to interact on a national level with public instances, it might be better to use the ICTU version, since the public organisations often use the public format. These concepts focus on an operational level specifying scope, concrete solutions and technical applications. The project start architecture tries to operationalize the contents of the guidelines and domains, if available.

The difference between DYA and ICTU formats is not that big, but lies mainly in the ease when comparing works within that domain.

According to Sogetti, the DYA approach is more business case driven (Sogetti, 2011). But these documents all serve as guidelines and there is not a single document which is all encompassing and therefore in this literature research it is disagreed that the DYA is more business case driven than the ICTU approach. This is also confirmed by the different sizes of the documents. A project start architecture can be large or small depending on the number of viewpoints e.g. business, application, security etc. This is also why there are "Thick" or "Thin" project start architectures. Most of the implications and differences between formats are there because of the choices made by the architect.

To explain this division De Boer (2009) gives an idea of the relationship of the project start architecture and the solution architecture. He states" It *is used in two ways: as a summary of all relevant principles, guidelines, reference architecture etc. that are relevant for the project and which the project then needs to use when crafting a solution; or, taking into account the principles, guidelines etc. and the project objective, as a description of the solution itself"* (De Boer, 2009). This quote explains the difference between thick and thin. The thin project start architecture is the scoping of the context as in this research and the thick architecture would be the solution architecture.

Franken (2012) states "*The PSA is of operational scope, concrete and technical. That is, the PSA is supposed to operationalize an Enterprise Architecture and a Domain Architecture in the context of a specific project"* This means the project start architecture is a combination of several architecture guidelines that provide the basic structure within an organisation during the project. Franken also states that the project start architecture is about "*taking into account widely accepted policies and standards of the organisation*" (Franken, 2012). Franken gives an example on how to apply the project start architecture within an organisation, but also says that the DYA approach is just a collection of previous works mended into a new format. This is seen throughout all formats seen during the literature research and therefore it is proposed that the best format is the format that fits best within the project domain and is again mostly an architects' choice.

However, is the use of a project start architecture a good decision? For criticism, it is good to look at blogs of architecture experts. For example, Grgic states "*PSA documents are one of the common impediments and are solved by putting them away and pushing team members to talk to others and think for themselves, instead of pointing at some document. Until they realize that, everything the document describes is better understood by talking to people or more often not even in line with changing reality"* (Grgic, 2012). ICT architects do not want to be impeded in their design freedom which might happen if they are restricted by following one format. Additionally, the problem stated by Grgic (2012) about delaying projects because of changing conditions and avoiding interviews are solved by regularly updating the document through interview with the project members and keeping it high level.

Conclusion - A new project within an existing organisation or a start-up can often use architecture as a method to scope that project. The project start architecture scopes the project with certain guidelines and standards often taken from existing sources. What those sources are can be very different and the setup of the document can be very different. The main use for this document is generating a starting point for the project and scouting the environment for the viability of the project.

In this section, two main versions are reviewed, the ICTU governmental approach and the DYA private organisation approach. Each of these documents are optimised for their public or private domain.

Looking at the critical notes found in the literature, an important aspect should be taken into account when designing the solution- and project start architecture. The documents used for taking guidelines, standards and design requirements should be used in an advisory manner, but alongside that process the key-stakeholders of the project should be involved in each step of the design. This predicts an iterative type of design.

2.2.2 - Enterprise architecture

An enterprise architecture describes the enterprise and connects the business processes with the IT landscape. Project start architectures and solution architecture can often use the guidelines from the enterprise architecture as a source for guidelines. Another reason to look into enterprise architecture is that the overall structure of such a document is very useful as a source for the solution architecture under design, but to use this efficiently there must be a basic understanding of this topic. Another reason why enterprise literature is interesting is because it gives an understanding of the total enterprise design. This is useful in the design of the solution architecture since there is no former enterprise and the solution architecture could be used to reverse engineer into an enterprise architecture.

The enterprise architecture is an overview or design of the total business, the enterprise. This type of architecture can be a complex description that describes all layers of the organisation. The enterprise architecture can consist of very large documents or elaborated schematics. To give a more detailed description: "*Enterprise Architecture (EA) aims to achieve coherent and goal-oriented organisational processes, structures, information provision and technology*" (Boh, 2007), (Richardson, 1990), (Ross, 2006), (The Open Group, 2011), (Wagter, 2005). This statement is used by many organisations and shows the goal of the enterprise architecture. This goal can also be used for the solution architecture. It

also shows that the enterprise architecture takes the organisational processes as the focus point. R. Foorthuis (2012) states "*achieving this enterprise-level coherence and focus should result, amongst others, in reducing complexity, realizing business/IT alignment, integrating processes and systems, and reaping organisation-wide benefits*" (Foorthuis R. , 2012). This statement shows that the overall complexity of architecture should be kept to a minimum if this is possible. The enterprise architecture would show the links between the business and IT and this idea could be taken into account during design.

Another type of architecture with a link to enterprise architecture is the project start architecture. The project start architecture uses the standards and models from the enterprise architecture for specific projects. This goes into much more detail than the enterprise architecture. When the new project is finished, the results are to be adopted into the architecture views of the enterprise architecture, such as a change or addition into the technology layer (Foorthuis R. B., 2007). Additionally, this operalisation of the enterprise architecture makes sure that the contents of the enterprise architecture are transferred to the project, but this happens vice versa. This is done using the project start architecture (Teeuwen P. v., 2010).

Both statements show what the result can be by designing a enterprise architecture in conjunction with a project start architecture or a solution architecture. It can be adopted to construct an enterprise architecture later on. This also means that project start architecture and solution architecture can be incomplete and multiple projects can lead to the establishment of an enterprise architecture. An architecture document does not have to be 100% complete.

Conclusion - This design research does not focus on generating an enterprise architecture but does take the design ideas into account. The enterprise architecture can be build up from individual project start architectures and solution architectures and I propose that it is also useful the other way around. This means that enterprise architecture can be used as input for the design. An important aspect to take into account is that although enterprise architecture could be all encompassing, it means that these are large cumbersome documents.

When there is no enterprise architecture, reference architecture can also be used as input for the project start architecture. The reference architecture is elaborated on in the next section.

2.2.3 - Reference architecture

When no enterprise architecture is present, reference architecture can be used as the source for guidelines and standards. This does not mean that they are the same documents. The enterprise architecture clearly is an overview of the organisational processes within an enterprise whilst a reference architecture can be designed for many different applications. The choices made during the selection of reference architectures therefore have a big impact on design. There the reference architecture is one of the design issues which need to be addressed during the design.

A reference architecture (RA) is used for the design of concrete architectures in multiple contexts serving as an inspiration or standardization tool. There are many types of reference architecture for architectural views such as business (Norta, 2014), information and technology (Battat, 2014). Another set of reference architectures is specified for different types of domains for specific businesses such as healthcare (PURA) (J. Murk ten Cate, 2013), government (NORA) (Noraonline, 2015). All these reference architectures are specified for certain domains and are therefore a choice. There is no institute, which oversees or enforce use of reference architectures, the choice for a reference architecture is then a design issues.

Reference architecture can be seen as guidelines on how to solve problems encountered before and then provide tips on how to solve those problems. When these problems are solved they can be taken in the reference architecture to prevent them in the future. This two-way interaction was also seen with the enterprise architectures but reference architectures, are often designed to work in a broader range of projects. To facilitate this greater application scope, reference architectures are less defined and have an increased stakeholder base (Bass, 2003.). This is reflected in the reference architecture for domains. For example, NICTIZ the Dutch reference healthcare reference architecture, gives standards for the whole Dutch healthcare and not just one organisation. Thus, where enterprise and reference architecture deviate from each other is the broadness of their scope. Taylor (2009) states "*These less defined architecture design and application contexts and stakeholders, affect the ability of the architecture sponsors and designers for clear judgment and decision making when articulating the*

architecture goals and elaborating the architecture design" (Taylor, 2009). It seems that using reference architecture might be helpful but an architect could also be lost in the immense choice between and within reference architectures.

The reference architectures can also differ in terms of organisational levels, for example: National, provincial, municipal. This is important for the following reason. If in the designed artefact, the NORA can be applied to be ready to collaborate with the government on a national level, but it might not be adequate or complete for a design on a municipal level. It can therefore be wise to fill in any gaps if there are any, with different reference architectures such as provincial: PETRA (Provincial EnTerprise Reference Architecture) (wikiXL, 2016), provincial healthcare PURA (ten cate, 2013) and municipal: Gemma (KING, 2016). All these different reference architectures offer best practises that can help fill in different parts of the project start architecture. Reference architectures offer, just as enterprise architecture, standards, standard solutions and models to help design architecture. These standards can be collected from many different organisations and often more than one standard is applied. This happens because new designs and projects often touch multiple domains. For example, a healthcare platform can use architecture reference architecture (IT4IT-opengroup) for the architecture layout itself but also use guidance on possible healthcare standards (NICTIZ, Paginas/Informatiestandaarden.aspx, 2016) including security of data, interconnection of public healthcare organisations and connecting healthcare services with financial services.

As described in section 2.1.1 the project start architecture describes the context of the design. This context influences the design and determines which reference architecture is necessary. Angelov (2011) states *"The architecture goals set constraints on the context in which the architecture should be defined and on the architecture design. Vice versa, the context and design affect the achievement of the architecture goals. Furthermore, the design choices are affected by the context and vice versa, a design choice implies a certain context*" (Angelov, 2012). This means that the context, the architectural goals and the choice for reference architecture are all interrelated. This interrelationship is shown in Figure 1.

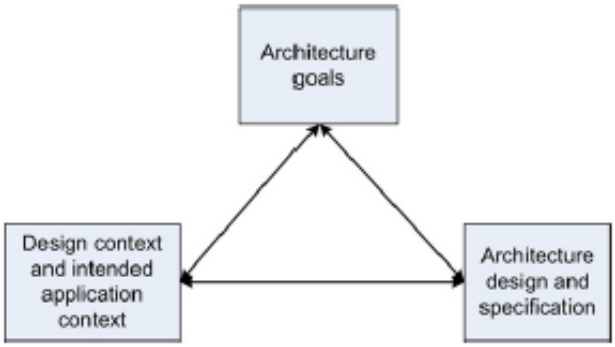

Figure 1: The relationship between architecture-goals, -design and –context (Angelov, 2012).

The architecture goals in Figure 1 are requirements taken from key-stakeholders. The design and specification can be set by architecture frameworks and reference architecture and the context is taken into account through the project start architecture.

Egyedi (2005) gives another definition of reference architecture: "*Reference architecture standards define how different components interrelate and procedural standards define the organisational/operational procedures to increase compatibility*". This definition shows that compatibility and interrelate (interoperability) are possible evaluation criterion for the solution architecture (T.M. Egyedi, 2005). The statement also shows the difference between reference architecture and standards. Reference architecture can offer a number of things: guidelines, standards and practical tips from experience including examples. Standards are thus a part of reference architectures. When talking about standards Egyedi (2005) has determined four characteristics of standards that are important:

- The degree of specificity – How much the standard varies in detail;
- The level of abstraction – A higher level of abstraction incorporates more flexibility than a detailed approach;
- The system level – The amount of sub systems and components and how they influence flexibility, and;

- The degree of simplicity – The amount of standard solutions used and the amount of options offered.

These points named above can help determine how helpful a reference architecture is when looking at the proposed standards. These points can help during the evaluation of the design

NORA - One such reference architecture is the Dutch Governmental reference architecture (NORA). The NORA aims to increase the interoperability between public (governmental) instances. The NORA as a reference architecture is defined as *"a tool intended to give direction and as a steering instrument. It contains frameworks and existing arrangements for organizing the information of the Dutch government. Realizing facilities within these frameworks and agreements ensures that they work well with other governmental facilities and make optimal reuse of existing solutions (architectural building blocks)"* (Noraonline, 2015) (Digitaleoverheid, 2009). So the NORA helps the design adhere to certain standards. This implies that if all governmental organisations do this with the same standards they would be interoperable. The NORA serves as an architectural framework based on 10 architecture principles and 40 derived principles for public instances with a focus on the Dutch government. The NORA is not a new concept as it has evolved through several versions over the years. The current version has transcended the last static version NORA 3.0 and is now called Nora Online. The use of a project start architecture based on reference architecture (NORA) is already obligatory for new projects bigger than €20, - million within the Dutch Government (Van Dijk P. , 2010). This makes the NORA obligatory for many projects within the government and according to ICTU, the institute that manages the NORA, the NORA is also used for many smaller projects.

The applicability of all the principles in the NORA is difficult and needs to be established during the research as a design issues. This is sometimes difficult to apply because of the differences in legislation and rights between public and private organisations. For example, some principles state that in order to deliver efficient services to a citizen they must collect data from one source, this might not be possible since the data may be spread. Another example is the use of the social security number of citizens. While a public party such as the government may use that number, private organisations simply have no access and even if provided by the end-user they might possibly not store it.

It seems logical to start small when a project is new; in business, this is called 'niche targeting' (source). After successful implementation in this niche, expansion is the next logical step. Van Dijk (2010) stated that bigger public projects, that are introduced in the government need to comply with the NORA. When a private initiative would expand from a municipality (niche) to a national level and interacts with public healthcare, it would make sense to incorporate the NORA into its design. Stating again that organisations using the same set of standards, thus the NORA, would be interoperable.

The project start architecture could then be constructed incorporating the NORA. The document then gives direction to the project, guides the development of the ICT platform and establishes clear definitions of the project needs and –borders within the public domain. This describes the first steps to continue with the design of a solution architecture.

So for private organisations that need to be interoperable with public organisations the NORA seems the reference architecture to use, since the Dutch government uses the NORA it seems logical this reference architecture is used but this is an assumption and not a given. It is also unclear how applicable the NORA is for these private organisations and if there should be more than one reference architecture used as source.

The general use of a project start architecture based on the NORA principles is only a few years old (Digitaleoverheid, 2009). This research area is slowly increasing but has an untended niche. According to the management of the NORA, the Dutch government ICT (e-government) integration is far ahead of other countries by using the NORA system (Noraonline, 2015), but finding foreign scientific research concerning the NORA is difficult. According to ICTU, the NORA has not been used or documented outside of the public domain, which means that there is a knowledge gap in using the NORA in private domains. This gap is widened by the low amount of practical knowledge on applying this reference architecture outside the government.

In the project start architecture, the platform itself is described as a black box model. A blackbox model asumes that the content of the box is not known and therefore the model only looks to the context/environment of the blackbox. The inputs of the project start architecture are the design- and

user requirements. The output is the service that is provided to solve the problems that the end-users or the market have. The context or the environment contains regulating bodies, legislation, financials,

To discuss the NORA, a look outside of the government was taken to get a more objective view on the NORA as compared to the Noraonline website.

There are a number of architects which are positive about the NORA and recommend it for enterprise architecture (Lange, 2014), use in other formats (Pauwe, 2010), when used by as many different organisations for multiple purposes such as legal, organizationally and not just architecturally (Kielema, 2010). Galster (2015) states that the use of NORA saves software architects a lot of time because not all architectural decisions need to be written down since they are included in the reference architecture (Galster, 2015). However, the NORA seems more of a high level organisational reference architecture than one for software architects, but the use of reference architecture and architecture in general is often debated.

But there are also architects that state that the NORA does not work (Rijsenbrij, /huidige-tekortkomingen-bij-digitale-architectuur, 2012), or is less relevant in for example information architecture (Klerks, 2014), and it seems that not all the principles are useful and provide the results civilians want. This is especially seen in the Dutch Tax system where through AP09 all the services are given through the internet instead of paper or service counters (Brinkman, 2015). The architecture model used in NORA 3.0 splits the total architecture in numerous layers, but this has disadvantages because it shows no discrepancy between the 'weight' of the different layers (De Harder, 2014).

According to Rijsenbrij (2012) the e-government should give an example of how a good information exchange looks like and should be based on how information exchange between civilians, civilians and private organisations and even between private organisations should look. All these stakeholders should use the same architecture to enhance this information exchange (Rijsenbrij, /huidige-tekortkomingen-bij-digitale-architectuur, 2012). The NORA would be the perfect architecture for this but Rijsenbrij states that the architecture is too focussed on the government and is not developed enough to provide for all the mentioned stakeholders.

Conclusion – There are many factors influencing the design of the artefact. In this section some reasons for choosing a reference architecture are mentioned and making a choice for one or more reference architectures has an influence and might exclude other reference architecture. On the other hand, it might also be possible to choose multiple. The choice for a reference architecture can have a big influence on not only the design of the artefact but also on the context and therefore this is one of the critical design issues. There is little research done regarding the effectiveness of the NORA and especially on the application in the private domain. The NORA is also constantly evolving and being updated.

2.2.4 - Government architecture

The artefact will be designed for a private organisation but it needs to collaborate with public organisations during the expansion from a municipal scale to a national scale. Therefore, it can be useful to know more about governmental architecture. This research is also trying to find a solution to deal with changes in the governmental regulations. These can have an impact on how public architecture is designed.

The Dutch government is transferring responsibilities from a national level to a municipal level (Rijksoverheid, 2016). The Dutch government wants to increase the level of care, get it closer to the end-user and lower the costs in the process. According to ICTU (Source) the easiest way to collaborate with public institutions such as the government is to follow their guidelines. For architecture, this means using the same reference architecture such as the NORA. Collaboration between public and private architects can also be increased by following the same structure. To incorporate this into the design of the artefact, it is useful to look at governmental architecture literature. It is assumed that when a private party incorporates public architecture guidelines it is easier for the private party to scale up to a national level that includes interactions with public organisations. The question in this section is "What is governmental architecture and is it different from business/private architecture?"

There two main types of architecture concerning important in this research: public and private architecture. Public architecture is labelled as governmental architecture or e-government. Yildiz states that defining Electronic government (e-government) is quite difficult (Yildiz, 2007). There are a number

of characteristics coupled to e-government such as interconnectivity, service delivery, efficiency and effectiveness, interactivity, decentralization, transparency and accountability. All of these are useful to apply within a government platform. However, most importantly the citizen is taken as the focus point in public design. This can be a critical design issue since it determines the architectural approach. Van Dijk (2006) defines E-government as "all data, communication and transaction processing activities related to governmental tasks and responsibilities in which ICT is being used" (Van Dijk J. A., 2006). This is a different definition in which the ICT is taken as the focus point and might be less inclusive of certain details, e.g. business processes.

One of the reasons for the government to switch toward a sophisticated e-government is to lower the administrative burden of businesses (R. Arendsen, 2014). Arendsen (2014) said that organisational characteristics prove to be dominant factors influencing the administrative burden reduction, as well as the size of the organisation and the amount of ICT staff. This will reduce the costs of private businesses when they interact with e-government. This can be important to take into account and can also be a possible evaluation criterion.

The importance of an integrated e-government is to improve services provided to citizens and businesses and increase their level of responsiveness in a dynamic environment instead of many single one-stop shops (Batini, 2016). Access and use of governmental services should be made easier to use by society. This efficient delivery of services from public organisations to private organisations is also the problem that was mentioned in the introduction of this thesis.

In design, it can be helpful to look at real life cases. The question that then follows is how one can define a 'good' case. In this increasingly dynamic environment, the best model to describe the desired level of e-government architecture is the growth stage model (B. Klievink, 2009). This model describes the level of customer orientation and flexibility. Klievink (2009) explains that there are five stages: stove pipes, integrated organisations, nationwide portal, inter-organisational integration and demand-driven, joined up government, where each stage level demands a higher level of interoperability and capability. Level four is described by Klievink as "*Clearly defined and standardized cross-agency services which are bundled and integrated as virtually one service via the portal and level five: "Instead of citizens or businesses having to find and request services, the portal will search for the relevant services and make recommendations*. The chain is reversed and becomes demand-driven rather than supply-driven" (B. Klievink, 2009). Whenever this is possible these levels can be used to distinguish between examples.

The interoperability and capabilities of level four and five will presumably provide the most useful cases. To be able to deliver this highest level of service private organisations can be used to function as delivery channels in a network. The needed architecture capabilities for such a platform are the ability to coordinate and integrate central facilities and local developments and the ability to improve current systems to fit within the enterprise architecture (B. Klievink, 2009). These levels can be used to benchmark platforms to find out in which stage they reside and how to improve their dynamic capabilities to grow towards the next level.

The artefact under construction, a solution architecture, is a private initiative. Can differences be found between architecture in the public- or the private domain, if the healthcare domain is left out?

2.2.5 - Solution architecture: relating the concepts

This section will relate the previous sections to each other, but before that is possible it is important to determine what a solution architecture is.

The goal of the project start architecture is the description of the context of the project, or black box. A next step would be describing the project in a project initiation document (PID). This document is created to estimate the cost and duration of the project. The PID transforms the black box into a possible solution that fits in that context. In this thesis case, the PID and the PSA are merged together. These documents are expended and then described elaborately in the solution architecture. The solution architecture gives a description of the overall system and the solution building blocks. Teeuwen et. all (2010) also states "*Making a solution architecture is a good investment in reducing project uncertainty about throughput time and budget*" (Teeuwen P. e., 2010). This is because when developers start they already have much of the thinking work done for them. They know what standards can be used, what the direction is, the context and what building blocks to build or re-use from their database.

The project start architecture (context) is often described in the first chapter, but this is a format choice and not a requirement (Slot, R., Teeuwen, P., Van Alen, R., 2010). Foorthuis (2007) uses the PSA framework to show that the project start architecture and the project exclusive design together form the project architecture (Foorthuis R. B., 2007).. The solution architecture is part of the project exclusive design as a "Thick" project start architecture as mentioned in chapter 2.1.1, but the project exclusive design also incorporates parts this thesis does not touch upon such as the software architecture.

Alternative SA - Another type of solution architecture is the service-oriented solution architecture. This design study does not use all the concepts of the service-oriented solution architecture but this architecture is reviewed because a lot of solution architecture development is going into the direction of service-oriented architecture. The second reason it is reviewed because the architecture might be adopted when current services are expanded *"by dynamically integrating and composing existing components into new business processes*" (Zhang, 2013) Another reason why this architecture is important is because the solution platform is also focussed around several functionalities. These functionalities could be described as services where services are the core deliverable of the artefact. A service: Is a logical representation of a repeatable business activity that has a specified outcome (e.g. Care plan, information sharing, finance, selling products) (Witte, 2012).

A service-oriented architecture is "an architectural style that supports service-orientation." Service-orientation is a method that places services or functionalities as the basis of development and their outcomes (Banerjee, 2007). The interrelationship between enterprise architecture and service-oriented architecture is addressed by Banerjee as "a portfolio of services that aligns business and IT via a set of planned business services. It provides the mechanism to feed processes and translating business needs into a flexible design capable of easily adopting to business changes (Banerjee, 2007)".

In this thesis, the entire structure of the service-oriented architecture is not completely adopted. This architecture is mentioned because it does fit the methodology of the design but is too complex technologically to use completely. The ideas taken from this architecture are: 1. clarity of objectives, 2. set precise requirements and 3. The definitions have to be located in an environment visible to all stakeholders. This is done through the construction of a functionality layer. Some of these ideas are taken into account but the proposed solution architecture will consist mainly of the architectural framework of TOGAF (The Open Group, 2011). The idea of an architecture that is focussed on services fits within the ideas of the NORA which is also revolving around services.

Relation of concepts - Figure 2 gives an overview of how all the previous elements are related to the solution architecture:

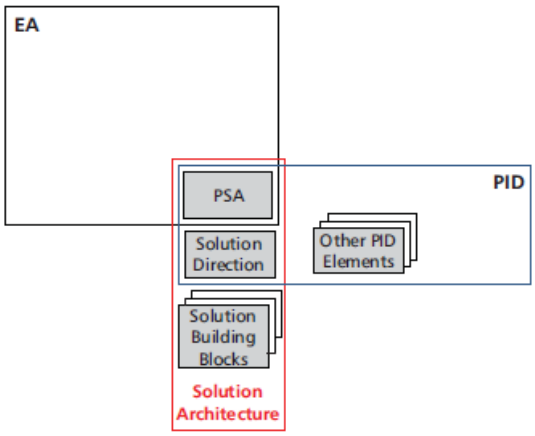

Figure 2: Relationship between project management deliverables and architecture artefacts (Slot, R., Teeuwen, P., Van Alen, R., 2010).

Figure 2 shows the first steps in bringing different architecture documents together to form the solution architecture. Here we see again the interrelation De Boer (2009) shows between the project start architecture and the solution architecture (De Boer, 2009). The enterprise architecture and the project initiation document are used as input for the project start architecture and the solution direction. The solution direction gives examples on how the problem stated in the project initiation document can be

solved. The description of the context (PSA) together with the solution direction (PID) and solution building blocks can be put together which revolve around a certain focus point. From the public architecture, this could be the citizen, or from service-oriented architecture, this could be a series of services. From figure 4 it is seen that enterprise architecture plays a significant role in the development as source for principles, requirements and models. This was also explained in section 2.1.2. The lack of a current enterprise architecture should be filled in by general and specific reference architectures (Luijpers, 2009).

Figure 2 gives a general description of the relationship of the architecture concepts. These are then specified for a specific purpose. Most of the models are derivatives from enterprise architecture. The enterprise architecture can be used as a basis for the solution architecture but specifies the same view in a much higher level of detail. The enterprise architecture describes the scope of the organisation, is low in detail and looks at strategic outcomes for all stakeholders. The solution architecture however, looks at the scope on the level of functions and processes, is high in detail and looks at the impact of operational outcomes for users and developers.

The enterprise architecture is also directly related to the reference architecture. Normally when a new project is started the enterprise architecture functions as the reference architecture which specifies the standards and formats. In this case where no enterprise architecture is present, the structure of the views is selected from the chosen enterprise architecture and the reference architecture is selected separately as shown in section 4.3 - Dutch Government Reference architecture.

A common interest of the enterprise architecture and a solution architecture is that both try to align the business processes with the IT (Banerjee, 2007). Banerjee (2007) describes the difference, as "enterprise architecture is a framework that covers all dimensions of IT architecture for the entire enterprise, while the solution architecture describes the same dimensions but in components and elements that deliver the specific solution" (Banerjee, 2007). So the solution architecture does not all encompass the entire structure just a part. This could also mean that the first roll-out of the platform can be described which can be used in the 'niche' targeting mentioned in the introduction. The entire platform as an end-result can be described later on during the project as an on-going design. Another distinction between the enterprise architecture and the solution architecture is that the former takes a strategic approach to optimize the interplay between a large number of systems while the latter takes a deeper tactical approach with a much smaller amount of applications.

Requirement analysis There are three detail levels of requirements. The enterprise architecture delivers the strategic long-term requirements; these are the high-level requirements. The translation of these requirements into more practical ones (medium level) are the tactical requirements which describe medium-term issues. As described in the previous section this is done with the project start architecture. These requirements are directly incorporated into the solution architecture (Slot, R., Teeuwen, P., Van Alen, R., 2010). The last levels of requirements are applied when the design is transformed into an actual product and transcends the scope of this thesis.

There are two main ways to design a solution architecture: the waterfall method (all at once) and the agile method (iteratively). *The discussion about waterfall vs. agile will be described in chapter 4-5.*

Conclusion – In this section all the previous sections were combined and show how together they form the solution architecture. There are different forms of solution architecture and choosing between formats is again a critical design issue. This section has also detailed on how to start the design work and where to get the data. A number of differences between the different formats were also detailed here giving a clear understanding of what is of important and how to scope solution architecture design.

2.2.6 - Conclusion

In this section the most important architecture aspects were defined and was shown how those concepts relate to each other. Within these sections, important design criteria are pointed out such as the use of specific reference architectures, enterprise architectures, examples from government architecture and solution architecture formats. These choices are defined in the methodology chapter and go more in-depth into the specific formats and standards chosen. The impact of these choices is evaluated in chapter 6.

It is not the only problem, however, because next to what reference architecture should be used there is an additional problem. This problem stems from the fact that documents such as project start

architectures and solution architectures are adjusted for their target audience and organisation. This presents a formatting problem.

The next part of the literature review consists of the evaluation of the design. The design has to be evaluated to check for inconsistencies but also if the design has incorporated all the requirement-and user specifications.

2.3 - Evaluation

This section will elaborate on the second part of the research, which is the evaluation of the designed solution architecture. This will help answer the second research question:

Sub question 2: "What methods are available to evaluate solution architectures and what possible evaluation criteria can be found in the literature?"

A small discussion is shown in appendix I to choose between validation or evaluation. In the end evaluation is the method of choice. In the first part of the literature review some evaluation criterion are pointed out. Additionally, to evaluate the designed solution architecture a number of criteria are searched by reviewing literature. The design case also includes some evaluation points and thus are taken into account. These points will establish a base for *chapter 6: evaluation of the design.*

The next section will first elaborate on evaluation methods including frameworks. The next section then continues discussing evaluation criteria often used in the business. The last section shows evaluation criteria which were found during the first part of the literature research based on scientific work.

2.3.1 - Evaluation methods

Before this literature review goes into the evaluation criteria itself, a short review is done concerning the methods of architecture evaluation. The requirements are derived from the case design stated in chapter 4. This section will explain methods used by other researchers and common evaluation criteria.

The search for evaluation methods and criteria are made more difficult since most of the work is focused on software architecture (Erder, 2016), using applications to do architecture evaluation (Tibermacine, 2016) or to use architectural significant requirements to evaluate separate solution (Reyes-Delgado, 2016). The proposed solution architecture focuses on the business and information plus application views on a medium abstraction level and is therefore not on the detail level of software architecture. This is important to keep in mind while searching for the term "Solution architecture". The search for evaluation framework and methods is also made more difficult because of the ongoing discussion of what a solution architecture is. Additionally, it seems that most architecture evaluations use a number of evaluation criteria based on the wishes of the developers or clients and tests them through interviews or questionnaires. Therefore, a choice is made between two methods founds in the literature.

Peer review – The peer review method, also named expert review, is one of the oldest methods to receive critique and pointers to improve that work. This method can be structured, semi-structured or unstructured. Unstructured will present the work under review to the reviewer and will only set a deadline for the review work. The structured review will set the method, framework, questions to be answered in stone. This will provide quantitative results since the results can be reflected against a baseline. The semi-structured approach will deliver a set of review criteria but still allows freedom to a certain degree in which the reviewer can do his bidding.

The most important aspects that the researcher should keep in check is the quality of the peer-reviews. Lamont (2016) states *"Most peer reviews are not a quality assessing process in which a set of objective criteria is applied consistently by various reviewers"* (Lamont, 2016). Peer-reviewers often look through different sets of lenses that shape the review work and this might even be an important part of the peer-review process. This is why a semi-structured peer review would uphold the better of two worlds; a set of objective criteria for each reviewer and the freedom to review through their own professional and cognitive lens. Lamont also states "*Among the most salient customary rules of evaluation, deferring to expertise and respecting disciplinary sovereignty, manifest themselves differently based on the degree of specialization of panels: there is less deference in un-disciplinary panels where the expertise of panellists more often overlaps"* (Lamont, 2016). The statement refers to the content of actors within the panel. Are they specialists or generalists? This is important to take into account when selecting the peer-reviewers, if that luxury is available. This leads to "*Overlapping expertise makes it more difficult for any one panellist to convince others of the value of a proposal when opinions differ; unlike in multidisciplinary*

panels, insisting on sovereignty would conflict with scientific authority. There is also less respect for disciplinary sovereignty in panels composed of generalists " (Lamont, 2016). This means that a logical build-up of the panel would be done by selecting internal architects to the project, external architects and design case owners.

Composed from the paper of Lamont (Lamont, 2016) a number of possible problems are defined that should be accounted for during the review design:

1. Finding the people that execute the peer review
2. Establishing a baseline of quality between peer reviews
3. How the panel is filled with what backgrounds?
4. Specialists or generalists
5. Cognitive particularism
6. Favouritism for the familiar
7. Peer bias

Especially the last three points show that peer or expert reviews aren't fully objective. The review will always be subject to subjectivity. Problem two is at least partly solved by implementing the same evaluation framework in each peer-review as mentioned below. It is important to scrutinize between different methods to show that such a review has been done consistently. Therefore, another method is also discussed often used in software architecture.

POSAAM - A evaluation method that uses pattern recognition to evaluate new designs on basis of a database of previous evaluated designs. This method is not fit for this research since the Institute For Informatik states: ***"****POSAAM is based on the identification and use of patterns as a means of evaluation. However, we are aware of the facts that (1) patterns are not always available for every problem, (2) patterns may not always present the best solution to a problem, (3) patterns may not always be easy to identify in architectural descriptions and (4) POSAAM can only be applied if the patterns are structured and stored in a form that supports the evaluation"* (Bettencourt da Cruz, 2008). This pattern recognition evaluation method sounds very consistent within one organisation but loses its usability when design within one organisation is different from each project to the next.

Conclusion - POSAAM is not applicable for this design research since it builds upon recognizing patterns and previously built design. The consistency within an organisation is very important and does not apply to every design case study. Those previous works also have to be evaluated to make sure that the baseline is something of value. Another point of objection is that the architecture documents could be too different from each other to efficiently recognize patterns for evaluation to make sure that the chosen method is always applicable and can be used by a large number of different actors, the peer review method is chosen. Another reason why the peer review method is chosen is because

In the next two sections, a selection is made from two sources of evaluation criteria. Section 2.2.3 shows evaluation criteria from the practise. It shows evaluation criteria used by large renowned companies. Section 2.3.4 however shows evaluation points taken from the scientific literature. This ensures that when a selection is made from both, the best is taken from both domains. The two-pronged method is also to be more congruent, an additional method is to review previous design projects and look at what criteria were used there.

2.3.2 - General evaluation criteria

This section shows a number of evaluation criteria used by other companies and institutes. These points are reflections of experience from the business side of architecture. This is different from scientific literature that has another focus. These points are shown in the next section. The criteria are first named and then discussed and the most appropriate are discussed.

The most objective evaluation criteria are based on the design case: User requirements, Quality requirements, Consult the existing enterprise architecture documents for criteria, business requirements, technical requirements, enterprise standards.

Not all these can be used, but at least the user requirements are set as well as business requirements and the functional requirements based on the user requirements.

Secondly, a look at general evaluation criteria shows additional sets. According to Critchley from www.solutionarchitecture.org there are seven principle qualities of technical design that, although

individually distinguishable, together characterise comprehensive & balanced architecture (Critchley, J., 2008): *Cohesion:* The action or fact of forming a unified whole; *Completeness:* Having all the necessary or appropriate parts; *Elegance:* Pleasingly ingenious and simple; *Equivalence:* Equal in value, amount, function, meaning; *Hierarchy:* An arrangement or classification of things according to relative importance or inclusiveness; *Modularity:* Employing or involving a module or modules as the basis of design or construction (*where module is* each of a set of standardised parts of independent units that can be used to construct a more complex structure); *Vision: A mental image of what the future will or could be like.* These seven points do not state how to make the solution architecture but they give a sense of what the result should look like. These seven points could be analysed through a survey or a questionnaire. Key-actors (end-users, project leaders and architects) of the project can then distinguish how complete the design is.

The evaluation criteria completeness is also seen and recommended by several other architects. Guernsey states that there are advantages for having a complete architecture (Guernsey, 2013). Completeness can be defined in two ways "creating many true-but-incomplete assertions rather than a single complete-but-false one". This statement means that a total architecture can have many incomplete parts but it makes sure that the all the necessary topics are there. This statement is enhanced by Zhu (2013) she states that completeness depends on the agreements made with the organisation for which the architecture document is made (Zhu, 2013) and is thus important to check if the document is consistent with these agreements. The TOGAF model also uses the definition completeness as to make sure that all the building blocks based on the design requirements are there (The Open Group - TOGAF, 2006). There are even methodologies for evaluation that focus for a part on completeness (Tang, 4-7 April 2005) as well as certain guidelines (Boehm, 2010).

The guideline provided by Boehm (2010) also describes another evaluation criterion for design requirements, namely: Consistency. Boehm states that the definition of consistency is *"A specification is consistent to the extent that its provisions do not conflict with each other or with governing specifications and objectives. Specifications require consistency in several ways"* (Boehm, 2010). According to Bhave (2011) being consistent between architectural views is quite difficult and states that consistency between models and architecture is important for the semantics of a system (Bhave, 12-14 April 2011).

Architects from Microsoft (Microsoft, 2016) suggest additional criteria that are known to be architecturally significant, such as: Integration with legacy systems; reusability of code; Reusing existing vendor libraries and platforms; maintenance; risks; cost. These are harder to put into use for this solution architecture since they focus on the finished product including code. However, the solution architecture might give an estimate of those values. Another look at evaluation points and how to work agile are described by the eXtreme laws by Microsoft (Hill, 2007): *Eschew Obfuscation; Maintain Flexibility; Provide Extensibility; Compileability; Develop Iteratively; Rapid Feedback*

Conclusion - The evaluation criteria described in this section were taken from best practises used by large developing companies and knowledgeable institutes. All these evaluation points are valid for their organisation, industry design phase or method. It could be that additional points are found during the design and whilst new knowledge is acquired during the research. These points have been iteratively developed and selected by these organisations based on their practical experience. The selection from this section is shown in 2.2.5.

2.3.3 - Non-functional requirements

During the literature research, multiple factors were found that might be applicable as a evaluation criterion. These criteria were not directly found in the frameworks and methods above. These evaluation criteria are frequently used in scientific literature and were found during the literature review. The evaluation criteria found are listed together and it is explained what their function is and how they are used.

These evaluation criteria are part of non-functional requirements. These differ from functional requirements in the sense that a non-functional requirement describes system attributes such as security, reliability, maintainability, scalability and usability which define how a system should act as opposed what it should do (scaledagileframework, 2016). A non-functional requirement specifies criteria that can be used to judge the operation of a system. They are different from functional requirements because those define specific behaviour or functions.

Flexibility - Flexibility will be described for this research as “The level of ease to connect to the system” where in a high level of flexibility will allow easy connection. One way to achieve this is using open standards.

Most systems are designed in separate parts to form a larger system over time. This can lead to a high level of complexity and this increases the demands on management and control. System designers generally want to achieve system flexibility through a set of objectives: Improving while preserving earlier investments, reducing engineering efforts, reducing operational costs, increase system efficiency and reducing maintenance costs (T.M. Egyedi, 2005).

According to Byrgstad and Hanseth (2015) the level of flexibility is increased by using open, dynamic and simple standards (Bygstad & Hanseth, 2015). Babiak (Babiak, 2008) said that flexibility between two organisations is very important especially concerning the amount of staff and the amount of control involved. If control is lost, more rules and regulations are likely to be adopted and reduce flexibility.

Consider again the four topics of the project start architecture: business, information, technology and applications. One of the criteria of sharing an information infrastructure is a high level of flexibility. Bekkers (Bekkers, 2008) stated that in order to achieve the required level of flexibility, it is important to have agreed on abstract guidelines which define the architecture instead of highly specified ones. These guidelines include not only technological requirements but also structure of the system and the dynamics of the political relationships between the organisations. On the business level economic agreements are of importance. High flexibility can be reached when the costs and benefits are balanced. Bekker (Bekkers, 2008) also states that concerning the information part of the project start architecture standardization and centralization are important. For the application section he advises that core applications should designed in such a way that they are organisationally independent.

Interoperability - The commission of the European Communities (CEC, 1991)) defines interoperability as “The ability to exchange information and mutually to use the information which has been exchanged”.

The fixed scope and context enhances information sharing between different stakeholders and lowers the amount of discussion about choices during the design. Starting with the right context also enables interoperability, because this makes sure that the collaborating parties go for the same goal. This is enhanced the project start architecture which is also chapter 1 in the solution architecture.

There are a few evaluation criteria that can be selected from the NORA principles to evaluate the design process. Loorbach (2010) has shown with quantitative analysis that interoperability and flexibility are positively influenced when local e-governments work in line with the same NORA principles.

These items return in the NORA principles and can be further divided in objectives that are more specific: exchangeability, portability, scalability and interconnectivity. These objectives can be achieved for example by using open interface standards. The application of NORA not only serves as a basic framework to develop the platform but also enhances interoperability and flexibility. These two important aspects allow new organisations to connect to the platform during scaling to a national level and allow the evolution of the platform, which can then offer new functionalities and remain state of the art.

Privacy – A very important non-functional requirement for the solution architecture is privacy. There are many concerns in the media and literature nowadays about civilian breaches of their privacy. This is because everywhere personal and sensitive information is stored and this raises concerns about the privacy and security of that information (Mouratidis, 2013). A very important tool to determine the level of privacy protection is a privacy impact assessment (PIA) (Clarke, 2016). The usage of PIAs is steadily growing and recommended in several reference architectures (Noraonline, 2015), (NICTIZ, Paginas/Informatiestandaarden.aspx, 2016). As discussed in the introduction of this thesis, the world is becoming more connected through the developments such as The Internet OF Things. This interconnection is also seen in the platform under design and the impact of that interconnection on privacy is very real (Caron, 2016)

Security – There are several types of security such as application security, data security, information security and network security. To state the importance of the platform’s security a IDC study interviewed 244 CIOS and stated that security was the number one requirement in 75% of all cases (Rittinghouse, 2016). For each of these topics the security must be in order. In solution architecture there are complete separate architecture documents describing the security levels. However, as this does not fit in the scope several guidelines and models are available which help determine the necessary security such

as the CIA ratings (Tech Target, 2014), stork levels (The Standardisation Forum, 2012), Dependencies and weakness analysis (Comfort-IA, 2016). There are also several NEN standards (7510-11-12) which prescribe how to determine the security levels. The importance of security is acknowledged by the existence of the many different regulations and guidelines. Additionally, there is a paper available which has looked into the security needs for Zo-Dichtbij (Mohamed, 2015).

To enhance the platform design standardized interfaces should be developed together with guidelines and conditions enabling integration and interoperability.

Conclusion –There are a number of additional evaluation criterion that can be used during the evaluation step or steps. The actual choices between these criteria are made during the design of the evaluation step.

2.3.4 - Zo-Dichtbij evaluation criteria

Zo-Dichtbij has some expectations as well from the reference architecture and the solution architecture. The expected benefits for the application of the NORA for Zo-Dichtbij are:

- Increase the interoperability (technical, semantic and organisational wise)
- Increase the service level and robustness of the platform
- Increase the ability to scale up the platform to a national level
- Increase the ability to collaborate with the Dutch government

Interoperability was already defined in 2.2.3. The level of collaboration is asked during interviews as it is very general. Scalability - is the capability of a system, network, or process to handle a growing amount of work, or its potential to be enlarged in order to accommodate that growth and Robustness - Is the ability of a design to cope with errors during execution and cope with erroneous input. Both were taken from the project start architecture

These criteria are partly seen in section 2.2.3 and 2.2.4. these criteria will be used in the questionnaire because they are based on practical and scientific literature. Another reason is that the design is for Zo-Dichtbij and therefore it is logical to base a part of the evaluation on their expectations.

2.3.5 – Conclusion

The quality of a system is connected with its architecture. The concerns for the quality of the architecture are referred to as non-functional requirements, quality attributes, architecturally significant requirements which describe attributes of the design such as completeness, consistency, security, interoperability and flexibility. Together with the functional requirements they describe the systems constrains and show what trade-offs must be made.

The two views, general, non-functional and functional requirements, are combined to evaluate the solution architecture design. A short overview of the selected evaluation criteria is presented first from section 2.2.3 then 2.2.4 and finally 2.2.5. Below the different evaluation criteria are shown. Their origin is shown by table 2.

Table 2: evaluation criteria

	Criteria expected by Zo-Dichtbij
	Criteria found in the literature
	Criteria based on previous ZD research

A selection is made from multiple sources. From section 2.2.3 the first criterion has been defined: **Completeness** - (Guernsey, 2013), (Zhu, 2013), (The Open Group - TOGAF, 2006) and (Tang, 4-7 April 2005). The second main criterion from 2.2.3 is: **Consistency -** (Boehm, 2010), (Bhave, 12-14 April 2011).

Then in the scientific literature often non-functional requirements are used to evaluate IT artefacts and architectures. From the non-functional requirements two were often seen in the literature namely:

From section 2.2.4 the third criterion has been defined as **Interoperability -** (Loorbach, 2010), (Noraonline, 2015). As well as **Flexibility -** (T.M. Egyedi, 2005), (Bygstad & Hanseth, 2015), (Babiak, 2008), (Bekkers, 2008).

Two more non-functional criteria were selected on basis of literature research and because of the general importance of the platform. The data which goes through the system is medical data and therefore the **Privacy -** (Mouratidis, 2013), (Clarke, 2016), (Caron, 2016) **and Security -** (Tech Target, 2014), (The Standardisation Forum, 2012), (Comfort-IA, 2016), (Comfort-IA, 2016), (Rittinghouse, 2016) and (Mouratidis, 2013) are of the utmost importance.

Chapter 3 - Research domain

To place the knowledge, generated through the literature review in context, two important domains were investigated. Knowledge from these domains enhance the solution architecture. In addition to the literature review, additional standards and rules might come from these domains. The first domain is about the Dutch healthcare and the second domain is about public/private architecture. From both domains a number of tensions were derived that placed unique limitations on the solution architecture. These two sections were used to generate answers to sub question three:

Sub question 3: "What are tensions occurring between organisations in the public/private healthcare domain?"

Before it is determined how effective the NORA is for private organisations or public/private collaborations, a number of tensions are searched for in the literature. This gives a sense of direction during the design and during the data collection and makes sure that common pitfalls are avoided. This is done for the healthcare domain. Section 3.1 specifically looks at limitations and tensions placed upon architecture design based on the healthcare sector. This will improve the design and durability of the solution architecture. Section 3.2 specifically looks at tensions between organisations in the public and private sector, between organisations and between architectures. Both sections are then concluded and allow a more efficient design, which already incorporates a number of solution to common pitfalls and steers the questionnaire and the interviews to evaluate the NORA.

3.1 - Dutch healthcare

The solution architecture describes an architecture that facilitates the matchmaking between end-users and healthcare providers. This means that the platform should help end-users to be self-supportive and work together with the healthcare providers. The platform should be easy to use for all actors, even those who are digit-inept. This should deliver the following advantages: a higher standard of living, a diminishing of the care burden and an increase in the performance of healthcare. The matchmaking function suggests that information is exchanged between different organisations. This information exchange between public and private healthcare organisations places constrains on the level of security, since medical data is very sensitive. Additionally, the matchmaking platform of Zo-Dichtbij wants to store medical information together with a diary function accessible for all actors which have a contract with the end-user and who have been evaluated. The information exchange and the storage of medical data increases the design difficulties.

Healthcare standards – There are different rules and regulations placed on healthcare platforms and they differ from country to country. These platforms need to comply with several standards but mostly Dutch legislation. The Coordination Platform Healthcare standards (CPZ) has formulated a number of conditions: Clients must be informed, clients must be supported throughout all platform processes, the processes and tools must be available 24/7, the choices made during design and development must be motivated with the care-user in perspective, there must be an individual care plan and the platform must be supported through digital infrastructure e.g. an electronic patient file (Coördinatieplatform Zorgstandaarden, 2012).

Many of these generic standards are also seen in the NORA. Apart from the NORA and the conditions mentioned above there are also principles for the information technology itself. NICTIZ prescribes these principles. NICTIZ is an independent and neutral party that has had the objective from the ministry of healthcare to support and coordinate the development, implementation and standardization of the information exchange within the healthcare domain.

NICTIZ is thus very important for a healthcare platform that has the main function to connect organisations and enhance the information transfer between those organisations. The NICTIZ standards could be useful to make sure that healthcare organisations within The Netherlands can operate together and thus raise the interoperability (NICTIZ, Paginas/Informatiestandaarden.aspx, 2016). NICTIZ also provides building blocks that might be useful to incorporate in the solution architecture.

Design requirements – A document from the workgroup self-supportive homecare prescribes guidelines for Dutch healthcare platforms and connects with the NICTIZ standards (Werkgroep Tooling Coöperatie Zelfzorg Ondersteund, 2014). This document is based on research done by a competitor of Zo-Dichtbij and might show how previous initiatives were handling problems. This document shows a

number of important criteria that also coincides with the results of Zo-Dichtbij research, table 3 shows these priorities.

Table 3: Priorities for healthcare users and providers

	Patients	Healthcare providers
1	Security and privacy	Security and privacy
2	Individual care plan	Individual care plan
3	Patient has data rights	Interfaces between platform and own system
4	easy to use	Single sign on
5	reliable healthcare information	use of standards and coding

These are user- and design requirements. Additionally, the platform itself, the technological part must adhere to a number of conditions: 1. Privacy, risk and compliance, 2. Authorisations and roles for the end-user, 3. Authorisations and roles for the healthcare provider, 4. Authorisations and roles for the platform management, 5. User support and 6. Updates and clear architecture documentation.

Especially the authorisation places restrictions on the design freedom. This can be taken care of with Role Based Access Control (RBAC). These roles will allow zoning and control of access of users that are signed in to the platform.

Another issue is the overload of scattered information. This information is spread across different healthcare organisations and might overlap. An organisation might also define the information objects differently and use different semantics. This increases the difficulty to transfer information between organisations, if two different ICT systems define two objects differently. For example, when does a platform actor transform into an end-user and when into a healthcare provider and how does a system name those users and the data that goes with those actors. The healthcare domain makes this extra difficult since all the information is highly sensitive and the platform actors (end-users and healthcare providers) must be evaluated. It is very important to know who is who.

Laws - There are also a number of laws that have influence on the form and content of a healthcare platform, but many of these are incorporated into the standards given by the organisations mentioned above. The law that describes the societal healthcare support has some guidelines on how to approach the process of acquiring self-supportive healthcare (Zorgwijzer, 2016). This website also prescribes the requirements that the municipality has to address, this is important for when the first roll-out of the platform cooperates with the municipality of Rotterdam.

There are many organisations, which prescribe standards and formats within the healthcare domain. Not all these organisations have jurisdiction and do not have to be followed. The main organisations are named above and will provide enough standards and formats specific for healthcare. Additional standards and rules can be found during the iterative design cycles.

Privacy - An additional problem that comes from the electronic patient files is privacy. These privacy problems are a hot topic in the Dutch politics. This is because of the sensitive information it entails. The Zo-Dichtbij platform either stores patient information on their platform or retrieves it from a database. This places a very big constrain on how the platform operates. It also predicts the level of security necessary that needs to be incorporated by the platform.

The Dutch law describes that a patient (end-user) always needs to give permission for a treatment or action. This is also true for the platform. This might generate conflicts since the end-user needs easy and simple use of the platform, but this is made more difficult if the patient needs to consent each action taken. Can this consent be stored in a contract? If so then there must be contracts between the patient and the platform, between the platform and the healthcare providers and between the healthcare provider and the patient. This shows the difficulties of storing medical information.

When the medical information is actually stored, additional legislation is written to protect this information. For example, there is the law of protection of personal data (WBP) and this is monitored by

the authority personal data (APG). Then there are European privacy laws that might even increase the level of security necessary to store this information because the law can generate immense fines for invasion of privacy (Skipr, 2015). The solution architecture must adhere to these rules and before implementation can happen a privacy impact assessment (PIA) must be done. There is also a format for the Dutch government. That format might be necessary for when the platform scales to a national level.

A privacy impact assessment aims to answer the following points: the impact of the project on the privacy of the platform actors, the risks associated with this impact and the different approaches that still fulfil the user requirements but have less impact. However, one of the interviewees from ICTU mentioned that (retrieved from interviews P. de Raaj ICTU), "*When the security of a system is airtight it is possible to store information. But you might consider a different solution since simply temporarily retrieving this information is much safer and easier to implement".* This quote gives an example of how a PIA can help design the platform with concern for privacy. This is also called privacy by design.

Privacy by design is a design methodology that tries to protect the users' privacy by incorporating this principle throughout the design of business processes, technologies such as platforms and physical infrastructure. Privacy by design stems from the idea that technology is neutral; it can be used to protect or harm privacy. Additionally, there are a number of protocols that a solution architect can use when designing the platform (IPC of Ontario, 2016).

Conclusion – There are a number of tensions involved during the design of a solution architecture for healthcare. To cope with these tensions though there are several organisations this assists the designer through a series of guidelines and standards. One of the main problems with healthcare platforms that store medical information is privacy. It must be of great concern to the architect to consider this. This can be done through privacy by design.

3.2 - The public and private domain

To discuss the tensions between the public and private domain, a definition must be given. Public organisations are generally not government-controlled. Public organisations however, are the collection of a countries collaborative organisations that deliver services and goods for society and its civilians. This sector is often reliant on government budgets and the conglomeration is called the government. There is also a sub division of the public sector which is also partly private which is the healthcare sector. The healthcare sector is partly funded by the government and partly funded by own income generation. These include hospitals, nursing homes, registration boards and healthcare providers in general (Campbell, McDonald, & Sethibe, 2009).

In this research, the government is described as a public institute and companies that need to interact with those institutions such as hospitals are described as public companies. Companies such as in home care providers and food suppliers are labelled private. Foundations supporting the government or public healthcare are labelled as public/private

Most of the existing literature on ICT led innovations in the public sector has not acknowledged the main differences between the nature of the public and private organisations. Additionally, the current literature about ICT in the public and private domain is mainly about how e-governance can use private sector ideas, drivers and technology to innovate public ICT (Bonina & Cordella, 2010).

One of the more common differences between public and private organisations is the usages of guidelines and regulations. Especially small private organisations want to start programming and coding as soon as possible to create a minimum viable product so they can test it in the market. Public organisations, such as the government, need to adhere to more rules and regulations because of a different level of responsibility. Of course there are guidelines to follow within private organisations but these are less strict and allow more freedom "As long as there is profit and you get it done its good". This responsibility together with legacy systems often make government changes slow. Although this is also seen in large private multinationals such as Shell, the information and data used in those systems is different.

Along with the influence of guidelines, the public sector is heavily influenced by politics on a national and international level. Much more so than private organisations. For the solution architecture this means that the platform needs to be flexible to cope with influences from the politics. These influences are for example: Downsizing, increasing security because of public data leaks, adoption of extra or new

regulations, healthcare reforms and other policy changes. This responsibility also generates distrust between private and public organisations. Who is responsible for what and are private organisations able to guarantee the safety of public data and information.

The availability of data and information is also restricted to the private sector because of the responsibility named above. This means that private organisations have limited access to public registers such as the Basic Persona Register (BPR), Social security number (BSN),

The main public organisation in this thesis is the Dutch government, which is a large conglomeration of different organisations under one umbrella. Under this umbrella there is one reference architecture in use. For the many scattered other public institutes and especially in private organisations there is no one reference architecture. The use of reference architecture is not mandatory for private organisations, only for the public organisations. This again is because of a different responsibility to society. The obligation to follow the reference architecture can also be a limitation when the core concepts change. However, there is no current rule about how strict the reference architecture has to be followed.

The construction of the solution architecture is done by implementing the governmental reference architecture, but this might collide with the wishes and requirements of a private organisation. Therefore, knowledge about the private/public domain is necessary to solve this problem. The amount of empirical research done in the public private domain is still little (Van den Boer, 2011). The Dutch Government has no competition and states that internal competition should be removed as much as possible. This is completely different from private organisations of course because of market incentives.

A difference between the private and public sector is that the public sector has to focus on societal obligations and concerns. The public sector often has an agenda filled with intangible or opposing goals with many stakeholders which have different opinions. This is in contrast with the private sector which is guided by market signals and profit. Another difference stated by Campbell, McDonald and Sethibe (2009) is that the governmental agenda 'must' be addressed whilst the private sector changes the agenda based on economic feasibility. There is also a different governance model in use. The private organisations are led by the board and management to make sure the company is running well. The public organisations however, have a very complex governance model with many more organisations that are involved. Public organisations such as the government are also structurally changed by elections etc. (Campbell, McDonald, & Sethibe, 2009).

A common method to support public/private collaboration is the use of platforms. Klievink (2015) says this is because platforms integrate horizontally (between interacting organisations) and vertically (services are shared between government agencies). The challenge lies in the equilibrium of control enforced by both business- and government agencies. The government demands a high level of security but the business partners need to ensure this. Therefore, it is sometimes difficult to find the right alignment between public and private goals. To counteract these difficulties Klievink (2015) advices to provide the right incentives to co-develop, standardize data definitions and system-interfaces. Additionally, policy instruments including agenda setting, adopting standards and benefit redistribution may help the collaboration between public and private organisations (Klievink, 2015). This is not so easily done and an in-depth understanding is necessary to ensure success.

Collaboration - Governments are working with an increasing number of non-profit organisations and the integration of all these systems can lead to issues. The data hold by public instances regarding public healthcare is very sensitive and access to this increases the accountability of the private firms using that data (Smith, 2008). A distrustful relationship can arise when the balance shifts too much towards one party (Eschenfelder, 2011)

A solution for these objectives is open communication, transparency and understanding of both organisations. Cross sector collaboration is difficult because of the diversity between the sectors, especially regarding governmental regulations and which when rules apply at what time. The downside is that when communication is bad, it is also the cause for the problems mentioned above (Babiak, 2008). To ensure optimum collaboration between the public and private domain while using governmental ICT building blocks are flexibility and dynamic capabilities.

There are a number of wanted characteristics coupled to e-government such as: interconnectivity, service delivery, efficiency and effectiveness, interactivity, decentralization, transparency, accountability and increase their level of responsiveness in a dynamic environment instead of many single one-stop

shops. This is important to keep in mind when designing for the public and private sector. The challenge lies in the equilibrium of control enforced by both business- and government agencies. The government demands a high level of security but the business partners need to ensure this.

This is also true when using governmental building blocks. These building blocks are adopted with rules and regulations. Equal control between the two organisations is important. A second important factor in public/private collaboration is the specified timeline for each organisation. Non-profit firms are working with a longer term timeline and this might not fit in the governmental timeline which depends on four-year election periods (Ferris, 2013). Additionally, this might be a constrain on public private collaborations, especially when research in involved.

Conclusion – There are a number of points which should be paid attention too when comparing public architecture. There are many differences between the two types of organisations and the rules to which they must comply. This has an effect on the private/public solution architecture. Especially, in the security and governance structure.

3.3 - Conclusion

Tensions derived from the healthcare domain and the public- and private domain need to solved or at least paid attention to in the solution architecture. The architect to pay special attention to healthcare standards, design requirements in healthcare, laws which need to be complied with, privacy concerns and a high level security. Additionally, to solve the tensions between the public and private domain, attention must be paid to are the different guidelines and regulations used by both, the effect of politics on the goals of each organisations, the availability of usable data for both, a different timeline and different concerns steered by society or the market.

The tensions found were split in two domains. The healthcare tensions were healthcare standards, design requirements in healthcare, laws which need to be complied with, privacy concerns and a high level security. As well as the tensions between the public and private domain; attention must be paid to the different guidelines and regulations used by both, the effect of politics on the goals of each organisations, the availability of usable data for both, a different timeline and different concerns steered by society or the market.

Chapter 4 - Design Methodology

This chapter will introduce the methods, standards and formats used to design the project start architecture and solution architecture. The design case wants to develop a platform for healthcare end-users and healthcare providers. This means that some knowledge of platform design is necessary. In reality, the solution architecture describes a possible solution. This means what components are necessary, what standards are related to these components and how the information goes through the system. The actual development of the software and physical components ultimately determine what the final product will be. This chapter will show how the solution architecture is designed and of what parts it consists. To do this sub question 1 is answered again but now from a practical perspective:

Sub question 1: "What architectural knowledge is needed to design solution architectures?"

This research can be defined as design-oriented research as mentioned by Verschuren & Hartog. They mention, "*That designers should be well aware that designing involves more "perspiration than inspiration". That is, the designer must be very critical as to the utility and satisfaction of the future users and the other stakeholders. So the artefact to be designed, once realized, should satisfy a set of design criteria*" (Verschuren & Hartog, 2005).This places the user in the centre of the design next to privacy concerns.

A start will be made in section 4.1 that introduces literature in platform design. There are many forms of design research e.g. waterfall method or agile/scrum. This chapter will then finish with section 4.2 that explains how the choices are made between formats, frameworks and standards. The last section will elaborate on the case study selected to provide the design requirements. This chapter might function as a guide for further projects and case studies.

The research methodology is constructed with the help of several sources (R. Bougie, 2013), (H. Doorewaard, 2010), (Yin, 2003). The overall research is structured in two parts, design and evaluation, but will be done iteratively.

4.1 - Design research

A case study often results in a "Messy" process and data gathering can be haphazard (Yin, 2003). This makes the design of the solution architecture also a "messy" process. The first version of the total solution architecture should be delivered within the first 4 months of the thesis project. During this time additional organisations can connect and can provide additional information or changes to the architecture. To make sure that the solution architecture doesn't have to incorporate huge changes in the end of the project, a project management concept will be applied called time boxing**. The agile alliance defines time boxing in the following way: "***Time boxing means setting a fixed amount of time in your calendar for a particular task."*** (Kos, 2016). This means that when the first deadline is approaching new developments which cannot be incorporated within the time schedule, won't be taken into account. This also means that the solution architecture will be a concept version until the final delivery date of the thesis and after each evaluationround the architecture can be adopted in a new time box.

The design is divided in multiple stages called the design cycle. This research will be based on the six stages from Verschuren and Doorewaard (H. Doorewaard, 2010), but will not use all the steps. The stages are the following: "First hunch, requirements and assumptions, structural specifications, prototype, implementation and evaluation". Prototyping and implementation are two steps that are done after the design of the solution architecture and are not part of this thesis.

1. **First hunch**

The first input in this research was done by the foundation of Zo-Dichtbij. The wish of a minimum viable product in the municipality of Rotterdam was the basis for the design. This was enhanced by the input of ICTU which provided the first works for the expansion to a national level by constructing a project start architecture based on the NORA. The effectiveness of the NORA for a private organisation such as Zo-Dichtbij is unknown and additional steps needed to be taken to investigate what was necessary for Zo-Dichtbij to collaborate with the Dutch government.

2. **Requirement analysis and assumptions**

A goal has been named above: the collaboration of the private initiative with the Dutch government. Thus the expansion of a local level to a national level. To realize this a specification of the requirements must be given and these requirements are taken from the design case study.

In this research there are a number of different types of requirements: Functional, non-functional and contextual. The functional requirements imply what the users and developers expect of the artefact under design and what the design must do.

The non-functional requirements specify how the design must do it. Examples are stability, security, interoperability and flexibility.

The contextual requirements place the solution or design in context. The context description is often the first step in the design. These show how politics, economics, jurisdiction and society influence the design. This is done through the DESTEP method.

There are also a number of assumptions of users and designers. These are taken from previous research done by Zo-Dichtbij and the TU Delft. The assumptions show what the developers think about what the consumers need and what functions are needed to fulfil these requirements.

From this design case the key actors, key documents, key developments and previous research requirements can be deducted.

3. Structural specifications

This part of the design cycle is about how the requirements and assumptions above influence the design and how they are incorporated. This is based on the case study and the literature review. It shows the structure of the artefact and what methodology was used to make it. These are structural specifications which expand on the functional, non-functional and contextual requirements above.

The first three stages will result in the solution architecture. The system is then transformed from a black box model into a white box model and shows a distinction between systems and sub-systems. This shows a general overview of the artefact under design.

Normally prototyping and implementation will follow but these are done during the realisation after this work. Thus the process skips to the last stage.

4. Evaluation

The last step off the cycle is the evaluation/evaluation of the artefact. All the previous inputs of the design cycle should be checked and reviewed. Often one design cycle is not enough and therefore an iterative design method should be incorporated. Next to this specific step, evaluation is taken into account during all the steps. A last note is that although the stages in the design cycle logically follow up on each other, a criss-cross of stages is often seen in practise since the project is not static.

Design research – The literature review places the artefact and the design process in a theoretical framework to build on previous research and explain the concepts used. Goldkuhl (2010) states that the literature research should inform the researcher so that the design decisions concerning the solution architecture are sufficiently grounded in abstract knowledge. Secondly, the literature review should at least it should make clear the variables / design issues that need to be tackled and reveal the evaluation criteria necessary for evaluating the designed solution architecture.

An important realization is that evaluation and grounding are always partial because of the concept of bounded rationality (Gigerenzer, 2002). The concept of bounded rationality confines the amount of data one person can take in. To increase the evaluation of the design, iterative evaluation steps are built in. the choice to do design research is made explicitly because it fits the research goals of Goldkuhl. Goldkuhl (2010) names two goals that should be accomplished by design research: "*Design research aims to contribute 1) through designs as solutions to practical problems and needs of people and 2) also to the knowledge goals of a scientific community"* (Goldkuhl, 2010). The first goal will help provide a solution to the practical problem mentioned in section 1.2 and the second goal will increase the scientific knowledge for section 1.3. Continuing on the goals this research accomplishes those goals in two ways: *"Design research uses and produces design knowledge. It uses abstract design knowledge and it*

produces abstract as well as situational design knowledge." This abstract design knowledge is extracted from the literature review and the practical knowledge is extracted from the design process of the artefact and translated into general recommendations.

During the design research, it is expected to come across design issues that must be resolved to continue or finish the artefact, therefore, making them critical. These design issues are variables, which can be tweaked, and those variables influence the design choice. These issues can have a powerful impact on the final artefact.

Design issues - To find the design variables / designs issues a requirement analysis is performed on the case of Zo-Dichtbij. Data is collected by interviewing key stakeholders of the Zo-Dichtbij project and reviewing research studies produced by Zo-Dichtbij. These are reinforced by the literature study in this chapter. Very impactful design issues are defined as critical design issues. A critical design issue is defined as "a design variable that is perceived to be (by practitioner and/or researcher) of eminent importance to the viability and sustainability of the business model under study" (H. Bouwman, 2008). This is taken from a business model study, but also translates to the design of the artefact. An additional name of a critical design issue is an architecture decision (Manteuffel, Tofan, Avgeriou, Koziolek, & Goldschmidt, 2016). These architecture decisions are often badly recorded if even at all. Most of this knowledge is tacit and resides inside the head of the architect. This increases the value of this research but it also increases the difficulty in finding previous research concentring the design issues.

These issues come from the design process. The construction of the artefact is done will the help of a number of documents and concepts. These concepts are elaborated on in the next section.

4.1.1 - Waterfall vs. Agile

This iterative character of the design process is acknowledged by using the agile method instead of using the waterfall methodology. The waterfall methodology is a sequential design process. Each of the design stages are done once and in order to continue one stage must be completed before the next stage can be entered. A newer methodology is the agile method. Agile was developed as a way to overcome the disadvantages of the waterfall methodology. The complete design transforms into an incremental process. The work is done in smaller steps and after a certain time are reviewed and tested, if possible. This also makes sure that new developments such as customer feedback, new technology or business events are incorporated into the design (Base36, 2012).

4.2 - Formats and standards

This chapter will introduce and explain concepts and terminology used during the design of the solution architecture. During the design, multiple standards and formats have been considered. During the literature review multiple standards, frameworks and formats were found. The most commonly used are elaborated on below. This decision-making on formats is done to scientifically ground the design in literature. Within each section is reasoned why such a standard or format is chosen. This is especially important when designing solution architecture since the content of such a document can change between different solution architects.

4.2.1 - Architecture formats

The format of the design might constrain what principles from a reference architecture need to be applied. There is no single consensus to what is the "best" format for either project start architecture or solution architecture. Depending on the project the architect is undertaking, the architect himself, the internal organisation of the organisation and design requirements of the client or case the document can change in format. These formats are called architecture frameworks; some examples are given:

1. ISO420-10 standard (IEEE-Architecture-Working-Group, 2007)
2. TOGAF by the open group (TOGAF-7, 1999-2011)
3. The Zachman Framework (ZACHMAN, 2008)

There are also a number of different modelling languages, Architecture description languages (ADLs) that are used to illustrate the designed solution (architecture). The three main languages are:

1. Archimate (The Open Group, 2016)
2. Unified Modelling Language (Object Management Group, 2015)
3. Business Process Model and Notation (BPMN) (Object Management Group, 2011).

A distinction is made between these different architecture concepts and a general basis is formed by using the ISO420-10 standard as it underpins a general overview of how different architecture concepts relate to each other. The entire system is described by the architecture framework.

An *architecture framework* is defined as “the conventions, principles and practices for the description of architectures established within a specific domain of application and/or community of stakeholders” (SOURCE). To conform to the Standard, an architecture framework must specify: the identification of concerns; the identification of stakeholders having those concerns; architecture viewpoints that frame those concerns; and correspondence rules integrating those viewpoints. The ISO standard provides a basis for architecture frameworks and does not substitute other methods such as TOGAF. In this research the standard is used as a collection of international best practises that is fused together with the TOGAF framework.

4.2.2 - ISO420-10 standard

The ISO420-10 standard is an international supported architecture framework which shows the total overview of a system in its architecture components. This standard forms the basis of the architecture product and is enhanced with another architecture framework: TOGAF. The ISO420-10 standard is discussed first and the latter will be discussed in section 4.2.3.

The ISO420-10 standard explains in general and on a high abstraction level how architectures should be described and designed. This standard builds on the concepts of IEEE 1471:2000. It tries to establish a set of guidelines which give plenty of room for deviations. The Standard has several parts. The first part is a conceptual model of the architecture description (AD). The conceptual model, sometimes called the “meta-model”, defines a set of terms and their relations. This meta-model has been widely used and discussed in industry and in the academic literature. The conceptual model establishes terms, their definitions and relations which are then used in expressing the requirements (iso-architecture, 2015). The model is shown in Figure 3.

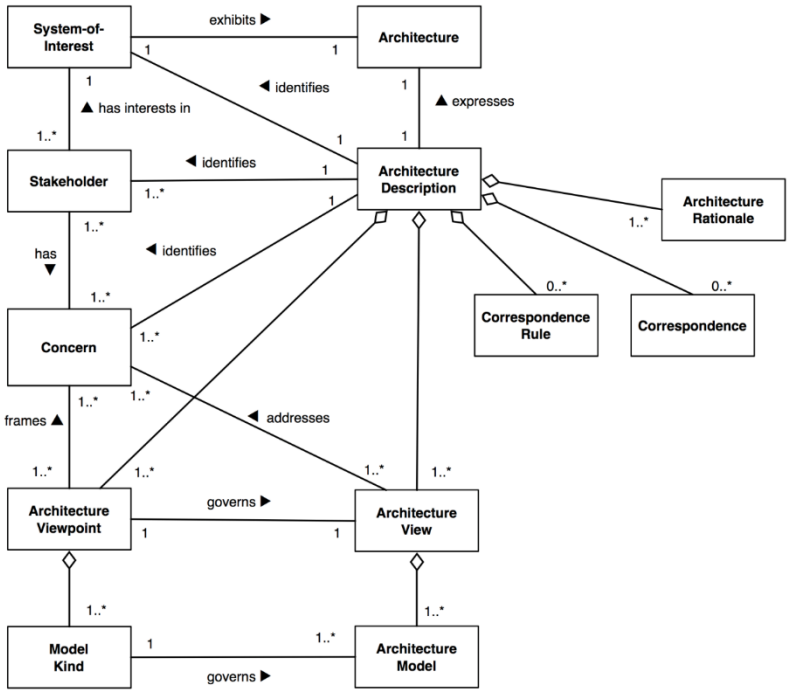

Figure 3: The conceptual model for the ISO420-10 standard described in UML-Unified Modelling Language (42010, 2011).

Figure 3 shows how an architecture description (AD) conforms to the ISO420-10 standard. This is true when it complies with the following requirements: identifying the stakeholders of the system and their concerns; choosing and defining viewpoints that frame, or cover, those concerns; documenting the views of the architecture, such that each satisfies one of those viewpoints; linking together those views

with correspondences and recording any known inconsistencies between views; and providing rationale for key decisions made in the AD. The ISO420-10 framework is enhanced with TOGAF.

4.2.3 - TOGAF

The TOGAF architecture framework has been adopted by many organisations around the world and is managed by The Open Group.

The licence used was version 9.1 of TOGAF: the open group architectural framework (TOGAF-9.1, 2011). TOGAF describes an architecture framework with a clear architecture development method (ADM). This ADM-cycle is depicted in Figure 4.

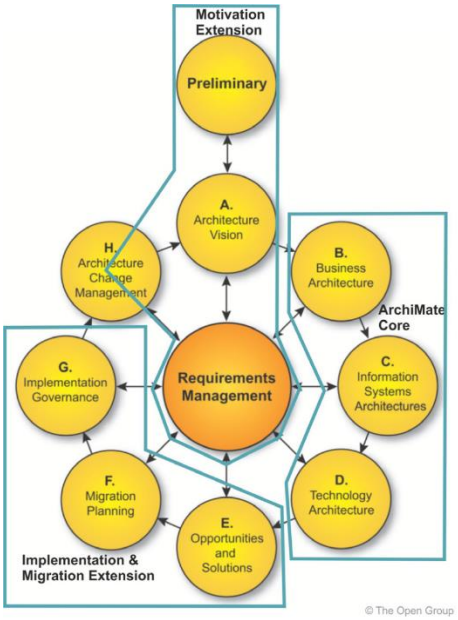

Figure 4: The TOGAF ADM-cycle which describes the total transition of a current situation to the new setting, in this research only A t/m D are used (TOGAF-9.1, 2011).

The Project Start Architecture is the embodiment of the preliminary phase of the ADM-cycle, see Figure 4. The groundwork done pre-design to make sure that the architect has a sufficient basis and knowledge to do his work. This phase describes which formats and standards for architecture design the solution architect will use, the reasons for it and describes the context. A very important property of the ADM-cycle is that it is iterative. This holds for the entire cycle and for each step (A-H).

The next phase (A) is the architecture vision. This is described as well in the project start architecture (PSA) and envisions the solution as a black box model. A more detailed description of the project start architecture is found in section 4.4 - Project Start Architecture.

Phase B-D are the subsequent sections for the solution architecture views. These sections include the business viewpoint (B), the information and functionality viewpoint (C) and the technology viewpoint (D). An additional view is included which is governance and security which is normally included later in the cycle but this is a deviation from the TOGAF 7 ADM-cycle. This solution architecture does not include the steps E-H. This does not fit within the time scale of the research.

4.2.4 - Architecture Viewpoint.

The architectural view in the ISO420-10 standard and the TOGAF framework address concerns for certain stockholders from a specific viewpoint. An architecture view *"Is a representation of one or more structural aspects of an architecture that illustrates how the architecture addresses one or more concerns held by one or more of its stakeholders"* (Woods & Rozanski, 2016). There are many different view models which include different viewpoints such as named in the TOGAF model. Using the same framework and views enhances the comparison between previous work and this is to promote reuse of

previous work. Each viewpoint solves a part of the design problem from a different perspective. The viewpoints can be read separately but should follow up on each other logically.

Business view – The business view describes the actors and the processes they go through. This view describes the main processes of the platform and how processes such as management processes support the main functionalities.

Information and application view – The information and application view show what the main functions are of the system and how they are realized. The information that goes through the system is described in an information flow model and a semantic model.

Technology view – This view shows what technological solutions have to be implemented during realization and what data goes through these systems. This part is kept small because of time constrains and knowledge limitations.

The TOGAF framework is used to show what viewpoints will be used, but there are many different formats to choose from. One of the different formats is the Kruchten 4+1 viewpoint model (Kruchten, November 1995). This model is not chosen because of the focus on software development.

4.2.5 - Architecture Description Language.

An *architecture description language* (ADL) is any form of expression for use in architecture descriptions. Examples of ADLs include: Rapide, Wright, Seem and AADL. The three most commonly used are:

Archimate (The Open Group, 2016), Unified Modelling Language (UML) (Object Management Group, 2015) and Business Process Model and Notation (BPMN) (Object Management Group, 2011).

The architecture languages show the system in a visual representation. These representations are used as an overview model and as a communication tool. The representations are accompanied by a textual description in the solution architecture.

Archimate - The Archimate language is designed by the open group, the same group which has developed the TOGAF system and is established as an open and independent modelling language for ICT architecture. This language follows the TOGAF methodology as shown in Figure 4 and is supported by many different users and enables those users to describe, analyse and visualize the relationships between business, application and the technology views in a vendor-independent way.

The open group manages Archimate and defines it as *"Just as an architectural drawing in classical building architecture describes the various aspects of the construction and use of a building, Archimate offers a common language for describing the construction and operation of business processes, organisational structures, information flows, IT systems, and technical infrastructure. This insight helps stakeholders to design, assess, and communicate the consequences of decisions and changes within and between these business domains"* (The Open Group, 2016)

The open group has defined the Archimate language in several figures and lines which has different meanings and interrelations. The meanings and interrelations of the figures and lines are shown in appendix II (A-D).

4.3 - Dutch Government Reference architecture (NORA)

The guidelines and standards that are used to design the platform are taken from reference architecture. During the introduction and literature review many different reference architectures are mentioned.

The main reference architecture for the Dutch government is the NORA. This is the reference architecture used in this research. The current paper version is NORA 3.0 and this version has transcended to an online version registered on www.noraonline.nl. Both are used since the website is constantly updated and might interfere with the research results because of sudden changes.

The NORA consists of 10 basic principles and from those 10 basic principles, 40 derivatives principles have been established. The basic principles are shown in Table 4. The rest of the derived principles are in the appendix.

Table 4: Main (basic) principles of NORA

Proactive	BP01	Service users will get the service they need.
Findable	BP02	Service users can easily find the service.
Accessibility	BP03	Service users can easily get access to the service.
Standard	BP04	Service users experience uniformity through the use of standard solutions.
Coupling	BP05	Service users are offered services which are alike together.
Transparent	BP06	Service users can access information which is relevant to them.
Necessity	BP07	Service users are not confronted with unnecessary questions.
Confidential	BP08	Service users should be able to trust that their information is not abused.
Reliable	BP09	Service users should be able to trust that the service provider keeps made agreements.
Constructive feedback	BP10	Service users can contribute to the service.

These principles have been made to enhance the interoperability between public organisations and the information sharing between organisations within the public domain (Digitaleoverheid, 2009). The principles are very general which lead to a high level of abstraction. These principles will be linked to the four architecture views of the project start architecture and elaborated with the derivative principles.

The NORA is based on the framework of TOGAF and the ADL Archimate. The standards used in TOGAF and Archimate are applied in the NORA whenever possible. This ensures that the NORA connects to the practise and to the language used by architects in the private setting, The NORA tries to form a common language so that interoperability between the daughters of the NORA is enhanced. Daughters of the NORA are determined as governmental reference architectures based on the NORA but specified to a certain domain. An example of such a daughter is GEMMA, which is the reference architecture for municipalities. This also brings differences to the surface and makes sure that services are better connected to each other.

The NORA 3.0 is connected and based on Archimate 2.0 and TOGAF 9.0. These two are mentioned above in chapter 4.2. The NORA consists of three parts: goals, principles and requirements. These follow up on each other.

There are also a number of different reference architectures that might be used to design the platform. This is necessary since the NORA mainly defines how services should be brought to the citizen and not so much as how to build the actual platform. Through advice of ICTU, two additional reference architectures are mentioned here.

Additional reference architectures are necessary because the NORA is very high over. Especially for the healthcare domain additional reference architectures are necessary. The reference architecture designed by NICTIZ can be used.

4.4 - Project Start Architecture

The project start architecture is used as input for the solution architecture and is often used as the first chapter of the solution architecture. The project start architecture gives a black box description of the system of interest and describes the context. Additionally, it can use a reference architecture such as the NORA to give a preliminary cause and effect of the rules and legislation concerning the system of interest.

The Project start architecture can be used as a communication tool for developers and architects and focusses more on a larger group of users, especially higher management. It can show insights into costs and possible problems.

The project start architecture uses an enterprise architecture as input whenever this is available. When this is not the case, a reference architecture will be used for input. From the project start architecture,

the transformation is made to the solution architecture and goes from a high over abstract description into a more detailed complex solution representation for developers.

The project start architecture is a separate document, alongside this thesis. The main results from the project start architecture is a first look at the applicability of the NORA principles for the Zo-Dichtbij architecture. This table is added in appendix VII. The red text depicts the results from the workshop hold with the Zo-Dichtbij members in 2015 and the black text depicts the new results during the construction in 2016.

4.5 - Solution Architecture

The solution architecture can be a very detailed document showing how developers can design the system of interest. The NORA will be applied as well as rules and legislation and the implications on development of both are shown.

The level of detail is high and the high over abstract representation of the project start architecture is transformed into a detailed representation in for example Archimate. A more detailed schedule shows how the solution architecture is designed. This is shown in Figure 5.

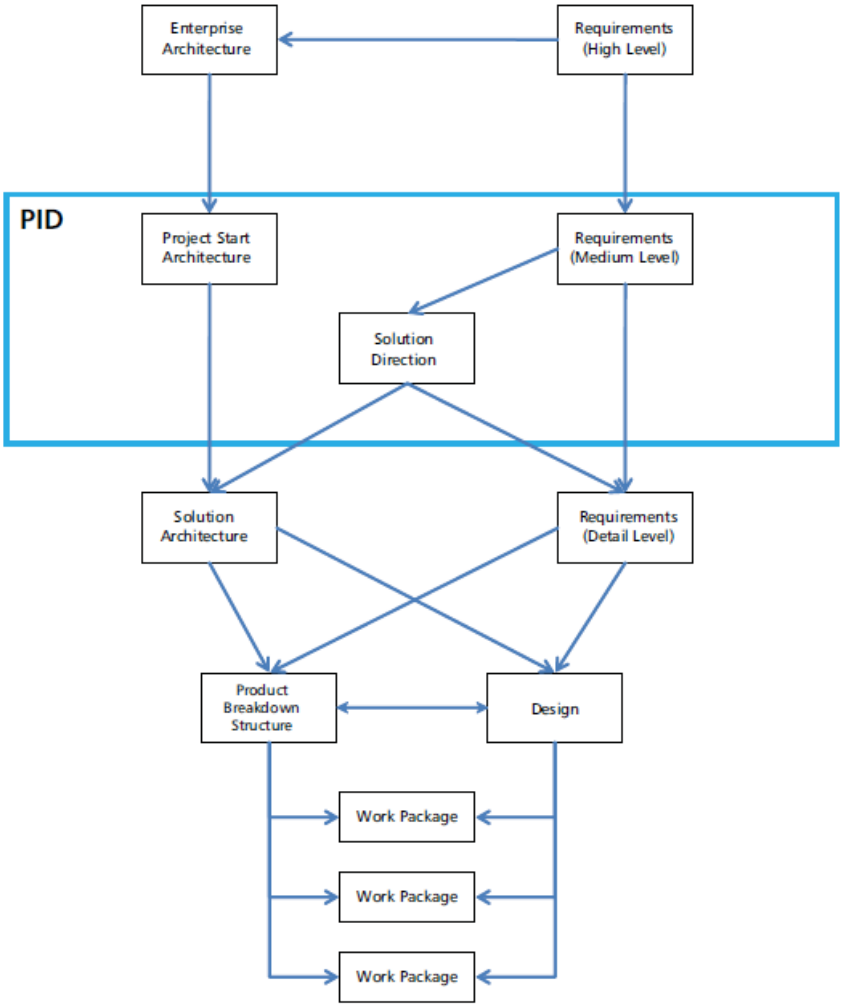

Figure 5: The general process from project start architecture to a solution architecture (Slot, R., Teeuwen, P., Van Alen, R., 2010).

The first part is already explained before in Figure 2 where the enterprise architecture is the start of the design by taking it as a design guideline. In this research that would be reference architecture. The enterprise architecture also shows the high-level requirement to which the project must comply. When these are not available, they must be taken from market and product research concerning the new project. The next step is describing the Project initiation documents. This detailed description of the

context (PSA) includes medium level requirements. These requirements are on the tactical level whilst the high-level requirements are more strategic. This was already described as one of the differences between enterprise architecture and solution architecture.

These requirements are described and fitted together in the solution architecture. The solution architecture itself then gives the lowest level of details which are practical. This also coincides with the agile and/or scrum method in which total system is broken down in multiple smaller work packages that are developed iteratively. The new term from this product breakdown structure is explained as “the breakdown of the total work in separate physical products” (productbreakdownstructure.com, 2014). Since this thesis only incorporates design products, a better term is Work Breakdown Structure. The Project Management Body of Knowledge (PMBOK) defines the work breakdown structure as a "*deliverable oriented hierarchical decomposition of the work to be executed by the project team*" (PMBOK, 2016). This is applied by selecting viewpoints within an architectural framework and start working on each of them and consider them a work package. When one is finished, an architect can then continue to the next viewpoint. This is often applied to software developers though.

The selected viewpoints are the following: Business, application, information, technology and security. These viewpoints are described in the same order as the Archimate figures. Actors, governance (management), business processes, front-end applications, back-end applications and the technology layer. The information layer is not seen in the Archimate figures but is present as a general layer connecting all the parts.

Chapter 5 - Research methodology

This research aims to research how the NORA affects the design of public/private architectures. This is done in two steps: Design a solution architecture and validating it.

The input for the design is derived from the case study. This input will help answer the research questions. The foundation Zo-Dichtbij is going to develop a healthcare platform that enhances the knowledge transfer between end-users and healthcare providers. The design criteria and requirements are collected from previous work done by the foundation and also from key-actors within the development team. As advised by Goldkuhl (2010) this thesis works with a design case. This design case leads to the development of an artefact and can be seen as a single case study. It is important to establish if the design is based on a single study or based on multiple studies (Goldkuhl, 2010). If possible multiple cases should be used. However, for this research no other case has been found.

The design case study is used to study one subject with more depth than other research methods. The solution architecture design process can be done in-depth together with its evaluation process. It can also target a more broadly defined subject such as the solution architecture because of the multiple views (business, information, technology and application) within the construct and the multiple steps taken during the design. Another reason to use a design case study is because the interviews will not necessarily point to one solution/answer. The case study inquiry copes with the technically distinctive situation in which there will be many more variables of interest than data points. This means that for each topic a new set of interview questions needs to be defined which cannot be answered for example with a single survey which doesn't allow the required depth and broad answers. During the design, the architect also makes assumptions that may or may not be scientific ally grounded, but these assumptions are more of a practical nature. The design case study also allows interviews with key actors directly involved within the project.

Another reason for the use of a design case study is because this case can serve as a starting point for further inductive research and contribute to novel theory. Research about using public reference architecture within an organisation that is operating in the private and public domain can be used as a starting point for additional cases and the results can be used for explaining or validating the research, especially because this is a novel subject. The case benefits from the prior development of theoretical propositions to guide data collection and analysis. It therefore combines theoretical and practical knowledge. It can be used as an inspiration for new research topics and help sharpen the existing theory by pointing towards gaps.

To generate an exhaustive research around the solution architecture, minimally two points in time are used. One point in time is used to generate the design and the second point is used to evaluate and evaluate the generated design. These points might happen intermittently and in different time settings for different parts of the design. Design case studies can be compared to case studies as described by Yin. Yin said "*Case studies can illustrate certain topics within an evaluation in a descriptive way*" (Yin, 2003). Yin also explains that if the intervention has no clear single set of outcomes, the case study method can be applied. This is true since open expert interviews will be conducted which can lead to different outcomes.

Additionally, there are a number of reasons specified by Yin (Yin, 2003) to use a case study research: 1. The small domain in which this solution architecture operates. 2. The data generation is very intensive because the design actually involves tight relations with all actors and takes place for a single case. This generates more depth than breadth for this design. 3. The single case could be a starting point to increase the breadth of this design when the design guide is applied to new cases. A multiple case study could also use this qualitative research as a starting point for more quantitative research. 4. It is also a very flexible method, which is very important during this practise-oriented research since the design is contemporary. 5. A final advantage is that the design of the solution requires the collaboration of many actors, which contribute to the project. An intensive case study will make sure that results are more easily accepted by the key-actors in the project, because the results are identifiable and more of an everyday nature.

The following reasons should be kept in mind when choosing for different research methods: Lack of rigor, could be sloppy, no systematic procedures, lack of basis for scientific generalization, might take too long and can result in massive unreadable documents, they are difficult to do, low external validity. The results are harder to apply to a more general population because of the low number of cases

studied. This is less of a problem in practise-oriented research where the case is applied to a single organisation. To counter this, a large n quantitative survey could be conducted, but this is suggested as further research and not possible within the time scope of this research.

5.1 - Unit of analysis: Solution architecture for Zo-Dichtbij

To resolve the mismatch of demand and supply so that healthcare providers and care users can find each other, an online healthcare platform in the smart living area is developed by the foundation Zo-Dichtbij. The healthcare platform focuses on elderly people (55-75 and 75+) to let them live longer at home. Platforms are defined as having no direct purpose to end users but serve as an infrastructure basis that allows one or more applications to function (Foster, 2011).

The matchmaking platform (Keijzer-Broers, De Reuver, & Guldemond, Designing a matchmaking platform for smart living services, 2013) will:

1. Enable end-users to search for smart living services;
2. Provide the possibility for suppliers to promote their services and;
3. Assist the matchmaking between (latent) needs and (yet unknown) services.
4. Additionally, the platform wants to conglomerate the medical data of care users.

The healthcare platform is a private initiative within the municipality of Rotterdam. From this starting point, the foundation will iteratively realize the platform and wants to scale up the platform to a national level in the future. The use of Dutch governmental reference architecture (NORA) is advised by ICTU to increase the chances of successful scaling to a national level and increase the possibility of cooperation and collaboration with public health institutes and the Dutch government. ICTU is a governmental foundation that assists the Dutch government in their digital services and is an expert in the use of the NORA.

The foundation Zo-Dichtbij wants to support citizens to live comfortably in their own homes for as long as possible. They stimulate and support collaboration of a multitude of services and businesses to achieve this goal. Zo-Dichtbij wants to connect the healthcare providers and private healthcare providers with the care users. In the future Zo-Dichtbij wants to be prepared to upscale their platform and connect to the ministry of health and wellbeing. Zo-Dichtbij is developing an online matchmaking platform that facilitates this process. This is done in the area of e-healthcare. The ICT platform is meant to support the elderly. The foundation wants to connect professional healthcare providers with end-users such as care-users, volunteers, family and friends (Zo-Dichtbij, 2015).

What is the role of the reference architecture? The Foundation Zo-Dichtbij is the project leader of the platform realization and started the development from scratch. To design such a platform an ICT architect could be hired. When a project is new and has no architectural framework, such as with the development of the Zo-Dichtbij healthcare platform, reference architecture can be used as a starting framework. The collaboration between the foundation Zo-Dichtbij and the governmental foundation ICTU has made the choice for the NORA explicit.

ICTU has assisted the foundation by constructing a project start architecture (PSA) which is a document that sketches the context of the problem in which the problem is the realisation of the platform in the public/private healthcare domain.

The Zo-Dichtbij platform is a private initiative but wants to incorporate public reference architecture to ensure future successful operation in the public/private domain. This process is facilitated by ICTU as mentioned before and the next step in this process is the evolution of the project start architecture into a solution architecture.

This is a well suited case because the case takes place in the public and private domain and the platform wants to apply public reference architecture that normally is not used in the private sector, as far as is known. Current research also focuses more on companies that are private and use formats such as a DYA not based on NORA (Sogetti, 2011).

The reason why the NORA is chosen as a reference architecture is because this is a wish of Zo-Dichtbij and reported in previous research done by Zo-Dichtbij: *"The reason to use this framework is to embark on a growth curve in maturity and to take the scalability potential of the platform into account"* (Keijzer-Broers W. J., De Reuver, Florez Atehuortua, & Guldemond, 2015).

Additional to chapter 2 the last evaluation criteria were taken from previous input of Zo-Dichtbij. The foundation together with ICTU have come up with a few criteria they expect to see from the application of the governmental reference architecture:

Scalability and **Robustness -** Both were taken from the project start architecture (Bergman & Greve, 2016). Finally, the last criterion is based on the **functional requirements**. The functional requirements must be checked and are based on the user requirements and are established by previous research by Zo-Dichtbij and Keijzer-Broers (Flórez Atehortúa, 2015), (Keijzer-Broers, Nikayin, & de Reuver, Main requirements of a Health and Wellbeing Platform: findings from four focus group discussions, 2015), (Keijzer-Broers W. J., De Reuver, Florez Atehuortua, & Guldemond, 2015).

5.2 - Single case study

The case revolves around the project start architecture and solution architecture build for one organisation. This research focuses around using governmental reference architecture within the private domain. The object under study is the solution architecture that is constructed for the foundation Zo-Dichtbij. This case study is considered a unique case because thus far the NORA as the governmental reference architecture has not been applied to private companies (confirmed by ICTU). This presents an opportunity that has become available. The single case will allow an intensive and thorough study. If possible, a triangulation of methods should be applied. This strategy is used to eliminate chance as much as possible, which is important since there is only one applicable case.

Yin (Yin, 2003) has suggested numerous reasons why a single case study could be conducted: This case represents the critical case in testing a well-formulated theory, this case is necessary to test the propositions as well as the circumstances chosen. The conceptual model constructed in the literature review is leading during the research. Semi-structured interviews with multiple sources within multiple domains will help validating the model. Another reason is the current uniqueness of the case. This case can be a representative case to be used to form a general idea about the effectiveness of NORA principles applied in solution architecture for private companies. Zo-Dichtbij did not have in-depth in-house knowledge about the construction of public architecture document and especially not one in the public/private domain. The organisations that are connected are mainly private organisations except for the municipality of Rotterdam. The collaboration between ICTU and Zo-Dichtbij makes this case therefore a unique possibility to study the phenomenon. The case is also longitudinal since interviews are taking at two separate times concerning the same solution architecture as topic. In the first round of interviews, the solution architecture is being built and during the second round of interviews, the expert review, the artefact is finished and evaluated. An additional reason to make this a single case study is because it is a running project which means that conditions might change during development of the artefact. If the results are satisfactory, it can be used to start a multiple case study with multiple project start architectures within the public/private domain, but this is a recommendation for further research. The guide that is expected as a result can also be used as a shell for the next case study.

There are also contextual conditions to choose for a single case study. This case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context: this is exemplified by constructing the architecture during the research alongside the platform's development.

The design case study is comparable to a normal case study and why this is chosen is has already been clarified above in section 3.3.3. Between the methods available, there are numerous strengths and weaknesses addressing construct validity, internal validity, external validity and reliability.

Construct validity -There are two methods to enhance the construct validity, namely select the specific types of changes that are to be studied and relate them to the original objectives of the study and demonstrate that the selected measures of these changes do indeed reflect the specific types of change that have been selected. The first two measures stated in figure 2 for construct validity are already taken into account in the case study protocol. The last measure could be used when the interview answers lies far apart and having key informants review the draft might offer a solution.

Internal validity - The internal validity will be addressed by building on the literature study conducted beforehand. Additionally, the two rounds of interviews allow for pattern matching. The literature study and the conducted interviews can also address rival explanations that might interfere with the data analysis.

External validity - The literature study beforehand will enhance the external validity. The results could be made generalizable beyond the immediate case study if they follow current literature. A particular set of results should be generalizable to some broader theory, the conceptual model. Additional methods within the study could be used in another study. This leads towards the evaluation of the process by using a survey, specialist interviews or a workshop. This could also prove if the results are also valid (generalizable) in other settings and times.

Reliability - A case study protocol is developed to address any problems with the reliability. This makes sure that the results will be the same when the same protocol is followed for the same case. Additionally, a case study database will be build and all the procedures followed in the case study will be documented.

5.3 - Sample and data collection

To make sure that the data is reliable the data should be triangulated. Yin (Yin, 2003) specifies three ways to do that: Use multiple sources of evidence, maintain a case study database and to maintain a chain of evidence. Multiple sources targeted at the same theory can help with construct validity because multiple sources of evidence essentially provide multiple measures of the same phenomenon. It is important to maintain a case study database. This is to ensure that the difference between the raw data and the research conclusions are clear. To maintain a chain of evidence the conclusions of the research should be traced back to the initial research questions and vice versa.

Interviews and a questionnaire will be the main method to collect data, as well as available documentation and archival records. The collection is done in two steps to link the data collection to the research (sub) questions. The first part of the research builds on data already collected as specified above. This data will be enhanced and reinforced with interviews. The second part of the research needs to evaluate the construct and this will use the data collected in the first part and will also be strengthened by a evaluation questionnaire and possibly interviews. After this the two parts need to be compared to derive general lessons. This will then lead to recommendations for future research and advice on how to use of public reference architecture within private companies.

There are two rounds of data collection. The first round will address the design of the solution architecture on the basis of the project start architecture already build by ICTU and the second round will evaluate the solution architecture and the building process. Guided open-ended interviews will be used rather than rigid interviews, together with open questions. The questionnaire will consist of open questions.

The question is if one-on-one interviews are the best method to collect feedback or if focus groups might work better to connect the different actors. Then for the evaluation protocol it might be better to use expert reviews and possibly follow-up interviews to clarify the results.

5.4 - Selection of subjects

The subjects that are selected for the interviews and the questionnaire are Zo-Dichtbij developers or architects from ICTU. The first group is primarily selected because they are directly involved in the developing process of Zo-Dichtbij and secondly because they consist of private organisations. A private reflection on the NORA would strengthen the evaluation results.

Expertise in using the NORA is found mainly in public organisations and their architects since the private sector does not use or because they lack knowledge about the NORA. This might present difficulties in finding subjects. This also presents a problem for the Zo-Dichtbij actors which might not have in-depth knowledge of the NORA.

To solve this the architects from ICTU are also selected as subjects. Their expertise in applying the NORA varies as well as their domain speciality. This means that there is a differentiation between different architect: business, information, enterprise, technology. Therefore, a broader selection of architects from different expertise would be used.

Users of the platform or persons from the Living lab in Rotterdam are not invited to join since the solution architecture requires a substantial amount of technical knowledge. The amount of subjects required for a thorough review is difficult to establish beforehand and is limited by their own availability and wish to help.

5.5 - Interviews

Interviews are used as a method to collection information. Berg (2007) stated that interviews are used *"for certain types of research questions and for addressing certain types of assumptions"* (Berg, 2001). From the three types of interviews, a choice was made for unstructured interviews. The main difference between the three types is the amount of control the interviewer has on the interviewee. This is especially useful when the interviewer does not know what the questions need to be in advance.

The goal of the first set of interviews is to determine the overall structure of the solution. At least two unstructured interviews were held during each design iteration process to increase the validity and reliability of the data. During each iteration a member of the Zo-Dichtbij collaboration was interviewed as well as an architect from ICTU. The goal of the interviews was to evaluate the current iteration of the design. These were unstructured interviews were the Archimate figures were used as guiding substance. All the interviews are recorded and transcribed.

The interviews will be conducted either face-to-face or using media such as Skype. The data will be used as a guideline and hold against current literature, especially in the case if the answers from the expert differ too much from each other. The answers from the interviewee are discussed with them during the interview and are not to be followed explicitly.

5.6 - Questionnaire

The evaluation of the solution architecture is done through a questionnaire among both Zo-Dichtbij actors and ICTU architects. The questionnaire is built up from five parts, with 2 main parts. An introduction to the questionnaire, a section for personal information, a set of evaluation questions based on the SA, a set of evaluation questions based on the NORA and the last section requests if anything is missed and if the person is open for a follow up interview.

As discussed in chapter 2.2, the method to evaluate the solution architecture was the peer-review system. Peer review can be done in different ways such as placing comments into one's work, write a feedback document or use a framework to assess the work. This last method was used. Architects from ICTU were asked if there was a framework to evaluate each other's work was available. Some architects did not use a framework at all and a framework was being developed to realize NORA reviews. However, the new framework was still under construction and was not deemed adequate. The reasons for this were that they used the 5-layer model of ICTU which was not used in this research and it did not use the evaluation points that were deemed useful in the literature review.

To obtain the right set of questions informal conversations at ICTU, the literature review and input from Zo-Dichtbij papers was used. The solution architecture will be added as an example of a public/private solution architecture. The questions about the solution architecture allow a check of the quality of the current design and inform the researcher about the NORA is applied. The questionnaire is fully electronic and is in the format of google forms. The entire questionnaire is found in appendix VI.A.

The main evaluation criteria used were taken from the literature review and based on the expectations stated in the project start architecture the Zo-Dichtbij members had about the reference architecture which was used during the solution architecture design. The criteria used were: Completeness, consistency, interoperability, flexibility, security, scalability, robustness and according to the functional requirements. The evaluation questions were based on these seven points.

A limitation is that the solution architecture document is large. It counted 77 pages including appendices. The size of the document is very limiting in two ways. Most of the people invited to fill in the questionnaire are very busy themselves and it makes it harder to answer the question when done in a limited time. To assist the volunteers, some of the questions guided the volunteer in stating where to look.

Another limitation is that for this thesis the solution architecture is written in English. While this isn't expected to be a major difficulty, however, all the architects are Dutch and are used to the Dutch semantics concerning architectural language. Therefore, the questionnaire is written in Dutch to increase the clarity of the questions. A sample question is shown in figure 6.

In what capacity is the semantics, the syntax description, clear and understandable? *

You can find this in section 5.3 - Information needs and semantics.

Your answer

Figure 6: A sample question showing the guiding description

All the questions are open questions and allow the architect to write a paragraph of text to explain their answer or opinion. The red asterisk seen in Figure 6 means that the question is mandatory. The two main parts of the questionnaire are explained below.

5.6.1 - Solution architecture

The main question underlying the questions about the solution architecture was: "Are you building the right thing?". This question needs to be answered to make sure that the solution architecture is complete and consistent. This is to found out if the quality of the design has any major impacts on the application of the NORA. The thought here is that if the solution architecture is inadequate, the results on the application of the reference architecture might also be jeopardized. Two questions from this section are shown in Figure 7.

What is your first impression of the solution architecture? *

This is about the architecture as a whole.

Long-answer text

Do you miss anything in the architecture views given the provided limitations? *

Long-answer text

Figure 7: Two examples from the questionnaire specifically about the solution architecture, about the evaluation point completeness.

5.6.2 - The NORA

This section of the questionnaire asks specifically about the application and use of the NORA in the solution architecture. This series of questions need to answer the following question: "Are you building it right?". This can also be called verification. The design will be built in accordance with a reference architecture. The reference architecture guides the architect and specifies how things must be built and what should be used. A selection of questions is shown in Figure 8. These questions show the three main components of the NORA: The principles, the national building blocks and the standards.

Are their any NORA-principles that are not applicable in this solution architecture? *

The NORA-principles are applied throughout the entire document and a overview is found in appendix IV.

Long-answer text

What can you say about the usage of GDI building blocks, which the NORA prescribes, in this solution architecture? *

You can find this in Ch. 3.6 Are there any missing building blocks? This mainly concerns AP07.

Long-answer text

What is your opinion about the application of the Use-Or-Explain standards and do you miss anything? *

You can find this in appendix V.

Long-answer text

Figure 8: A selection of the questions about how the NORA is applied in the solution architecture.

5.7 - Follow up interviews

After completing the questionnaire, a week later follow up interviews were held with respondents. All the respondents of the questionnaire could fill in if they were open to this. These interviews were voluntary.

The open interviews were held for several reasons. If a respondent did not understand all or some of the questions, he/she could ask for an explanation and elaborate on the questions during the interview. A second reason was to increase the understanding of the given answers in the questionnaire. Another reason for this is because through an interview more detail can be given about the questions and answers of the questionnaire.

The questionnaire itself has also been discussed to increase clarity and the quality of the questionnaire. This is important because if a second iteration is held after the solution architecture is improved, the questionnaire must be improved as well.

The interviews were semi structured. The questions of the questionnaire were followed and discussed at random as the interview went. The summaries of the interviews can be found in appendix VIII. The questions are stated in bold with the questions following below.

Chapter 6 - The solution architecture

This chapter will elaborate on how the solution architecture was designed. First, as a prerequisite, an Archimate model was designed. This is shown in sections 6.1 and 6.2. The Archimate model depicts the entire system or Zo-Dichtbij platform and is therefore necessary before the solution architecture document can be written. The model shows which parts need to be described, the design issues and design choices. The results from the model will then be incorporated into the solution architecture document. The design of the solution architecture is shown in section 6.3.

The first part will show the input reviewed before the design was started. This includes previous research of the collaboration between Zo-Dichtbij and the Delft University of Technology and the requirements taken from the design case. The next section will elaborate on the design steps. At least two architects per iteration design have been interviewed with unstructured Interviews with the use of the Archimate design. These interview are summarized and quotes from the interview with the main conclusions of that step have been added below. The Archimate v1.8 shows the current design of the platform. This chapter will answer sub research question 4:

Sub question 4: "How is a solution architecture for the public private healthcare domain designed?"

6.1 - Introduction

To generate the research data an artefact was designed and evaluated with the use of a single design case. The artefact, the solution architecture, was designed iteratively. The role of a project architect is not so much the sole creator of an architecture but primarily a generalist which combines all the requirements and ideas from the project developers. Therefore, much groundwork for solution architecture of Zo-Dichtbij was already done by other TU Delft researchers and Zo-Dichtbij stakeholders. The design uses the old or current input by combining the previous research results and generating new data through interviews. The partners from Zo-Dichtbij are continuously involved in each step.

This leads to two methods. The Archimate design is iteratively designed as the overall system with the help of interviews. At the end of this step, the next phase, the solution architecture document will be written in a waterfall fashion. This means that an entire concept will be delivered and used for input for the evaluation. After this step, the evaluation input will be used in a new waterfall fashion therefor combining agile/scrum smaller iterative steps and larger waterfall based steps. The basis for the design, the previous input, is first shown in 5.1.1.

The main goal of the solution architecture is to get insight in how the NORA gives direction in the design and how effective it is as a reference architecture for a private organisation. Due to time constrains and limitation of architectural knowledge not all parts are fully finished. This means that suggestions are given where complications lie in the design but not how this must be done.

The solution architecture is a work in progress which means that it can be incomplete and that it will be updated in the future. The steps so far do give an insight in how a solution architecture can be designed with the use of reference architecture.

6.1.1 - Previous input

The Zo-Dichtbij research project has been running for a few years now and is the study object of Keijzer-Broers' PHD study. This study has connected the foundation of Zo-Dichtbij with developers, researchers and students. This has resulted in a number of papers and thesis' which form a solid basis for the solution architecture. As a side note: it is important to realize that this thesis is written in 2016 and most of the previous results were generated in 2015 and before. This has as a result that previous results were outdated or had to be adapted to new developments.

The work of the collaboration between Zo-Dichtbij and the TU Delft has determined many different inputs for the solution design: platform actors, the platform purpose, actor and design requirements. The results generated was mainly done through focus groups and interviews. The end results which are used as input are shown in appendix VI. (A-G).

The platform main actors were determined through the creation of persona's and cross checking this with the focus groups.

Design and user requirements - The functional requirements are foundational to the design of the platform functionalities. The requirements (appendix VI A-C) were discussed with Keijzer-Broers (**Interview 22-02-2016**). Keijzer-Broers did previous research on the functional requirements that end-users and healthcare providers expected from the Zo-Dichtbij platform. This research was done in 2015 (Keijzer-Broers, Nikayin, & de Reuver, Main requirements of a Health and Wellbeing Platform: findings from four focus group discussions, 2015). Based on new developments discussed during the interview two more requirements (functionalities) were added:

Requirement 14: Care plan; The platform shall offer a care plan that realises the diary and task management and incorporate also the sharing of medical information and connecting end-users.

Requirement 15: Information sharing; The key-stone of the platform is information sharing. Therefore, the platform shall realise a forum functionality to facilitate this and incorporate a search function and its engine.

A group of student from The Hague college found out that the market often sees the elderly as Digi-inept but that the elderly themselves think they can handle ICT (Haagse Hogeschool, 2015). The foundation Zo-Dichtbij has attracted a development partner which can partly solve this through a new functionality:

Requirements 16: "The platform shall add a matchmaking assistant application"

This matchmaking assistant can assist platform actors through an interactive chat-bot. A first concept of this chat-bot functionality is designed and tested by Van Den Houdt, E. (The effect of digital healthcare and well-being platforms on the capabilities of elderly). The application can also scroll through documents and quickly provide a number of answers. This Matchmaking application automatizes the matchmaking process between end-users and healthcare providers.

From the navigational map (appendix III) designed by Florez Atehortua, the first overview of the functionalities is composed seen in Appendix V.A (Flórez Atehortúa, 2015).

All these functionalities need to be embedded in a secure system. There has also been another student from The Hague College which has looked into the security of the Zo-Dichtbij platform. These results are taken into account when designing the solution architecture (Mohamed, 2015). The main results show that role based access control (RBAC), zoning and filtering and logging is important. The document shows an advice how to implement this.

The workshop results and a pre-structured project start architecture made by ICTU will form the basis of the Zo-Dichtbij PSA seen in figure 2. The ICTU project start architecture is modified for the current situation in 2016 and is a separate document.

6.2 - Archimate design

This section will show how the solution was developed in several iterations. The starting input as discussed in section 6.1.1 are used and continued on. The iterations are reviewed and updated using unstructured interviews with at least two architects, including ICTU and Zo-Dichtbij partners. Each iteration is illustrated in Archimate and quotes from the interviewed architects are used.

Multiple methods were used to acquire the knowledge to make this design. The result is shown in chapter 4. This was done through self-study, a literature review, reading example architecture document from ICTU and through conversations with ICTU Architects. A side note must be placed in that there was only one solution architecture example available within ICTU. Much of ICTUs work consists of design either project start architecture or software architecture documents. The self-study consisted mainly of the Archimate language, the program Archi and TOGAF as well as the ISO420-10 standard.

The knowledge required to design the system depends on the depth of the design. This solution architecture is meant to give a general overview of the system and to elaborate on the high level architecture design from the project start architecture and show a more detailed design. This means that much of the information available is gathered but not intensively expanded since this does not fit in the available time. The resulting Archimate design is still a medium level depth where all blocks within the design can be described in more detail (zoom in).

The total platform is first completed in Archimate as to make sure that all components are present and to make sure the Archimate scheme is correct. After this step the work is described in the solution architecture document with the help of the NORA. This design step generated much needed knowledge to gain insight in how to write the solution architecture document.

Section 6.2.1 describes the start of the design were all the functionalities are modelled. This was necessary to gain a good insight of the total platform and to make sure that these were the desired functions of the platform.

Section 6.2.2. shows the first iteration after section 6.2.1 and the functionalities are now combined into a full Archimate model with the different lanes above each other. Each lane depicts a chapter from the solution architecture as well as the logical build-up of the system. Each iteration has between one and three evolved models of the starting model from that iteration and again interviews were held to discuss the current results and the final model of that iteration. The Archimate models are located in the appendix and each iteration after that only discusses the changes between the former and the current Archimate model.

Overview – The final artefact is the complete solution architecture, with the limitations kept in mind considering what complete is. However, before the description of the solution in the solution architecture document, the total solution is designed in Archimate in three iteration rounds. During the first three iteration rounds interviews were held. The fourth round in section 6.2.5 shows the final Archimate model. This final change of the model was not discussed during interviews but came about through insights gained during the construction of the solution architecture document. These insights are elaborated on in section 6.2.5. After the model is deemed complete by the interviewees and the architect, a more detailed description is given in the solution architecture document.

Limitations – There are a number of limitations. First because of time constrains the design is not 100% Archimate since becoming Archimate trained or certified did not fit the time schedule. Secondly, it can be debated, as seen in the literature review, what a solution architecture consists of. The goal of this document is to expand the project start architecture in such a way that the solution architecture gives a more detailed description of the Zo-Dichtbij platform and that the design shows possible problems and to what rules and guidelines the platform must comply with. Lastly, the solution architecture document is built with the NORA which gives insight in what possible complications are for the development.

6.2.1 - Platform functionalities

The first step of the design was to create a global overview of the system functionalities based on the previous input.

The main functionalities of the platform are based on the results of the previous input from focus groups. Zo-Dichtbij developers have proposed solutions (their own products) to realise these functionalities. However, to make the solution as general as possible the actual products and names are not used in the solution architecture. This ensures more usability and makes it more resistant against changes within the developer team. Below are two examples:

- The matchmaking of the two groups of platform actors is done through the Watson functionality. The Watson functionality offer a chat bot application built on the cloud platform IBM blue mix.
- The API store, suggested by Medvision, can provide most of the applications to realise the necessary functions such as MedRecord (care plan, medical data storage), and the market place.

The main functionalities include a Matchmaking assistant (Watson), End-user functionalities and interface, Healthcare provider functionalities and interface, a medical data storage application (Med record) and an intermediary between the vault, Watson and the platform actors (end-users and healthcare providers). The results are shown in appendix V.A and the separate functionalities are described in more detail below.

General – The platform user wants to have a profile and a log in function. This has to be embedded in the interface between the users and the functionalities.

Care plan - The care plan functionality consists of 3 main functions and is globally described, so how the functionality should look is not part of this thesis. The main functions are: an agenda which contains tasks and activities of the end-user, the diary which both end-users and healthcare providers can use to keep record of observations and the storage of medical and insurance information. A care plan keeps track of all actions performed by or on a patient.

Contacts – This functionality allows platform users to add/edit contacts with other users, search for other users, a message functionality and the possibility to join events together.

Social – The platform also wants to help end-users with their social needs and therefore allow users of the platform to create events, add/edit them and to join those events.

Market place – The platform wants to facilitate matchmaking between healthcare providers and end-users. Although this happens throughout the platform, a focus is placed in this functionality on the showcase of products and services. An end-user must be able to search for a product or service, make a purchase possibly outside of the platform and place a review concerning the purchased service or product. The placement of reviews is stated as very important by end-users.

Information – The matchmaking assistant has the ability to scroll through documents and websites and search and present that information. This is done through a chat bot functionality which helps the end-user to search for certain information. Additionally, the platform provides a forum which can be used by all users of the platform.

Conclusion - These functionalities are supported through business processes, applications and technology. The figures depicting the functionalities in appendix V.A are used as a basic overview to discuss the total system. The discussions were held as unstructured interviews and are the results are summarized per design layer.

Section 6.2.2 will elaborate on the first three iteration rounds and the conclusions from the interviews. The intermediate results are round in appendix V.(B-D). After that the final result (Archimate v1.8) is displayed and discussed in section 6.2.5.

6.2.2 - First iteration

In this iteration the following people were interviewed**:** John Waser DICTU (EA1), Paul van Raaij ICTU (IA1), Peter Bergman ICTU (IA2). The summaries of these interviews and the advice they gave are stated in appendix IV.A. Based on the information of these interviews the first iteration was made. The changes and advises given by the interviewed architects are structured according to the structure of the Archimate lanes seen in appendix V.B.

The main topics during these interviews were: introduction of student and project. Approach and timeline, the figures from appendix V.A (functionalities) and appendix V.A (Archimate v1.1).

The platform functionalities were discussed on two angles. The Zo-Dichtbij partners were involved to make sure that the design adheres to the design requirements stated by Zo-Dichtbij. On the other hand, the ICTU architects assisted in a more general way by giving general advice on how to realise a functionality and design in Archimate. The architects interviewed are coded in the following manner: where EA# means External architect number # and IA# stands for Internal architect number #.

Main structure - The main advice in this iteration was to alter the mains structure of the design (IA2). A global overview that describes the entire architecture should be made. As a result, appendix V.B shows the total system in Archimate. The different lanes depict a part of the total solution and should be read in a linear fashion starting at the top. Additionally, a selection was made from the different type of relational arrows used in Archimate as to make sure that the figures do not become too complex (IA2). This hangs tightly together with the interrelation the different lanes have with each other. The total Archimate scheme should be read as a story starting from the top and reading down to the end. This is seen in the different lanes (actor, business processes, services, applications and technology) and must show the interrelations with each other e.g. actors go make use of business processes which are

realised by services which are realized by applications which in term are realized by technology components. This should also be based upon the high level architecture from the project start document (IA2). Duplicates must also be removed if available to increase the clarity of the Archimate figures (EA1).

Actor Layer - Both IA1&2 advised a clearer description of the actors of the platform. This was then discussed with Keijzer-Broers and the following actors were defined based on the terms used in their research: group 1 end-users: informal care taker, elderly and care users. Group 2: Product and/or service providers: Informal care taker and professional caretaker.

Business process layer – The log in process as depicted in appendix V.A is changed according to the advice of IA1. There are multiple steps that an actor goes through before he/she enters the platform. Therefore, a more elaborated process is designed for an end-user and a product and/or service provider. A role based log in is suggested but how this is enforced should be thought of in the solution architecture (IA1&2) The role based access is also directly linked through authentication steps and this is taken into account (EA1).

Functionality layer – The chosen functionalities seem logical if they are based on actor demand (IA1) but the most important issue here is the storage of sensitive data. Which data is public and which is private must be determined in the solution architecture. This can be done through high security levels but also through privacy by design.

Application layer - The introduced intermediary between the platform actors, the vault and the matchmaking functionality is transformed from a person into an application which needs to be designed by a third party. The vault is a critical design issue as medical data is stored here (EA1, IA1). This is possible if the application and technology is secured according to the highest levels of security norms such as NEN7510 standards and IZO2020 (IA1&2). The two functions are also taken apart. The vault and the Watson both should have a general description and should communicate with the intermediary through interfaces (EA1).

Technology layer – Nothing in this round.

All these comments have resulted in the Archimate 1.2 and 1.3 figure seen in appendix VI.B.

6.2.3 - Second iteration

In this iteration the following people were interviewed: Arno Schots Oracle (EA2), Peter Bergman ICTU (IA3) and Jan-Marc Verlinden MedVison (EA3).

The main topics during these interviews were: discussing the progress, appendix VI.B (Archimate schemes 1.2 and 1.3).

Main structure – Nothing new in this round. Two advices were given though: Look at NEN 75010-11-11 and NEN13606 standards as well as the use of REST based architecture which increases flexibility and interoperability because it provided an open platform (EA3). Another general comment form the interviewees was that the Archimate scheme must be clear and understandable (EA2, IA3). IA3 pointed to missing connections/interrelations between blocks which must be resolved.

Actor layer – The developers of the project are to be included so that a clear overview is given of all the current actors, not just platform users (EA2). It must be described how users access a certain part of the platform, this can be done through zoning or filtering of the available applications. This is added in the business process layer (EA2)

Business process layer – there must be a user agreement which states what the rights and obligations of each user are. Next to that a contract should be made between care users, healthcare providers and the platform stating what the services are provided and what rights each user has. This is made obligatory through the BIG law. This coincides with the obligation of users of the platform to authenticate themselves. This is done through IAA: Identification, authentication and authorisation (EA2&3). This is shown in the application layer but a business process is necessary to enables this (EA2). The business process layer is extended with an elaboration on how users of the platform determine their needs and what functionalities they want (EA2, IA3). The business process block: Identify needed ZD services is expanded for more detail (IA3).

Functionality layer – It must be made clear in the solution architecture that the main process of the platform is the matchmaking of end-users and product and/or service providers, but that this is done through different functionalities. These functionalities as included in the design shows how the matchmaking in that particular section is presented. Based on the other recommendations of EA2 and EA3, IA3 suggested that a functionality must be available in the care plan which provides the consumers the possibility to view what information is collected stored by whom, viewed by whom and used by whom. Another change stated by IA3 is that the functionalities are now presented as business processes but they should be applications. Business processes transform input to output which is not happening in these functionalities. Therefore, they must be changed (IA3).

Application layer –The main change in the application layer was the addition of the API store (EA3, IA3). The API store is the solution provided possibly by a third user party which can provide the basis for all functionalities. The API store provides a platform on which functionalities can be designed.
The financial application function was discussed as it was new (EA2&3). In the end it was recommended by Zo-Dichtbij to include the financial section as it was a future need, this was acknowledged through an interview with Keijzer-broers as advised by (IA3). All solution provided by possible new or current developers must be stated differently to keep the architecture general (EA3) this means transforming Watson->Matchmaking assistant and Medsafe->Vault-> Care plan with Security Storage Medical Data,

Technology layer – The technology layer is made more general and shall not be expanded more because of the limitations in knowledge and expertise. This section will need to be expanded in a later stadium or provided by solution of third parties (EA2, IA3).

All these comments have resulted in the Archimate 1.4, 1.5, 1.6 figure seen in appendix VI.C.

6.2.4 - Third iteration

Interview with Peter Bergman ICTU (IA4), Arno Schots Oracle (EA4) and Jan-Marc Verlinden (EA5).

The main topics during these interviews were: discussing the progress, appendix VI.C (Archimate schemes 1.4, 1.5 and 1.6).

Main structure – The business processes for end-users and products and/or service providers should be placed next to each other for more clarity (IA4). The functionality (business) layer has been transformed into a (application) front-end layer (EA4, EA5, IA4). Another change is the addition of the business overview layer which presents all the supportive management functions (IA4). Components which have more than one connection should have a different relational line (IA4). The wording of the functions and processes should be changed according to: (Function: noun, Process: verb) (IA4).

Actor layer – Check if all platform users are presented and named correctly (IA4). Take into account that care providers are also users of the platform for the solution architecture (IA4). Check the connections of the users and the processes they access (IA4). The role of the actor must be determined in the Pre-access steps process (EA4). The needs of the actors need to be reflected in the business processes, so they are described in more detail in the solution architecture. EA4 determined that another actor should be added for purely social needs. This is not included in such a way because this is solved by giving an end-user (informal care taker, elderly or care-user) a certain role which can just access the social/events functionality (EA4).

Business overview layer - Another layer that was missing is the governance layer here named platform management. This is critical to describe because these processes needed to be included in the solution architecture document and provide the basis for the platform to function (IA4). The name was changed to business governance instead of business overview for clarity (IA4, EA4).

Business process layer – The role based access needs to be accessed by a process in the business layer and in the application layer (IA4, EA4)**.** Since the role of the platform actor is determined through the Pre-access steps process, the starting process should be the same (EA4). Remove duplicate blocks.

Application front end layer – A security check has to be added that is being enabled by the IAA in the back end and which enables the role based access process in the business layer (EA4, EA5)

Application back end layer – Federated identification function was added to the role based log in function to make sure that the user can log in at applications using the same log in data. API store was filled with the necessary applications needed to realize the front end functionalities.

Technology layer – Technology layer should be simplified even more (IA4, EA4). Use third parties to fill this layer (EA5).

EA4, EA5 and IA4 determined that the Archimate figure was consistent (IA4), generic (EA5), clear (EA4, IA4) and complete (EA4, EA5, IA4). During the writing of the solution architecture however, some new insights were gained and the Archimate designs were changed from 1.6 to 1.8, where 1.8 is the final schematic.

All these comments have resulted in the Archimate 1.7 and 1.8 figure seen in appendix VI.D.

6.2.5 - Final iteration

After the first three rounds the solution architecture document is written. This writing resulted in several additional changes to the Archimate v1.6 design because of new insights. The end result is shown in Figure 9. In this round no more interviews were held and the Archimate designs were only changed through new insights during the writing of the solution architecture document.

Main structure – Several connections between the API store and business processes were missing and added.

Actor layer – No changes.

Business governance – The platform governance function is changed to platform management which combines all the previous blocks in this layer. This is to make it more consistent and clear what falls under platform management. Some functions were changed in name and missing functions were added.

Business process layer – One big changed also stated by EA4 and IA4 is that the platform actors' role is only determined after registration. This means that both groups of platform users register and only then become an end-user or a product and/or service provider with the according roles. The role based access function was in the wrong order, it only was used after accessing the platform interface. The role based access process should always come for the platform interface and be continually be check through the security front end application and the Role based log in back end application.

Application back end layer – No changes.

Technology layer – No changes.

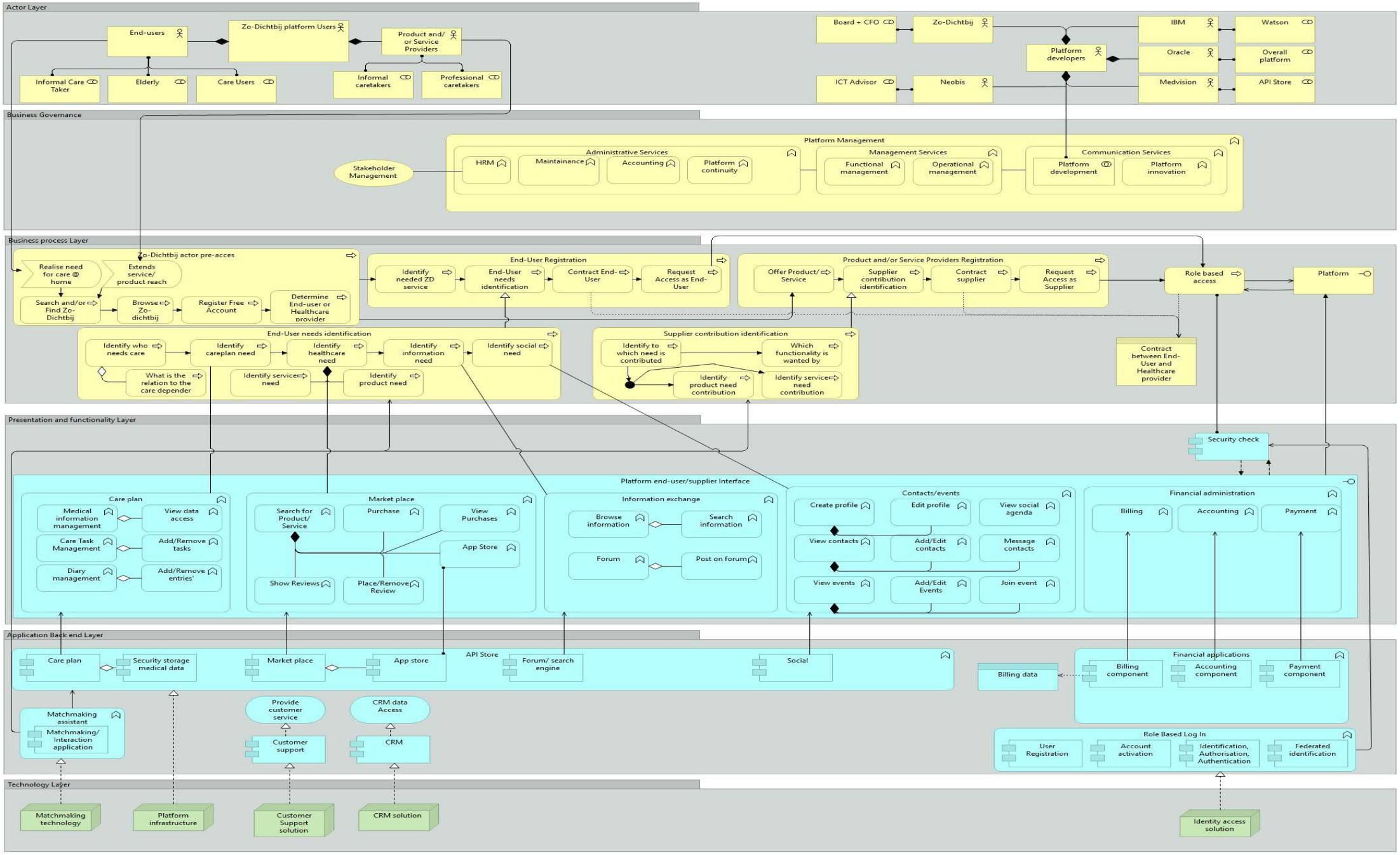

Figure 9: Archimate v1.8 final.

Figure 9 depicts the end result of the platform designed with Archimate. Section 6.2 elaborated on all the steps and choices which were made together with many architects from ICTU and Zo-Dichtbij. Figure 9 is read as follows: Top to bottom and left to right. Starting out with the users of the platform which are clients (patients and product/service providers) and developers. These actors enter the system through the business processes which are overseen by the management processes. When a contract is concluded each actor can access the functionalities based on their contract. These functionalities are supported and provided by the back-end applications and the technology behind those.

The reasoning for all the changes is thus collected in section 6.2 and in the appendices which show the summaries of the interviews. An overview is given as well in figure 10, which shows a summarized figure of the total ArchiMate design.

6.3 - The solution architecture document

The Archimate v1.8 design presented in Figure 9 is used as a guide throughout the whole document. As the blocks used in the Archimate design do not explain what they are, what they should do, only if it is an actor, process, function, application or a piece of technology. This explanation is given in the solution architecture document. The document can be fully read as a side document and is 77 pages long; this is not added in the appendix. An overview is given below of the most important aspects of the solution architecture and is done according to the evaluation criteria used in chapter 7, so that the discussion in chapter 7 is understood without reading the entire document.

It must be noted that the solution architecture document is never a static work and should be evolve and adapted along the changes in the project. This document then gives a general description of the system and through evaluation and feedback from peers the design can be adapted.

6.3.1 - Introduction

To design the system and write the solution architecture document a reference architecture was used. The foundation Zo-Dichtbij wants to match end-users and product and/or service providers with each other. This means that private and public organisations are involved. The foundation Zo-Dichtbij is a private organisation and wants to exchange information, collaborate and possible use public organisations. This means that a certain level of interoperability is needed. As explained in the introduction there a several reference architectures for private organisations and just one governmental: The NORA. Therefore, to increase the interoperability of a private organisation the application of the NORA is suggested to help. To research this, the NORA has been used as a guide while writing the design.

6.3.2 - General description

This section will give a general description of the entire solution architecture. For more in-depth information, the solution architecture is added as a separate document because of the length. A main difference between this thesis and the solution architecture document is the type of language used. This thesis is written using scientific language and writing style, much different from the solution architecture which is written in a more general style which applies to a broader type of public since the audience of the document are architects, general and software developers. The project start architecture is written for an even broader audience since the project start architecture is also written for policy makers and managers.

Chapter 1 describe the context of the problem to which the design should be a solution for. This is the practical problem presented in chapter 1.1 of this thesis. This is done according to the DESTEP method (Muilwijk, 2014). Immediately after this, in chapter 2 the current situation is described which is the minimum viable product in the living labs in Rotterdam. This chapter ends with a simplified overview of the total solution architecture. This is an intermediate between the high level architecture from appendix III.F and Figure 9.

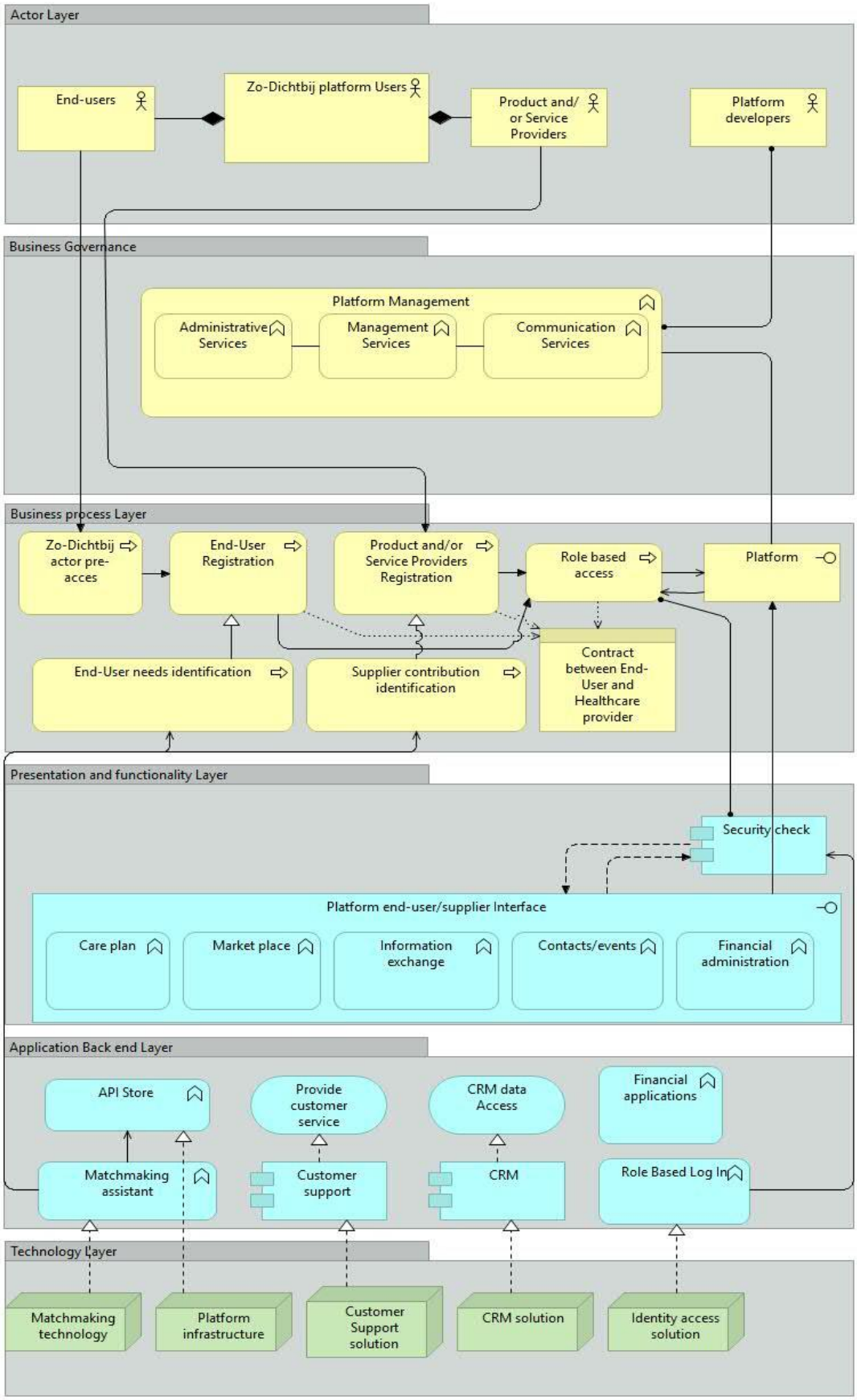

Figure 10: A medium level architecture of the total solution for simplicity used in the solution architecture

Figure 10 shows the linkage between the layers that are described in the solution architecture. Chapter three shows the design restriction, the general borders of the system. These include the functional requirements, non-functional requirements, Dutch laws and regulations and domain specific guidelines, the NORA. The functional requirements are already stated in this thesis as previous input in chapter 6.1.1. The non-functional requirements should be selected through a workshop session with the Zo-Dichtbij developers. A document provided by NICTIZ provides with insights in which laws (BIG) and guidelines (NEN-standards) are needed for the further development of the system (NICTIZ, Wet- en regelgeving zorg, 2013). The applicable laws and guidelines for Zo-Dichtbij are selected and shortly explained. Not all immediate implications are elaborated on since that is the work of a developers and much resides in the technology domain.

This chapter together with the Archimate model provides the basis for the rest of the solution architecture. Many of the design choices are depicted in the Archimate model and described in the text and must then be adopted and expanded in more detail by applying the NORA.

To be completely compliant to the NORA, a definition of compliant must be given. Compliant is defined as *"meeting or in accordance with rules or standards."* The NORA consists of principles (rules), building block (GDI) and standards (explain or use). This means that in order to be NORA compliant an architect must apply the three parts in its entirety.

The goal for this research was to find out how effective Dutch governmental reference architectures are for private organisations. To do this the forty principles are applied. The results of this are shown in appendix VII. An example is given in Figure 11.

AP07	Use the national building blocks (The service uses the nationwide building blocks of e-Government)	This involves building blocks designed for government organizations or for communication with government organizations. http://www.noraonline.nl/wiki/Bouwstenen. Most of the building blocks are not available for private organisations and is therefore not applicable. When new developments arrive which couples the government building blocks to private ones, this might come into relevance again.	1

Figure 11: An example of the NORA Results based on 2015 (Red) and 2016 (Blue).

Figure 11 shows what the previous thought was about the (AP=derivative principle) AP07. The whole table show likewise results in the following order: AP #, Name of the principle with a hyperlink to the Noraonline web depository, a short explanation, the 2015 result, the 2016 (this thesis) result and the estimated relevance of the principle according to Zo-Dichtbij.

The building blocks needed were selected on basis of the Zo-Dichtbij functionalities and through the web functionality http://beslisboom.othersight.nl/ but as of 23/06/2016 it is out of use. The website asked questions and on basis of the results provided a list of potential governmental building blocks and standards. One of the questions was about being a private or public organisation so this website was deemed suitable. The web functionality was still in beta version so the list of standards and building blocks was also studied manually at: Openstandards. A selection was made and a small review was held to see which ones were applicable to the architecture and if they were usable.

The rest of the solution architecture consists of Chapter 4: Business architecture which describe the Archimate lane 1-3. Chapter 5: Information and functionality which describes Archimate lane 4-5 and chapter 6: Technology gives a small description of lane 6. Each chapter describes the blocks used in the Archimate design: what is it, what should it do and to what is it connected. In those same chapters there are also specific NORA principles applied and it is shown possible consequences of those principles, an example is shown in Figure 12.

5.1.1 - NORA Principles

- **Standardisation and reuse/recycling of building blocks** (AP01, AP06, AP07, AP08, AP24)

  The level of effectiveness and efficiency of the solution are stimulated by good and thoughtful recycling and reuse of existing building blocks and use of standards.

  - Open standards:
  - The use of open standards is an absolute criterion for success since the platform of Zo-Dichtbij is a nexus in the service chain. The use of accessible and open standards is necessary for chain- and network parties to connect easily to the platform and vice versa.

  Consequence: Possible useable standards need to be inventoried especially in the areas of the chain- and network parties (healthcare and wellbeing)[2].

  - Provide reusable interfaces

  Next to the standards which should be provided also the interfaces should be easy to connect to and useable.

  Consequence: Design and describe the API store as general as possible and make the usability very high. Join the national service register.

  - Efficient reuse of functional building blocks

  Reuse should be considered when general functionalities are already taken care of with common and available building blocks. This should not interfere with the offer of a competitive advantage. Possible examples are: Reuse of marketplace software adapted to the style of Zo-Dichtbij (design skin). Possible governmental building blocks are DigiD, message box (Berichtenbox) and My government (MijnOverheid).

  Consequence: Inventory the reusable building blocks.

Figure 12: An example of the NORA principles applied in each chapter

Figure 12 shows what possible consequences a series of principles can have. In this example a number of principles are grouped together and show a common theme of open standards and building blocks.

6.3.3 - Information needs and semantics

The interoperability of an ICT system is partly reliant on two or more systems exchange information. This can be modelled through information and data models. No data models were made because the data models are part of the chapter technology. However, two information type models were made.

The first model is an information flow model. The program Archi is used to model what process or platform actor stores or uses or stores information. *The Archimate language is used to depict the flows but it is not according to the Archimate rules.* The model is shown in Figure 13.

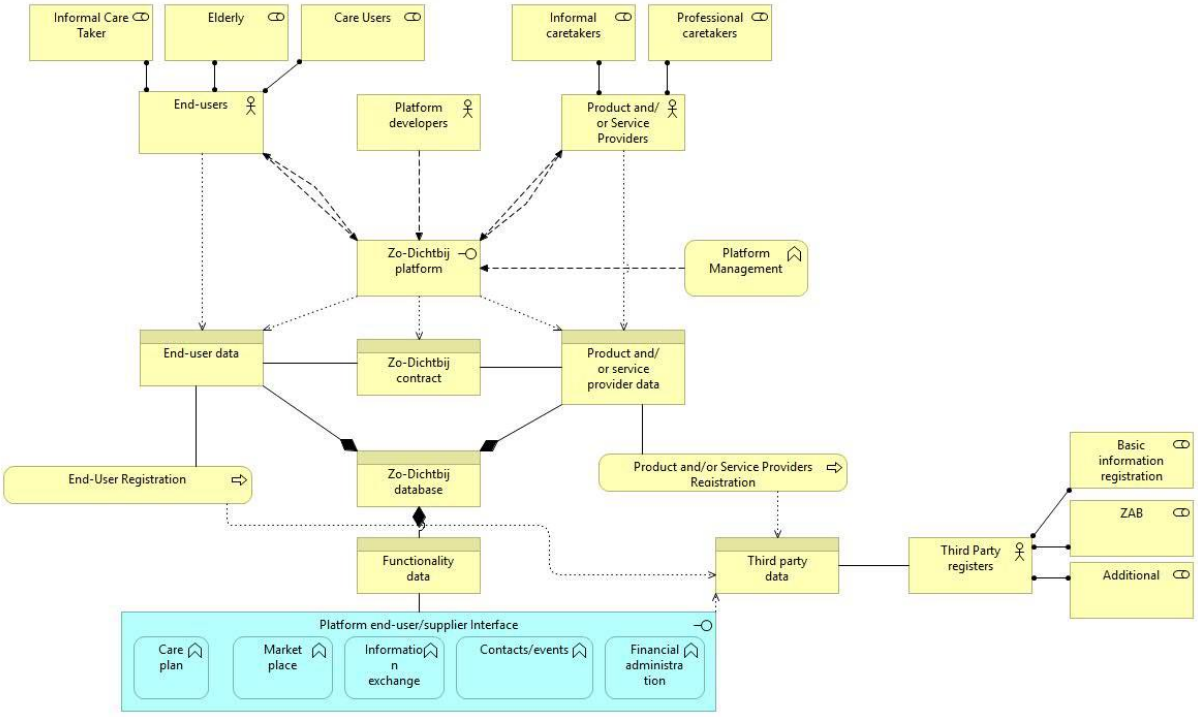

Figure 13: The information flow model

This model is not taken from the literature (TOGAF-9.1, 2011) or methodology but devised on own accord to show what the information objects in the system were. This is however not something new however information flow models are made for many different subjects, such as software architecture (Moonen, 2016).

From the information flow model, Figure 13, a number of information objects are defined. Information objects are defined as: "*An Information Object is a set of attributes defining the semantics of a data object. An IO may refer to a piece of music, a film or a webpage. Can be static, dynamic or real-world objects, including streams and services"* (Ohlman, 2009). From these information objects a semantic model is devised, shown in Figure 14.

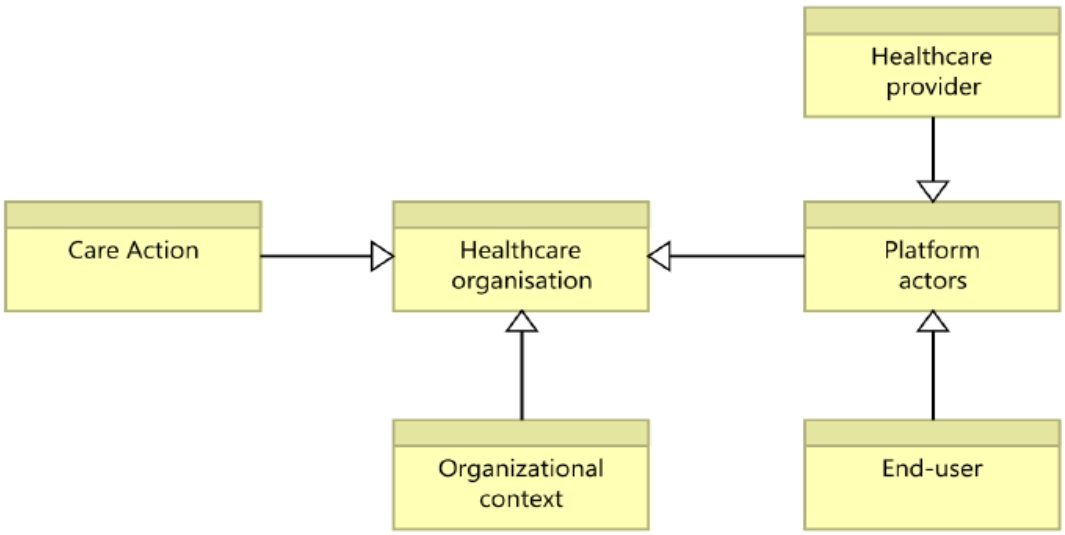

Figure 14: The semantic model

The semantic model defines how the information stored or used throughout the platform is named. When two systems exchange information, that information needs to have the same syntax or name.

To increase this in The Netherlands there is the National Semantic Plane which is: "*the set of all the concepts that are relevant to the Dutch services and information management from the government, with their definition, relationships and the context in which they are used.*" This can be seen as a dictionary which states how public organisations name their information or data. The national semantic plane is also governed by the NORA.

The national semantic plane redirects to the dictionaries for the Dutch Healthcare, but since this is an English thesis with an English solution architecture it is difficult to align the Dutch and English words. However, when the Dutch words are translated directly to English and vice versa it amounts to the same definition.

6.2.4 - Security

Chapter 7 in the solution architecture describes the security advice.

The security level in terms of availability, integrity and confidentiality of the information of the digital healthcare Zo-Dichtbij platform is partly determined by the privacy legislation and partly by the level of ambition of the organization. The reliability requirements of a digital platform that stores medical data and processes are high and the platform must abide to privacy guidelines. Another important requirement is that the integrity and confidentiality of information on the platform is ensured by a strict procedure.

The process for identification, authentication and authorization cannot be assigned to one official. Logs of ICT systems must be stored in a separate IT environment for audits and fraud investigation. A management process must be adapted in order to show that the data carried on information is secured in a structured way. The process for risk management such as risk identification, mitigation and acceptance is integrated within normal operations. The organization must have policies for privacy and information security, and the information security must be structurally tested by external auditors. The management accepts that within her role she is ultimately responsible for the information security process and in as such, informed through reports on the state of affairs.

The main findings and recommendations for the solution architecture at this point in the development is to determine the security needs through Stork levels and by performing a privacy impact assessment (PIA).

6.3.5 - Conclusion

The entire solution architecture document is very large and was designed as a separate document next to this thesis just as the project start architecture. The main parts of the suction architecture which are also touched upon in the evaluation of the artefact were described.

Chapter 7 - Evaluation and discussion

This chapter shows the evaluation results of the solution architecture. A questionnaire consisting of open questions is used to evaluate the solution architecture. After receiving 6 filled questionnaires, two additional follow up interview were held. The results of both are shown in section 7.2 and 7.3.

This chapter reflects on the design process by using the evaluation Q&A to guide it and the two follow up interviews held after the questionnaire. This will be done in two parts: 1. Discussion of the solution architecture, 2. Discuss the NORA and its effectiveness in this private design. this chapter will answer sub question 5:

Sub question 5: "What parts of the NORA can be used by private organisations and does using the NORA makes connecting to public organisations easier?"

7.1 - Introduction

The evaluation of the design was done in 4 ways, namely:

1. Evaluation using the project start architecture as a baseline document to which the solution architecture must comply.
2. Evaluation of the iteration steps in design through interviews and feedback sessions together with private architects that collaborate with Zo-Dichtbij such as Medvision, Neobis and Oracle and together with public architects such internal Architects from ICTU.
3. A questionnaire based evaluation after completion of the Archimate model and the solution architecture document
4. Follow up interviews with 2 architects after the questionnaire.

Part 1 was realized by evaluating the project start architecture from 2015 and updating it to the context of 2016. The project start architecture is then processed into the solution architecture. This is mainly seen in the context description and in the 2015 results of the NORA workshop seen in red in appendix VII.

Part 2 consisted of interviews with ICTU architects at the ICTU office. Interviews were unstructured accept for the Archimate model v1.X which was discussed. A number of external architects were also interviewed. This was done for two reasons: 1. To make sure that the solution was in line with the demands and requirements of Zo-Dichtbij and 2. To evaluate the current design and resolve any design issues at that point in time. Again only using an Archimate model v1.X (.1-.6) at the time.

Part 3 consisted of the evaluation of the Archimate model and the solution architecture. The questions were based on evaluation criteria found during the literature view and on documentation from Zo-Dichtbij (Keijzer-Broers, Nikayin, & de Reuver, Main requirements of a Health and Wellbeing Platform: findings from four focus group discussions, 2015). The questions and the evaluation criteria can be found in VI.A and VI.B.

Part 4 consisted of two semi-structured interviews with architects that filled in the questionnaire to allow them the possibility to elaborate on the answers given, fill in questions they skipped for a reason and to ask additional questions that came up after the questionnaire were viewed by the researcher.

The questionnaire was send to 18 persons which included private domain architecture and public domain architects. 6 persons filled in the questionnaire either completely or partially leading to a response rate of 33.33%. Two of those also send substantive feedback in a separate document. Two architects were also interviewed as a follow up on their results and to discuss the results with them in a free non-structured setting.

7.2 - Part I: Solution architecture

The solution architecture was evaluated to see what the quality of the work was and what possible points of improvement were. Additionally, the quality of the work was determined to see if this might have an effect on how applicable the NORA is. 7.2.1 - Introduction

The first section of the questionnaire was about the identification of the so that some background information was available. The results are shown in table 5.

Table 5: Coding of architects

Code	A1	A2	A3	A4	A5	A6
Name	Anonymous	Steven Gort	Jeroen Neerincx	Menno Gmelig Meijling	Paul van Raaij	Michiel Dirriwachter
Job title	Business/Enterprise Architect	Data whisperer	Business architect	Business ICT architect	Architect Adviser	Policy maker Information security
Area of expertise	More business than technical	Autodidact	Government	Generic, especially business and functional architecture, link with change management	Architect	Information security architect
Public or private?	Public	Public	Public	Public	Public	Public
Where do you work?	ICTU	ICTU	ICTU	ICTU	ICTU	ICTU

Table 5 shows which architects have filled in the questionnaire and how they are coded for the rest of the thesis. Only A1 wanted to remain anonymous. The expertise of the 6 architects is mainly business or enterprise and no technical or software architects. All 6 were public architects as no private domain architects had responded. Additionally, the researcher of this thesis is hereafter called solution architect for the purpose of self-referring during the discussion.

A1 and A3 also obliged to a follow up interview, the summaries as well as the questions are found in appendix VIII. A3 is coded as FI1 (follow-up interview 1) and A1 as FI2. These two architects were selected because they had filled in the least amount of questions in the questionnaire, so the follow-up interviews allowed additional explanation of the questions as well as the possibility to discuss the content in more detail.

7.2.2 - Discussion

It should be mentioned first that an evaluation of a public organisation is often done through a third party. This is not possible because of on time and money. A major drawback of this analysis is that only public architects have answered the questionnaire. Reasons and explanations for this are given in 8.3 - Limitations. The questionnaire consisted of two parts. Section 7.2.2 discusses the first part of the questionnaire: solution architecture by using quotes from the architects.

The first evaluation criterion was completeness. The architects were first asked what their first impression was. Most architects stated that the design was complete but very long (A1,3,4,5,6) and only one architect thought that the document did not live up to his expectations of what a solution architecture should include.

"Seems complete, touches upon many choices in the solution and the structure seems consistent" (A4)

However, there were some negative answers or improvement points mentioned as well, this were mainly A2 and A5 which have also sent separate documents with improvement feedback. It seems that the expectations of what a solution architecture is, is quite relevant when validating this. What a solution architecture must contain was discussed with IF1, IF2 and they missed concrete decisions on design issues. IF2 stated that because of the limitations of the solution architect it seemed more like an architecture description as used in TOGAF (TOGAF-7, 1999-2011). This was touched upon in the literature review as well as there is a gap between project start architectures and software architecture documents. Somewhere in between is the solution architecture document. This was also stated by A5 *"Doesn't seem specific enough. There are many choices still open within the document."* And this is true

however, being able to make these choices is highly dependent on the expertise and knowledge of the solution architect. IF2 stated that it would take a multi-disciplinary team of architecture experts. Conversations were held beforehand and this gap in knowledge was made clear, however, their expectations of what a solution architecture must consist was still leading during the evaluation. Overall the architects were positive, considering the background of the solution architect (4/6).

A1,2 did miss the information models (Figure 13 & Figure 14). Where A1 explained during the follow up interview that he was confused since the Archimate language was not used properly and therefore did not show a proper information model (IF2). A2 however thought that the information model was of very low quality at this point in time. Another thing some architects missed was the specification of all the choices in the solution architecture. They stated that all the choices were there but not completely defined and described yet, mostly the implications were missing (A4,5).

"Architecture is choosing, showing limitations and give direction to the design. I still miss what these choices are about and what the considerations are for those choices. It seems mainly inventoried" (A4).

While this statement is true, it was provided at the beginning of the solution architecture: "*The black box description of the project start architecture is in this document 'partly' transformed to a white box description, the solution architecture. Partly means that this document does not go into the development detail and it does not contain software architecture documentation (SAD)."* This is probably not read because of the limitation of this document which is its length (77pages) and IF1, IF2 both stated that they missed this. These architects have all explained that they were pressed for time and were not aware of the time it would take to answer the questions and read the document. This was misjudged by the solution architect.

The questionnaire also contained a question to test if the architects thought that the functional requirements were sufficiently provided for in this design. This question seemed very difficult to either understand or answer. A1, A3, A4 and A5 did not answer of which 2 couldn't find the functional requirements and two architects stated that the design must progress first before this can be answered (A2, A5). However, after additional explanation, IF1 stated during the follow-up interview that solution satisfied the functional requirements.

The next evaluation criterion was consistency, to see if the structure of the solution architecture document was sufficient.

"Personally I think it is too static. Especially because of chapters such as Business Architecture, Information Architecture etc. I don't like the story flow" (A5). "Start directly with the solution. This is the core of the document, after that the explanation comes in the next chapters" (A6), "I needed to get used to the structure but when I did it looked very good" (IF1) and *"Looking at the index, all the chapters which I think are necessary are there, you even included a security chapter"* (IF2).

All architects had comments on the structure of the document. This was again due to what a specific architect expected of the solution architecture (A1, A4) but also their own preferences where seen here (A5, A6).

Following on completeness, consistency and the functional requirements, more in-depth or specific evaluation criteria were used. These were non-functional requirements: Security, interoperability, flexibility, scalability and robustness. These evaluation criteria show important design issues.

Concerning the security of the design, a general advice was given in the solution architecture and was focussed on the role based access in line with AP38, 39 and 40. There was also a selection of laws (BIG) and guidelines (NEN & ISO) which need to be incorporated when further developed. However, it seems that most of the architects expected a more detailed elaboration of the security layer:

"I miss the relation or reference to the ISO norms and the healthcare guidelines" (A3), "Personally I think that the NORA is not sufficient enough. I rather see an A&K analysis" (A5). "I rather see a separate document specifying the security architecture to make it secure by design" (A6).

The quotes above seem to give a wide range of different topics concerning the security of the solution architecture. Again this might also come from personal preferences and there is no document available that states which of these solutions must be used or addressed, so this is always up to the scrutiny of the solution architect. IF1 and IF2 stated that they missed the laws and guidelines since they did not

read the appendices. During the interviews it was determined that architects have a lot of design freedom and therefore suggest different methodologies. There is apparently also no clear consensus in the NORA. IF2 acknowledged this by stating that his misses a lot of the implications of the NORA principles and that the security section was outdated.

Following the security architecture (A6), the robustness of the design was a requirement expected from Zo-Dichtbij when using the NORA. The architects were asked to describe the robustness of the system:

"No, where have you stated the CIA rating?" (A3), "I did not read chapter 6 (security)" (A4), "I don't think the NORA is suited for this purpose" (A5).

The first two statements were based on the technical architecture which this design did not describe in detail. Secondly (A5) just applying the NORA principles does not seem enough, which is strange since the NORA includes at least three principles based on security. Since the robustness of the system find its application in the technical layer, this criterion won't be used further. However, one statement provides an advice:

"The required robustness can only be determined by the key stakeholders, mainly because of the impact on cost and manageability with increasing demands on robustness. Since it is a complex set of cooperating parties with divided responsibilities (a real collaboration chain) I see the greatest risk (in the organizational side), not so much in the technology." (A6)

This is very interesting since this was posed by the information security specialist, because this statement seems to put the problem in the agreements between the collaborating organisations and not the technical architecture. Again it is seen, that solving a problem within architecture does not have a clear method.

One of the wishes of Zo-Dichtbij was collaborating with public organisations. This is done through the use of the same principles, standards and building blocks but also the information models and semantics. Therefore, the quality of the information model and semantic model were judged.

"I miss the information and data models" (A3), "It is not clear and not unambiguously" (A4) but also "As layman in this domain it is difficult to say anything about the content, but it is understandable for me as layman" (A6), "It looked rudimentary, for the matchmaking it is fine but if the platform is going to store much information this must be expanded" (IF1) and *"Because the models are not 100% Archimate proof it is confusing if this is not" (IF2).*

These models however were discussed before these were send to the architects and were deemed clear with the given limitations. However, there is a difference between architects in how they grade or view the work because of their expectations and their own preference but also because TOGAF and Archimate were not 100% used according to the standards. The question is then asked more directly in the questionnaire: What are your expectations concerning the interoperability?

"Based on international standards" (A3), "Not good if the information architecture doesn't improve. In my opinion there are not many people who really understand what interoperability means" (A4), "If the interfaces between the components/ building blocks are standardised… the flexibility of the system can be guaranteed" (A6).

The answers here indicate that two out of three architects move of interoperability to the use of standards and only one actually tracks it back to the information architecture. A3 later elaborated *"This is mainly based on the use of building blocks and standards" (IF1)* and shows that interoperability can be affected in two ways: Information and semantic models and standards and building blocks. It seems that the complications stated by the architects will be solved if the architecture is further developed through the use of standards in the technical architecture.

Another objective of Zo-Dichtbij was scalability. The platform of Zo-Dichtbij starts out as a minimum viable product in a living lab in Rotterdam. The expectations are that if this goes well the platform could be expanded, therefore the scalability of the system is discussed. One way to increase scalability is to design separate services that can function separately through an API store.

"It is very desirable to increase the manoeuvrability. Especially because during the realisation and exploitation many new insights will rise or laws could change" (A6) but it's hard to get a clear answer

because of *"Difficult question that I cannot answer while reading it globally" (A4)* and *"I can't see how that is possible outside of the platform" (A2).*

Since this question was hard to answer, it was directly asked of IF1 and he stated that it was possible and seemed a good solution. To get a clearer answer the architects were asked if the design would make scaling to national level possible.

"If the information architecture is scalable then yes" (A4), *"I don't know, an A&K analysis can point this out"* and *"Technically this would be possible but the question is if this is manageable on this scale. Other big healthcare initiatives have failed on this account through privacy aspects and complexity"* (A6)

It seems that the information architecture is very important to describe in further detail in a later stadium during development. As well as performing an A&K analysis which is a dependencies and vulnerabilities analysis as described by Kanters (Kanters, 2016), however this would require additional time and knowledge.

Progressing on scalability, the question was posed to the architects if the privacy of the users of the platform would be secured enough:

"Section 7.1.3 – Privacy is not clear" (A3), *"Done insufficiently, missing the handling of data storage"* (A4), *"This cannot be judged with what is presented as of now. A PIA is suggested but that must be done first before continuing"* (A5) and last *"There is attention for privacy by design, risk based security measures and design, building and exploitation and a periodic independent audit, but the elaboration of this is missing"* (A6).

The limitations of the missing technology layer were noted again by these quotes. A6 stated that the groundwork was there but a more detailed explanation was missing. The privacy concerns must be investigated first through a privacy impact assessment but this has to be done by Zo-Dichtbij (IF1) and did not fit in the scope of the research, however it was recommended. The PIA was suggested many times in the sections security and privacy, which are two interrelated topics, by A5, IF1 and IF2 although the expectation was that this was an implication of one of the NORA principles, however no implications are currently stated at Noraonline.

7.2.3 - Solution Architecture Conclusion

This section discussed the design of the solution architecture according to the results of the questionnaire and the follow up interviews. The main problems of the document were the length of the document, the underestimated knowledge and expertise of the solution architect and the misunderstanding of what the solution architecture should contain and how this should be done. As this document is an advice and a progression on the project start architecture it is not a complete solution architecture and/or software architecture document, but this was never the intention of the solution architect. Still, it should be noted that more work on the document is required. A PIA was suggested multiple times as well as an A&K analysis and this would be considered the next steps in the design process during further development.

7.3 - Part II: NORA

This section discusses the use of the Dutch Governmental Reference Architecture (NORA) for the private solution architecture design of Zo-Dichtbij. This is the verification part where the question: "Am I building it right?" is answered. Is the solution architecture build according to the NORA?

7.3.1 - Introduction

The second part of the questionnaire is used to guide the discussion of the NORA as well as the two follow up interviews and the NORA table in appendix VII. The same architects have filled this in therefore the same coding is used as seen in Table 5. One observation is that this section was filled in with more detail and by more architects. This is probably because the principles are nicely summarized in a table (appendix VII) and because there is more consensus about the NORA in general. This section also used an email correspondence of one ICTU architect coded as A7.

7.3.2 - Discussion

To design the solution architecture, the NORA principles, standards and GDI building blocks were used. This section will not discuss each principle or standard separately but will focus on the main results of

the application of public reference architecture for private organisations. The questions of the questionnaire and the evaluation criteria are used to lead the discussion.

The first four questions were used to determine evaluation criterion completeness. Architects were asked to give their first impression of the application of the NORA principles in the document.

"fair to good" (A1), *"First impression is good: The NORA principles are applied with discretion"* (A3) but this is contrasted by *"Principles are not design guidelines, I would rather place them in a chapter and then discuss the relevance of them with the client. They belong more in a PSA than a SA."* (A4) and *"Personally, I think the application of the principles are to globally and high over. I would expect the direct implications and choices from those principles"* (A5).

There is a contrast between A1, A3 and A4, A5. It seems the two groups use the principles in a different way. Another explanation is their expectations of what should be included in the solution architecture. Not all the principles were applicable and many principles can be applied because they are common sense. The NORA principles are clustered but this is not always very clear and especially the interrelation of those 'similar 'principles. This is supported by: *"I find it very difficult to answer this question. I have big problems to apply and understand the NORA principles concerning their interrelationships and context."* (A5). A5 did state, in conversion, that his general opinion of the NORA was bad. During the design the application of the NORA principles often took common sense but most of the principles were helpful as the knowledge of the solution architect was little. However, some of the principles are very hard to apply because of the difference between public and private organisations. The main culprit here is that the government as main public organisation has no completion problem and it is not driven by market demands and goals as much as private organisations. This is supported by A7 which provided three conclusions on the NORA for private organisations, she stated: "1. *Based on the internal organisation some principles are 'handy' AP02: process optimisation, AP06: use standard solutions and AP10: deliver through the internet. 2. Based from a marketing perspective 'self-evident': AP04: the service is positioned clearly, AP12: information is requested only once, AP13: Source registrations are leading, AP20: Use a personal approach and AP23: The service is automated where possible. 3. Based on a competitive perspective 'inapplicable': AP01: Re-use of solutions and AP03: No overlapping services." (A7).* A3 also confirmed the commercial applications of AP02 and AP06.

To specify which NORA principles were specifically inapplicable for private organisations, this was asked directly of the architects.

"There is especially one inapplicable principle and that is AP07: use national building blocks. Other principles might be applicable but change in meaning for a private organisation" (A3) During the interview IF1 also stated that AP07 is inapplicable.

Some of the architects also stated a more general answer on which principles were inapplicable. This was also found during design and were also mentioned above. Depending on what part of the architecture is being designed different principles need to be applied. It is harder for some of the principles to determine if they are inapplicable, because of the current stadium of development. This is supported by two answers:

"Some principles must be operationalized before they get a meaning on SA level because they have a higher abstraction level" (A4) and *"This is always the case. It is up to the judgement of the architect to determine which principles are applicable"* (A5).

The next part to test the completeness criterion is the GDI part of the NORA which prescribes the building blocks for the public organisations. During design the list of building blocks was screened for usable parts and a decision three, as explained in chapter 6, was used. It seemed that no building blocks were available for private organisations. To support this finding this was informed by the architects:

"The building blocks are not usable for private organisations with the exception of the 'ondernemersplein, e-herkenning'. The only useful thing would be the web guidelines which are no actual building block" (A3), *"The GDI does not seem applicable because of the status of the foundation."* (A4) and *"These are meant for governments and I think you are discussing a private initiative."* (A5).

So it seems that the findings were correct, but to make sure that the whole NORA was used the last part has to be confirmed as well, which are the Use-Or-Explain standards. When the standards are open such as presented by the Forumstandaardisatie.nl then the private organisation can benefit from them as long as the public organisation they want to collaborate with uses them as well. However, the Use-Or-Explain standards are specifically used in public organisations such as sTuF and seem not applicable for private organisations.
"Seems well applied, but I don't believe in the use of standards" (A2), *"Many of the standards are technical and need to be reconsidered during the design of the technical architecture"* (A4) and *"the standards are as far as I can see not applied and named in the solution architecture"* (A5).

It seems that not completely reading the document might be a reason for the difference in the answers, but also again the perspective of the architect. Without designing the technical architecture, it is pretty clear which standards can or cannot be applied.

2 architects deemed the design NORA compliant, however 1 architect explained that the NORA was insufficient all around and therefore not needed and 1 architects stated *"I see the attempt to conform to the NORA but cannot say at this time if the design is actually NORA compliant, this is the Achilles heel of the NORA."* (A4). This last statement is completely in line with what expectations do when the rules and formats grant much freedom as is seen in the solution architecture design, the discussion of the solution architecture seen in the questionnaire and seen in the discussion concerning the NORA in the questionnaire.

This discussion is explained by A2 in his answer to the question: If there are any pros or cons of the NORA for private organisations that are missed so far? *"NORA is for everybody much to instrumental. I cannot find any vision or idea as to what the end goal is of the NORA, except for a slightly better operational ICT administration. The restrictions and problems are really seen in this SA, what about public-private and how do we bring that together with the NORA without distortions of the power positions and responsibilities of each party." (A2).* This statement shows the goal of what the NORA was expected to do when used in this solution architecture and while partly fulfilling these expectations there are still many gaps left open. These gaps will be explained below with the next set of evaluation criteria: Security, Interoperability, Scalability, robustness and flexibility.

The security of the system needs to have a high priority in the development and if medical data is indeed stored in the care plan than the applications that store it need to follow the highest level of security protocols. Based on an advisory document from NICTIZ (NICTIZ, Wet- en regelgeving zorg, 2013) and were noted in the appendix and throughout the document. Next to this a cluster of NORA principles also state how to provide security. The architects were asked if they thought that applying the NORA principles made the solution architecture secure enough:

"No, the question is if this part of the NORA is still up to date" (A1), *"Don't know but I think that for such a part the NORA has no added value at all"* (A2), *"No, because need to define the Stork levels and how the system is encrypted"* (A3) and *"No."* (A5).

It doesn't seem that applying the NORA principles provide enough substance or guidance to secure the system sufficiently, although how this might be resolved depends on the method of preference of the architect. The NORA does provide some principles about zoning and filtering and identification, authorisation and authentication. However, IF1 stated during the interview that AP38 zoning and filtering is outdated.

The same answer was given for the robustness of the system:

"No, you don't need the NORA for this..." (A1), *"I don't think. The NORA does not 'arrange' this because of a lack of vision"* (A2), *"Robustness is a broad term, but I think the use of standards make the system usable and adaptable*" (A3) and *"No"* (A4).

A4 had the opinion that the NORA was too high level and therefore does not arrange any detail level implications. This is seen in his answers on security and robustness. This might also be explained because of the still missing technical architecture but it seems that if the NORA does not suggest enough substance.

The absence of a complete technical architecture also provided some difficulties to answer the scalability of the platform (A4), one architect stated that the scalability, interoperability and flexibility all depended on the information and semantics model which he thought of as underdeveloped (A2). However, at least two architects thought that the use of the NORA did make the design scalable to a national level (A1, A3) and this was also acknowledged during the follow up interview (IF3). The level of interoperability could also be influenced by the use of standards (A5), so we see different solutions and different approaches. One architect even suspects that the level of flexibility could be negatively affected by using the NORA (A2).

The architects conclude by stating that being NORA compliant would not be a problem if other private organisations would want to connect to this NORA compliant platform (A1, A2, A3, A4, A5). This was however, limited if GDI building blocks or governmental standards were used. The collaboration between organisations on the Zo-Dichtbij platform should be facilitated by connection requirements in a contract. The same question was posed for public organisations and the conclusion was that the application of the NORA would not be necessary to cooperate with public organisations but it would make it easier (A2, A3, A4).

7.3.3 - NORA Conclusion

This section discussed the application of the NORA in this solution architecture according to the results of the questionnaire and the follow up interviews. While the questions were specified for this solution architecture, many answers seem to go about the NORA in general. It is possible that the architects changed their answer according to this specific design. However, the answers often stated if the feedback was meant generally or explicitly targeted at this solution architecture.

7.4 - Conclusion

The questionnaire and the interviews consisted of two parts. The first part tested the quality and progress of the solution architecture and the second part tested the effect of the NORA on the solution architecture and the NORA in general. The tensions were used together with the evaluation criteria to form questions which were discussed with architects. Of the tensions found in chapter 3 the focus lay on security and privacy in healthcare and the main tension between public and private organisations was the availability of usable data for both as seen in the data registers not usable for private organisations.

The general quality of what the solution architecture described was good and noted as containing all necessary chapters. However, while showing all the important aspects of the solution, the level of detail was expected to be higher. What was noticed after the analysis of the results was that each architect focussed on their area of expertise. whether this was because of the length of the solution architecture or because architects always do this cannot be said. It seems that the architects not always have a system overview or choose not to do so. Architects look mainly at their area of expertise and do not go into detail on the rest, therefore they miss details in their area of expertise but find the solution architecture overall too long. It seems that architects are often specialists and connected to projects which fit their specialization. This means that because this solution architecture is very general because of the expertise and knowledge of this thesis architect, which means that all parts are partly described and not very detailed in each specific part. The reason for the absence of this level of detail was put in a disclaimer in the solution architecture but this did not change how the architects graded the solution architecture or the disclaimer was not read. To assess the usability of the NORA, however, the complaints on the solution architecture did not diminish the results of section 7.3.2. This problem was noticed during discussions of other peer reviews within ICTU. Architects are assigned on basis of availability instead of a wide range of expertise to evaluate a product.

The NORA seems to function fine as a guide but does not help to design a complete detailed solution architecture. To solve this enterprise architecture and domain architecture is necessary including the needed standards and building blocks. From the main three parts of the NORA, principles, building blocks and standards, there a number of items that cannot be used by private organisations. The GDI building blocks cannot be used at all, as well as many Use-Or-Explain standards and a number of NORA principles which are government targeted or seen as outdated.

The main obstacle found during the first part was that apparently there is a disagreement to what a solution architecture is and what should be included in the document. The number of solutions/methods to solve problems is also very different from one architect to another. The big limitation was the length

of the document and the time it took for the architects to answer the questions. This reduced the number of responses.

The architects did state that the requested work took much more time than was suggested in the invitation. The questions posted the location in which the required knowledge for that question could be found to reduce the needed time. The expectation was that the architects with their knowledge and experience would go through the questions in about an hour while skimming the document, but they stated that to give a really good review they needed at least one full day.

Chapter 8 - Conclusions and recommendations

This chapter concludes this thesis and shows in section 8.1 the conclusion through the answers of the sub research questions (Ch. 1). The findings (Ch. 6 & Ch. 7) are then discussed in section 8.2 using the literature study (Ch. 2) and the domain research (Ch. 3) and show the addition to this knowledge. Section 8.3 then discusses the limitations of this research and this chapter is concluded in section 8.4 recommendations and future research.

8.1 - Conclusions

The main research question is answered using the sub research questions. The practical contribution is the designed solution architecture for the healthcare platform of Zo-Dichtbij. The designed artefact progresses the research and development surrounding the platform for the benefit of both the end-users and the product and/or service providers in the Netherlands. The scientific community benefits from the insights generated on the use of public reference architecture (Ch. 2) to solve common tensions between public and private healthcare organisations (Ch. 3). The research objective was derived from section 1.1 and 1.2:

“Design and evaluate a private domain solution architecture for a matchmaking platform based on governmental reference architecture to investigate NORA’s effectiveness in private architecture”.

It can be concluded that, based on the questionnaire answered by the respondents (Ch. 7), the solution architecture is an intermediate between the project start architecture and a complete solution architecture. However, while solution architecture was not deemed complete, the design process still generated knowledge about the use of the NORA as a public reference architecture in private domain architecture. The resulting artefact was, with the considered limitations, complete and consistent as based on the first two evaluation criteria.

The main research question was:

"**How effective is the Dutch governmental reference architecture (NORA) for private organisations that want to connect to the public domain?”**

The main research question is answered through the use of the sub research questions. The first step in this research was informing the researcher about what is necessary to design the artefact: the solution architecture:

Sub question 1: “What architectural knowledge is needed to design solution architectures?”

The results are stated in section 2.2 and the main topics discussed were project start architecture because it served as the input and starting point of the solution architecture. Enterprise architecture was discussed since many of the guidelines and frameworks come from enterprise architecture and were used as frameworks for the solution architecture. Reference architecture in general was discussed showing the differences between public and private reference architecture and a more detailed discussion on the NORA. The usefulness of the NORA is contested and no consensus is shown between different architects. The public reference architecture is mainly applied in governmental or public architecture. Therefore, literature concerning governmental architecture was also reviewed and showed that many principles of the NORA actually stem from previous research in this area such as a high level of interoperability and a one stop shop. These findings were combined in section 2.5 which described the interrelationships of the previous sections: The solution architecture should be designed with the services (functionalities) as focus point and use the concepts of TOGAF and Archimate within the design. Normally the solution architecture would also use enterprise architecture but this can also be filled by general and domain reference architecture (Luijpers, 2009).

The solution architecture was evaluated to generate data on its quality and on the use of the NORA. Therefore, the literature review was also used to inform the researcher on evaluation frameworks and criteria:

Sub question 2: “What methods are available to evaluate solution architectures and what possible evaluation criteria can be found in the literature?”

First the discrepancy between evaluation and evaluation was made (appendix I). The evaluation was split up in two sections: Evaluation and verification. This was used in the questionnaire (appendix VI) to answer two questions:" Am I building it right" and "Am I Building it correctly" (Boehm, 2010).

The next part of the literature review concluded two things: The framework to evaluate the solution architecture and the evaluation criteria. There are many different frameworks which have different uses for multiple purposes. Two applicable frameworks were discussed POSSAAM and peer review. POSSAAM was selected because it showed a proven use of pattern recognition between solution architectures made by one group of architects, however, the consistency between the ICTU products was not good enough. Therefore, the framework of peer review was suggested which uses a number of evaluation criteria which are used by multiple peers (public or private architects) to review the solution architecture.

The list of evaluation criteria consisted of criteria found in chapter 2 consisted of evaluation criteria found in practise which were general, of evaluation criteria often found in the literature which were non-functional requirements and derived from the design case. The criteria used were completeness, consistency, functional requirements, interoperability, flexibility, security, scalability and robustness. These criteria are also connected to the tensions found in chapter 3 and were used in chapter 7.

Sub question 3: "What are tensions occurring between organisations in the public/private healthcare domain?"

The healthcare tensions were healthcare standards, design requirements in healthcare, laws which need to be complied with, privacy concerns and a high level security. As well as the tensions between the public and private domain; attention must be paid to the different guidelines and regulations used by both, the effect of politics on the goals of each organisations, the availability of usable data for both, a different timeline and different concerns steered by society or the market.

The evaluation criteria and connected questions were also based on the tensions between public and private organisations. It was concluded that security and privacy are closely connected and the tensions because of security and privacy issues in the public private healthcare domain cannot be solved by just applying the NORA. This was shown through: 1. the principles concerning the security cluster are outdated and show no consensus in how to solve this. 2. The NORA is too high level and shows no implications of the applications of the principles and while many methods were stated by the architects, they were absent in the NORA documentation.

The interoperability and scalability of the system seems highly connected through the information and semantics model as well as the application of standards and building blocks. However, an implication was found as it seems that not all public organisations use the NORA and therefore it is concluded that the use of the NORA is very situational. This is also enhanced by the fact that the reference architecture is discussed with the stakeholders of the project causes that certain principles are not used at all which makes the interoperability between two organisations more difficult. IT was however stated that as a common starting point between two organisations, the use of the NORA would make collaboration between public and private organisations easier

To research the tensions and the effectiveness of the NORA an artefact must be created to research this, therefore the following sub question was devised:

Sub question 4: "How is a solution architecture for the public private healthcare domain designed?"

The methodology expanded on the more practical methods to design the solution architecture, such as ArchiMate and TOGAF, which were both used in the design. The design requirements were taken from the case study described in chapter 5 and the structure of the iterations were based on the design principles of Goldkuhl (Goldkuhl, 2010). The answer to the research question is seen in the combination of the final Archimate design, the description of the solution architecture and the results of the iterative interviews.

Many of the problems found during the design of the solution architecture stemmed from the many different formats used in architecture. During this research an absence of consensus concerning formats of public architecture was observed. This was observed because of the design freedom most public and

private architects have. Many formats and evaluation criteria are selected together with the clients or target audience and therefore using other architecture documents as examples is difficult hard.

Another finding based from the design process was which parts of the NORA were usable. Most of the Use-or-Explain standards noted in the solution architecture cannot be used in architecture. The same can be concluded for the GDI building blocks. This makes the only usable part of the NORA the design principles.

Many of the principles are high level and no implications are stated at Noraonline which is the current version of the NORA. A summary is given below and a more detailed description is found in appendix VII. A number of principles cannot be used because of the competitive market nature of private organisations: Services are re-usable, Services complement each other, Use standard solutions, bundling of services, General perspective: Use the national building blocks, additional channel and similar results regards less of channel. It also seems that applying these principles on a high level do not solve the tensions mentioned in chapter 3. This is because they are solved on a higher detail level through a number of different methods such as privacy by design, privacy impact assessments and the use of standards (solutions) and GDI building blocks which cannot be used by private initiatives.

To find out if the conclusions derived from the design process were acknowledged by other architects, the work was evaluated by six public architects. This was done through sub question 5:

Sub question 5: "What parts of the NORA can be used by private organisations and does using the NORA makes connecting to public organisations easier?"

The NORA seems to be more helpful for an architect with less practical knowledge and expertise then it seems helpful for senior architects. This is concluded from my own design process and is acknowledged by the questionnaire. When no previous experience is available a new architect needs to go through the entire NORA, as compared to a senior architect which has his/her own principles through experience, knows which principles are necessary and will discuss important NORA principles with the clients. It was also stated that not all public organisations use the NORA because of their own experiences, time limitations and document length constrains.

The NORA is a high level abstract reference architecture and does not predict or suggest possible implications when applied, this is known through experience but is not yet collected and presented in Noraonline. The absence of implications ensured that a many different approaches can be used which are not documented by the NORA such as CIA ratings, A&K analysis and formatting.

Most of the principles seem to be common sense as stated by the architects in the questionnaire and the follow up interviews. The respondents of the questionnaire and the follow-up interviews reached the same conclusions regarding the inapplicability of some principles for private organisations. It was also found during the interviews that not each architects views the NORA objectively, which results in a reduced use. It might also be the case that the principles must first be applied before anything can be said about possible implications, which means that in-depth knowledge of the NORA has to be acquired before application.

The reference architecture does provide a list of governmental building blocks and standards which give a good insight in how governmental architecture is designed, but most of those cannot be used by private organisations. From these observations it can be concluded that the NORA in its totality is not yet ready to be adopted or used by private organisations. The NORA does not solve most of the tensions between public and private organisations because this is done on a more detailed level using different methods.

The reflection on the iterative design process together with the evaluation of the solution architecture and its applied reference architecture will answer the main research question:

"**How effective is the Dutch governmental reference architecture (NORA) for private organisations that want to connect to the public domain?"**

The main findings during the design were that to solve the tensions between the public and private healthcare domain an emphasis must be placed on security, robustness, the information models and semantics and the use of building blocks and open standards. At this point in time it is also concluded that, based on the design process and the questionnaire together with the follow-up interviews, to solve

the tensions generated through security and robustness, the technology layer of the solution architecture must be further developed and a selection of standards usable by public and private organisations musts be made. The tensions which arise from the high security level and privacy protection were also named and acknowledged by the interviewed architects and in the questionnaire in chapter 7. The effectiveness of the NORA is not that high in this area since there are no explicit recommendations in this area and currently no implications are shown for each principle connected to the tensions.

For many tensions such as security, privacy and scalability placed upon the design because of the healthcare domain that the NORA is a good starting point to solve them. But it seems that this is mainly done through the use of detailed solutions through the use of open standards and security protocols in the technical architecture which the NORA does not provide. Many of the problems were also used as evaluation criteria (security, privacy) but the methods suggested by architects were very different from each other which suggests that the NORA is either not consistent in this or gives total freedom on how to solve these problems. The architects also gave several different answers on how to solve these issues which points at a uniformity problem. It is hard to say at this point if this is a problem or not since the researcher is not familiar with the named techniques, if they are different and if the use of different techniques or methods between architects causes problems. It is however a limitation on the uniformity of reviews.

However, on an organisational level the NORA seems to provide a solid basis for public private architecture as many principles are applicable on a high abstract level and show how to organise the basic structure of a solution architecture. The NORA also results in a common language which public and private architects can use to communicate with each other. This makes collaboration between them easier (IF1 and IF2). To resolve a number of the tensions between public and private organisations, attention must be paid to the different guidelines and regulations used by both (AP08 open standards), the effect of politics on the goals of each organisations (, the availability of usable data for both (AP16, AP17, information model), a different timeline and different concerns steered by society or the market.

The effectiveness is not graded or tested on a scale but it can be said that in a qualitative way the NORA is not yet at its peak effectiveness. This is because of the large gap between the public and private world.

8.2 - Scientific contribution

This research adds to the research done in the field of using governmental reference architecture to solve tensions between the public and private healthcare domain. Solving tensions between public and private healthcare organisations require experience and practical knowledge. This was assumed to derive from the NORA. Solving is defined here as proposing a solution for a problem, if this was not possible because e.g. lacking technical expertise only a start was made. This means that the NORA is not that easy to use in science unless a proper understanding is generated. A guide would be helpful to speed up the learning process.

This research shows gaps in the NORA, concerning the use of the NORA to solve tensions for public/private organisations. The NORA does prescribe a number of ways to solve these tensions, however, they are not specific enough, lack practical examples and the proposed solutions are focussed on public organisations and not for private organisations. It is true that this is not the purpose of the NORA but if is it adapted and expended for private and public/private organisations it would have a much larger reach. This was confirmed by the interviewed architects which proposed different solutions outside of the NORA. Private organisations have different rules and regulations to which they need to adhere to and the NORA does not take these regulations into account. There are overlaps such as regulations for data protection of citizens, but the NORA could give recommendations on what laws and regulations apply to both organisations (public and private). The availability of data is also a limitation because the NORA recommends the use of the public databases such as BPR (basic person registration) which is not or under strict conditions usable for private organisations. This means that the NORA needs to show the implications of the principles, standards and building blocks

The area of public and private architecture is not new neither is the research on the collaboration between the two but the use of public reference architecture to design private architecture and possibly resolve the tensions between them is novel. Up to now the main focus was to solve these tensions through public private partnerships and how e-government can use the ideas of the private domain (Bonina & Cordella, 2010). As stated the amount of empirical knowledge done in the public private domain is little as stated by Van Den Boer (Van den Boer, 2011) and this research can progress this

area. Klievink (2015) stated that the right incentives to co-develop, standardize data definitions and system-interfaces might resolve tensions between public and private organisations and I propose based on the finding that the common language that the NORA provides, might solve those (Klievink, 2015).

It seems that this area is novel and that the NORA is not ready to be used efficiently for private organisations that want to collaborate with public organisations. There are gaps between the requirements in private architecture and public architecture and the provided guidelines and recommendations from the NORA. As of now it is not clearly stated what in the NORA is only available to public organizations. Additionally, as stated in 8.1, there are a number of principles that are not usable by private organizations and the NORA alone is not enough to solve the mentioned tensions or completely develop the public/private solution architecture especially for new/inexperienced architects. This is because the gaps are less noticed because senior architects can fill them in using the NORA on the side instead of as the main guide. This means that it generally takes a lot of time to use the NORA and to fully understand it takes time as well as it takes time to explain to the recipients of the solution architecture what of the NORA is used, what that means and why certain parts were skipped. This makes the use of the NORA a big investment for private organizations and does not incentivise the use. To make this investment worthwhile and thus effective the NORA needs to be adapted and improved for public/private organizations.

Currently, it is not necessary to use the NORA in private and even some public organisations which leaves much room for improvement and new research. This is concluded based on the questionnaires and the follow-up interviews. It appears that not all public architects want or feel the need to use the NORA as it is not enforced upon the Dutch government. There are also parts in the NORA governmental building blocks such as infrastructure that are just too expensive to use as a small public organisation of which ICTU itself is an example. If the NORA would be enforced to the government as a whole in which the larger organisations help pay for the smaller organisations it would make a big impact within the government and would be a great example for private organisations.

To start the NORA should not adopt completely to private organisations since that is not what the NORA originally was for. A different reference architecture specifically for public/private organisations might be more worthwhile. The NORA should not be made obligatory for private organisations that want to collaborate with public organisations but the same organisations should be made more aware that the use of the NORA makes collaboration easier. The NORA should make the clear what is specifically for public organisations and what parts can be used by both. This reduces the time necessary to understand the NORA. This should also be constantly updated by the architects which use the NORA, additionally the reviews done on architecture which has used the NORA should be collected and infused with the architects own experience and practical examples. This could perhaps be a side page on www.noraonline.nl in each principle. This makes the actual impact of such a principles visible for many different applications which builds up over time.

It is recommended that the NORA improves the level of possible collaboration between public and private organisations, however, this is not efficient at this time. This is because the NORA is now specifically tailored to public organisations and wo not mention interfaces and other possibilities for public/private collaboration. This means that if public organisations, such as the government, keeps working at the same level of standardization as stated in the NORA than the level of collaboration is not increased. This is in contradiction with what the government wants (and needs) since outsourcing has become much bigger. To improve this situation, the NORA must either lower the requirements on standardization or improve/incorporate standards such as interfaces between public and private organisations.

This research can be used as a starting point for new case studies in this area to perform multiple case studies to increase the validity of the work and it can be used as an example of solution architecture design in practise. The first showcase of the usability of public reference architecture in private organisations makes a unique contribution to the area of public private architecture. It has shown a negative conclusion for problems in the healthcare domain but more work is needed for this. It also shows improvement points for the NORA.

To conclude this section a last recommendation is made. In the world of public/private collaborations it is clear that the government cannot work alone or wants too. An increasing amount of private organizations gain access to markets which were previously taken care of by public organizations such as the healthcare section. This was also explained in the introduction chapter in which was stated that

the government outsources more to the private sector. If the government want to keep part control it can be necessary to work with public/private collaborations which could be enhanced by using a single reference architecture, such as the NORA. This also helps to keep the level of public standardization wanted by the Dutch government. However, a contrast must be made, because it is simply not possible to allow private transitions into the public market and demand the same level of standardization. One item which could be an intermediate solution is to make a standardized interface. For example, allowing the secure use of the electronic patient data through one interface for public and private organizations.

8.3 - Limitations

There were a number of limitations during this research. The first limitation was that the subject was completely new to the researcher and therefore it took more time to determine which was new and which was novel knowledge as a scientific contribution. The lack of knowledge or technical expertise also placed limitations in how detailed the solution architecture could be designed. This generated a more general advice document that can be seen as an expansion from the project start architecture towards a solution architecture. This has caused also some confusion in the architects that answered the questionnaire. Without reading this disclaimer, which was also part of the solution architecture, some of the answers were answered negatively because of different expectations.

To solve this lack of knowledge, a comparative study was conducted with examples available within ICTU. However, this was limited because many of the documents were either project start architectures or software architecture documents with only one solution architecture available.

The second limitation of this research was that the solution architecture itself was long, 77 pages. The time it would take for the architects to read the solution architecture and answer the questionnaire this was also misjudged. This was because of the expectation that the architects'' knowledge and expertise would speed up the processing time considerably, but in their opinion at least one full day would have been necessary instead of the proposed one-two hours. This was the most probable cause for the low response rate (6/18). Another reason might be that the private organizations didn't understand or know how to use the NORA and therefore found it hard to review the solution architecture and the review questions based on the NORA.

The architects were however guided in answering the questions. The architects also stated that the solution architecture was too long but also lacked detail. The two statements seem to be in conflict with each other. Perhaps the writing was too elaborate and not punctional enough. Another explanation is that most architects have one area of expertise. This narrows their vision and because the solution architecture is very general covering many aspects, the areas they are familiar with are not detailed enough whilst the other parts are too long.

Another reason for the low response rate was that the choice was made for an open-question questionnaire to get qualitative answers from the architects however open-ended questions do have some drawbacks: Respondents don't always like them much because it requires more work. This can result in short insufficient answers. They lengthen the time to complete a survey which lowers the response rate which was already limited because of the length of the solution architecture and no graphical visualisations or SPSS tests that can be performed. The questionnaire was sent through email to the various public and private architects. This channel was chosen because of time limitations and easy reach. A better alternative in sense of response rate and quality would have been a workshop in which the public and private architects would review the work beforehand and then discuss the work and questions together in the workshop. This method was rejected after the difficulties in bringing the many architects together within the allotted time. Another reasons for the response rate might have been connected to the clarity of the questions. The questions were fairly long and since the content was about the long solution architecture and the NORA, the questions might have been too difficult for the architects, especially the private architects. To enhance the quality of the data generated by the questionnaire in-depth interviews were held. Doing interviews as the sole method might have resulted in a higher response rate. This is because architects might have had more incentive to respond and the interview questions can immediately be explained.

A third reason for the low response rate and immediately another limitation was that the private organisations of the Zo-Dichtbij foundation did not respond or responded that they could not answer the questionnaire because of 1. Time constrains and 2. Lack of knowledge. This meant that only public architects have responded to the questionnaire. The invited group, public and private, was sent an email, weeks before the questionnaire, with a personal message stating the status of the work and when the

questionnaire would arrive. This was again sent a week before the questionnaire was send. After the questionnaire was send, a reminder was sent a week after and another one a week later.

The range of the answers in the questionnaire were also divided into two groups, where one group was fairly positive and the other group was moderately negative with one respondent being very negative. This can have multiple causes. Solution architecture could be out of the technical expertise of the architects as no software architect or technical architect responded to the questionnaire. It could also be that the negative group did not like the researcher, had a bad day or did not like solution architecture documents or the NORA itself. The last reason is at least partly acknowledged by one of the respondent and was an outlier compared to the other respondents. At least two respondents acknowledged that their knowledge of the NORA was not sufficient and that their technical expertise resulted in more global answers. It could be that, however impossible to find out, that the outlier was the only truthful respondent because this was a new colleague and the other respondents have worked with me for the complete length of the study. This might also be the answer as to why they did respond and the private architects did not because they are further away and did not have daily contact.

A possible solution to these limitations and a conclusion from the results is that it might be better to design a solution architecture with a group that consists of a number of different expertise.

8.4 - Recommendations & future research

On top of the recommendations that were given in the section 8.2, additional recommendations are given below.

8.4.1 - General recommendations

This study consisted of a single design case study concerning the application of the NORA for private organisations that want to collaborate effectively with the Dutch government. Therefore, additional research through new case studies is needed to acknowledge the findings in this research. To facilitate this. this case study could be used as a basis for further research or a comparative case study.

Additionally, I would recommend that more qualitative interviews would be held which also include private architects using a shorter solution architecture document. This ensures a higher response rate and gives a more in-depth analysis.

I propose that many of the tensions and complications between public and private healthcare organisations, as seen in chapter three, could be solved in the following manner. Design a basic framework for public and private organisations that use the NORA as a fundamental basis and fine-tune it with domain architecture and other reference architecture, possibly a combination of both public and private. On top of this new basic public private framework, a methodology should be added which support the evaluation of public private architecture using the same evaluation criterion.

8.4.2 - Foundation Zo-Dichtbij

This design research could be used as the first steps to generate an enterprise architecture. The project start architecture its expansion into a solution architecture could both be used as input. This could add to the research of using reference architecture in private enterprise architecture

The foundation needs to do a privacy impact assessment as well as an A&K analysis and from there design the technical architecture in high detail. This would include the data model and together with the PIA and A&K forms the basis of the rest of the document. Therefore, another solution architect should use this solution architecture document as a basis and continue with the development, especially the technical architecture. I would however, suggest a multi-disciplinary team of different architects because no architect contains all the qualities to design a complete and total solution architecture. This document would then be ready to be used by a developer.

8.4.3 - NORA

The NORA is often discussed in the board of users which consists of many public organisations and also internally with the NORA architects. Therefore, I would suggest that these two bodies look at the NORA to not only discuss it for themselves as public organisations but also to make it more understandable and usable for private organisations outside their normal scope. For example, within the principles, standards and building blocks it could be added which are governmental only or those sections would need to be updated as to incorporate private organisations as well. However, this is quite

difficult because the entire e-government would have to be redesigned and new building blocks must be designed which are also accessible by private organisations.

The added implications to each principle would also add to the practicality of the NORA. This would make sure that the NORA will be used by additional architects including private domain architects. Additional to the recommendations given in section 8.2 the NORA should make an inventory of the biggest differences between public and private organisations. This can then be adapted into the

Before the NORA can be used efficiently to design a solution architecture for private initiatives, the NORA needs to be updated. Implications for private organisations need to be added in the list of NORA principles, since many of these implications differ between public and private architecture. There are also a number of principles which are just not usable for private initiatives. Alternatives have to be suggested for those principles, all GDI building blocks and the Use-Or-Explain standards. Additionally, more case studies or examples should be made available which would help future architects in the design of public private architecture. This would be a new reference architecture or framework usable by public and private architects.

The NORA could also design a review system that each architect would have to use. This would generate sustainability for the NORA overtime, incorporate uniformity between architects and allow different architects with different backgrounds to use their expertise, see what they lack compared to other architects and increase their learning experience. This also enforces the architects to use a system view.

ICTU – There are also a number of recommendations for ICTU/NORA. This combination because the NORA is managed by ICTU.

Reviews have more value if they are implemented by architects from different backgrounds/expertise. Create a rudimentary classification of areas of expertise of architects and base it (and character) who is going to do a peer review or NORA. Choose where possible for a review from multiple angles and by different people. ICTU or architects in general should do this more central. However, the question is what backgrounds are needed and whether they are represented. This should be investigated. Additionally, architecture products made by architects should be used to make an overview of which principles where used in their project, with an explanation why they didn't use the principle. This could then be shared to learn from each in for example a summary page in the wiki. In addition to updating the NORA principles. Set a review guide or publish a central template and ensure that architects make adaptions or collect these somewhere. This should be evaluated periodically in both process and quality of the reviews.

These products could then be used as case studies to see what the implications of certain principles are. Concrete norms/implications should be connected to the principles such as implementation guidelines, et cetera. This also solves another problem: The NORA principles alone are too abstract to inspire/motivate. The principles can be approved by using the cases and stories of the architects and share them within ICTU and the NORA user board. Discussion on (NORA) architectural elements brings them to life and gives them value. Substantive discussions deserve attention in the architecture meetings.

It is necessary to keep in mind that when researcher want to use the NORA in the future, it should be possible to use or make static documents. This feature should be added since the NORA has transitioned from the static NORA 3.0 to the Noraonline website. Additionally, if the website is translated to English more researcher can use it and it is also easier to relate and compare it to the EIRA, which is the European initiative for a reference architecture. This translation should be agreed on since many variations within translation allows information to be lost.

The results of this thesis could be summarized in the Noraonline website in a section devoted to private or public/private organisations, thus an addition to the wiki page. This allows easier connection with other domains to see how they can collaborate with e.g. Healthcare and education because the interfaces and overlap with the daughters (GEMMA among others) are still not clear enough.

In addition, the term Solution Architecture deserves a better definition and examples: preferably made by in-house architects (cases). A working definition within ICTU is the minimum if some uniformity in approach is expected, especially for externally hired architects.

The disorganization of the data within ICTU makes it difficult to share knowledge. As a novice architect it is difficult to find examples or to determine whether they are there at all.

8.4.4 – Future research

I recommend a two-pronged research which continues on this research. The both could start in collaboration with ICTU and NORA. Based on the conclusions and the recommendations, it should be researched which organisations within the Dutch government and other public organisations use the NORA and which don't. This should include the reasons why and how this can be solved. This improves the position of the Dutch government to show their results and coherence to the private sector. Additionally, another research should be started preferably simultaneously which investigates how well known the NORA is in the private sector, if it is used, by which organisations and why. This research should also include the possible use of public reference architecture within chains such as distribution. Both research should then be combined which could lead to a research about how public and private organisations can use the NORA in a better way, better informed and based on up to date data.

Another idea is that this thesis could form the basis of a multiple caser study on the use of the NORA or public reference architecture for private organisations or public/private collaborations. If similar results are found it would increase the validation of this thesis.

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Appendix

I - Evaluation vs. validation

In this section, an explanation will be given as why to differentiate between evaluation and validation. During the literature search, two items came up often in the research results: evaluation and validation. Many researchers use the two terms indiscriminately, but there is a difference.

So what is the difference between evaluation and validation? In term of processes Marwedel (2011) states:

- *Evaluation: is determining whether the process in its entirety can yield an output that meets the desired requirements. Evaluation is the process of computing quantitative information of some key characteristics of a certain (possibly partial) design.*
- *Validation is the process of checking whether or not a certain (possibly partial) design is appropriate for its purpose, meets all constraints and will perform as expected (yes/no decision). Validation with mathematical rigor is called (formal) verification.* (Marwedel, 2011)

Validation then makes sure that the design will be in line with customer needs. Verification will be only possible when the design is actually build, which is a later step. The more specific the needs and requirements are the more subjective the analysis can be. This project is at a beginning phase of design which implies that room to manoeuvre and adapt later on are also required, thus making the requirements less specific. Easterbrook (2010) states: *"In contrast, validation is an extremely subjective process. It involves making subjective assessments of how well the (proposed) system addresses a real-world need. validation includes activities such as requirements modelling, prototyping and user evaluation. Validation is relegated to just the beginning and ending of the project: requirements analysis and acceptance testing"* (Easterbrook, 2010). While the subjectivity makes validation sound negative it is very valuable in this design, since it is design. This research focuses on critical design issues and that causes a question to arise: "Who agrees on what is a critical design issue?" This implies that designers have a certain freedom. Remember the normative restriction on this freedom? This is also enforced through a Validation step in which the design is tested and scrutinized by experts in the field. All the data taken from the design case is applied in certain frameworks and must be tested. From the validation then the lessons can be generalized to a larger population. The designed solution architecture will be checked through evaluation based on the above definitions, since this is a qualitative study and no quantitative data is available.

II - Archimate explanation

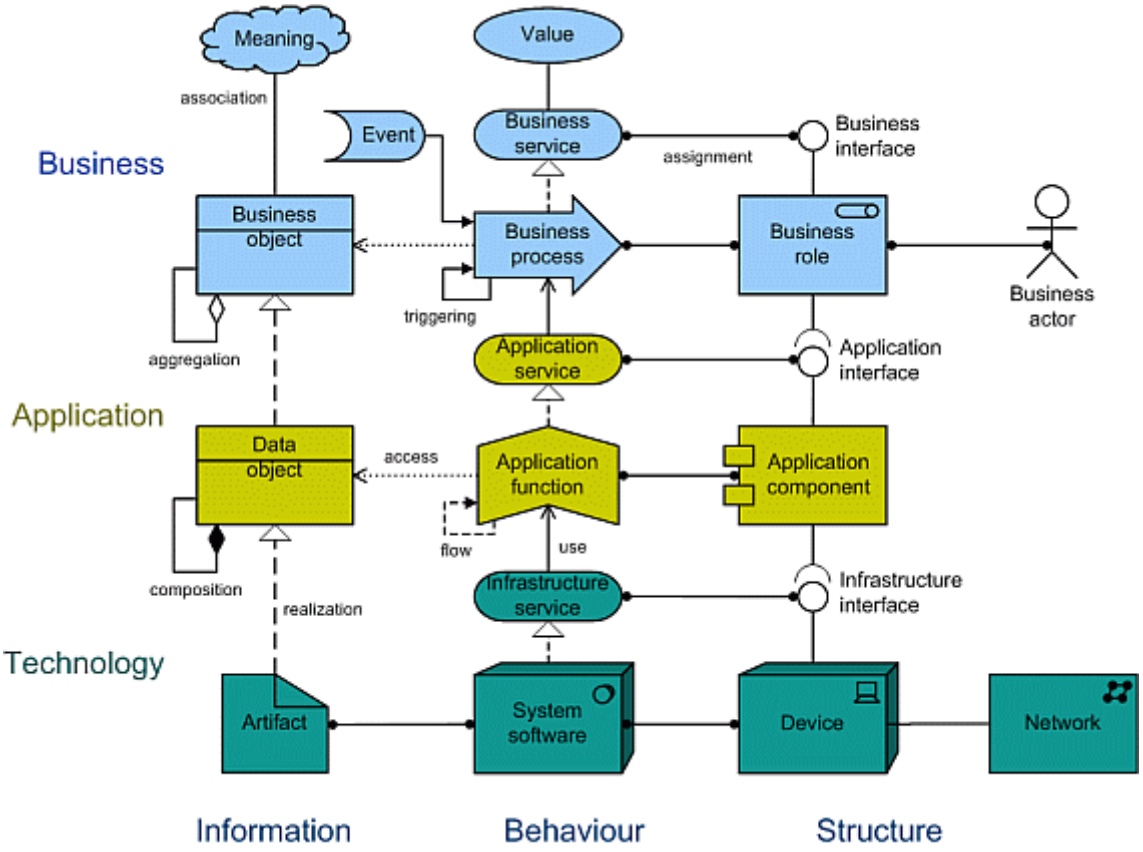


Figure 15: The entire business described in three main layers: business, application and information and technology (The Open Group, 2016).

II.A - Business layer

Concept	Description	Notation
Business collaboration	An aggregate of two or more business roles that work together to perform collective behavior.	Business collaboration
Business interface	A point of access where a business service is made available to the environment.	Business interface
Location	A conceptual point or extent in space.	Location
Business object	A passive element that has relevance from a business perspective.	Business object
Business process	A behavior element that groups behavior based on an ordering of activities. It is intended to produce a defined set of products or business services.	Business process
Business function	A behavior element that groups behavior based on a chosen set of criteria (typically required business resources and/or competences).	Business function
Business interaction	A behavior element that describes the behavior of a business collaboration.	Business interaction
Business event	Something that happens (internally or externally) and influences behavior.	Business event
Business service	A service that fulfills a business need for a customer (internal or external to the organization).	Business service
Representation	A perceptible form of the information carried by a business object.	Representation
Meaning	The knowledge or expertise present in a business object or its representation, given a particular context.	Meaning
Value	The relative worth, utility, or importance of a business service or product.	Value

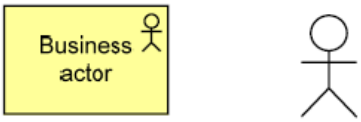
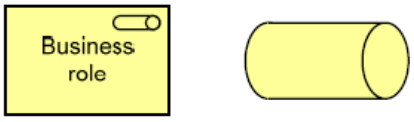
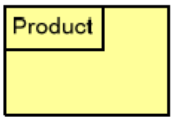
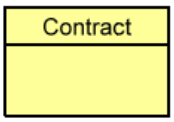
Concept	Description	Notation
Business actor	An organizational entity that is capable of performing behavior.	
Business role	The responsibility for performing specific behavior, to which an actor can be assigned.	
Concept	**Description**	**Notation**
Product	A coherent collection of services, accompanied by a contract/set of agreements, which is offered as a whole to (internal or external) customers.	
Contract	A formal or informal specification of agreement that specifies the rights and obligations associated with a product.	

Figure 16: Business layer archimate items

II.B - Application layer

The individual blocks are described below in table X

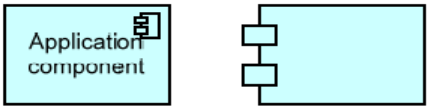
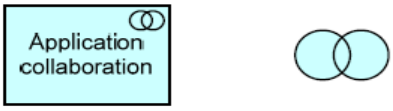
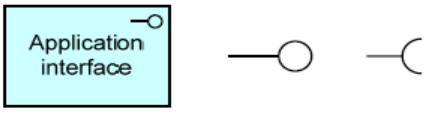
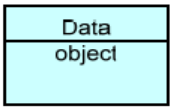
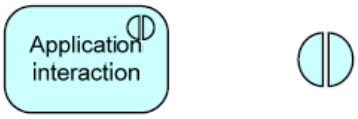
Concept	Definition	Notation
Application component	A modular, deployable, and replaceable part of a software system that encapsulates its behavior and data and exposes these through a set of interfaces.	
Application collaboration	An aggregate of two or more application components that work together to perform collective behavior.	
Application interface	A point of access where an application service is made available to a user or another application component.	
Data object	A passive element suitable for automated processing.	
Application function	A behavior element that groups automated behavior that can be performed by an application component.	
Concept	**Definition**	**Notation**
Application interaction	A behavior element that describes the behavior of an application collaboration.	
Application service	A service that exposes automated behavior.	

Figure 17: Information layer archimate items

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II.C - Technology layer

The individual blocks are explained below in table X

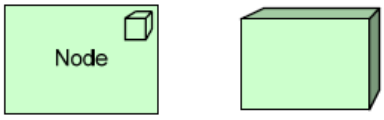
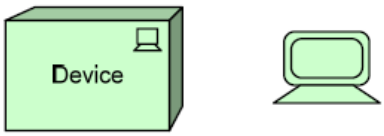
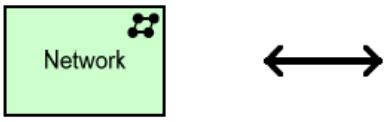
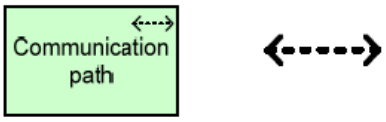
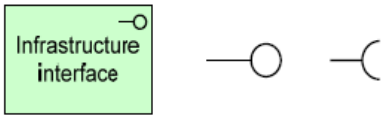
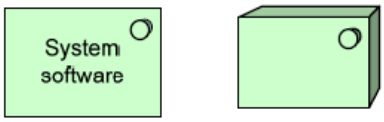
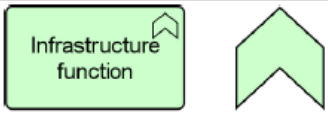
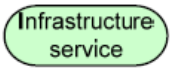
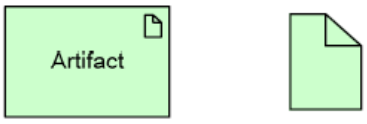
Concept	Definition	Notation
Node	A computational resource upon which artifacts may be stored or deployed for execution.	
Device	A hardware resource upon which artifacts may be stored or deployed for execution.	
Network	A communication medium between two or more devices.	
Communication path	A link between two or more nodes, through which these nodes can exchange data.	
Infrastructure interface	A point of access where infrastructure services offered by a node can be accessed by other nodes and application components.	
System software	A software environment for specific types of components and objects that are deployed on it in the form of artifacts.	
Infrastructure function	A behavior element that groups infrastructural behavior that can be performed by a node.	
Infrastructure service	An externally visible unit of functionality, provided by one or more nodes, exposed through well-defined interfaces, and meaningful to the environment.	
Artifact	A physical piece of data that is used or produced in a software development process, or by deployment and operation of a system.	

Figure 18: Technology layer archimate items

II.D - Relationships

Structural Relationships		Notation
Association	Association models a relationship between objects that is not covered by another, more specific relationship.	
Access	The access relationship models the access of behavioral concepts to business or data objects.	
Used by	The used by relationship models the use of services by processes, functions, or interactions and the access to interfaces by roles, components, or collaborations.	
Realization	The realization relationship links a logical entity with a more concrete entity that realizes it.	
Assignment	The assignment relationship links units of behavior with active elements (e.g., roles, components) that perform them, or roles with actors that fulfill them.	
Aggregation	The aggregation relationship indicates that an object groups a number of other objects.	
Composition	The composition relationship indicates that an object is composed of one or more other objects.	

Dynamic Relationships		Notation
Flow	The flow relationship describes the exchange or transfer of, for example, information or value between processes, function, interactions, and events.	
Triggering	The triggering relationship describes the temporal or causal relationships between processes, functions, interactions, and events.	

Other Relationships		Notation
Grouping	The grouping relationship indicates that objects, of the same type or different types, belong together based on some common characteristic.	
Junction	A junction is used to connect relationships of the same type.	
Specialization	The specialization relationship indicates that an object is a specialization of another object.	

Figure 19: Relational connectors between archimate items

III - Start input for the solution architecture.

The thesis work of Florez Atehortua (Flórez Atehortúa, 2015) and the research papers have shown insights in the design requirements (Keijzer-Broers, Florez-Atehortua, & De Reuver, 2015a), (Keijzer-Broers W. J., De Reuver, Florez Atehuortua, & Guldemond, 2015).

III.A - Persona's

Taken from W.J.W. Keijzer-Broers, F.A. Nikayin, G.A. de Reuver (Keijzer-Broers, Nikayin, & de Reuver, Main requirements of a Health and Wellbeing Platform: findings from four focus group discussions, 2015)

Persona 1 : Frans Berkhout

put in scene

Age	49 years
Place of birth	Schipluiden
Home environment	residential area
Marital status	married, 2 children
Profession	home care products supplier
Social class	average income
Internet use	work and private

Figure 20: Persona 1 represents a product provider.

Persona 2 : Annie Ammerlaan

put in scene

Age	79 years
Place	Schipluiden
Home environment	rural
Marital status	single, no children
Profession	housewife
Social class	below average
Internet	has no internet

Figure 21: Persona 2 is single and isolated

Persona 3 : Kees van de Ende

put in scene

Age	81 years
Place of birth	Maasland
Home environment	residential area
Marital status	married, no children
Profession	retired engineer
Social class	average income
Internet use	private

Figure 22: Persona 3 takes care of his partner with dementia.

Persona 4 : Ria van Marrewijk

put in scene

Age	55 year
Place of birth	Den Hoorn
Home environment	terraced house
Marital status	husband and 3 children at home
Profession	part time care giver at Buurtzorg
Social class	average income
Internet use	private

Figure 23: ***Persona 4 takes care of relatives (sandwich generation).***

Persona 5 : Ellen van de Windt

put in scene

Age	47 years
Place of birth	Delft
Home environment	city center
Marital status	married, 3 children
Profession	coördinator Foundation Welfare Elderly
Social class	average income
Internet use	work and private

Figure 24: Persona 5 represents service provider for healthcare.

Persona 6 : Anton Gielissen

put in scene

Age	62 years
Place of birth	Delft
Home environment	terraced house
Marital status	single, 2 children living away
Profession	civil servant Social Affairs Delft
Social class	more than average
Internet use	work and private

Figure 25: ***Persona 6 represents the department of social affairs.***

Persona 7 : Petra de Kort

put in scene

Age	25 years
Place of birth	Den Haag
Home environment	city center
Marital status	living together with a boy-friend
Profession	advisor WMO office Midden Delfland
Social class	average income
Internet use	work and private

Figure 26: Persona 7 represents the WMO desk at a municipality.

Persona 8 : Hakkan Bitez

put in scene

Age	55 years
Place of birth	Delft
Home environment	poor neighbourhood
Marital status	married, 6 children, 1 living away
Profession	unemployed
Social class	below average
Internet use	private (with help of the children)

Figure 27: Persona 8 is a foreigner and unemployed.

Table 6: Potential users of the platform (1 = absolutely not and 7 = absolutely)

Actor	Mean ($\bar{X}$)	Standard Deviation (SD)
Young elderly (55 – 75)	6.43	0.63
Service providers	6.36	0.91
People with physical limitations	6.29	0.9
People with chronic conditions	6.21	0.92
Product providers	6.18	0.9
Voluntary caretakers	6.07	1.11
Elderly (75+)	6.07	1.22
Citizens in general	5.96	1.04
Volunteers	5.93	1.15
Government (municipality)	5.68	1.63
People with mental limitations	5.21	1.5

III.B - Zo-Dichtbij actor platform function requirements

Taken from W.J.W. Keijzer-Broers, F.A. Nikayin, G.A. de Reuver (Keijzer-Broers, Nikayin, & de Reuver, Main requirements of a Health and Wellbeing Platform: findings from four focus group discussions, 2015)

Table 7: Requirements of the platform according to the participant itself (n =13)

Requirements	Mean ($\bar{X}$)	Standard Deviation (SD)
Information about local activities	6.39	0.87
Integration local platforms	6.08	1.12
Contact with others	6.08	1.44
Health services	5.92	1.38
Wellbeing products	5.62	1.66
Information ageing in place	5.54	1.45
Integration national platforms	5.46	1.66
Domestic products	5.39	1.8
Health products	5.23	1.96
Wellbeing services	5.15	2.19
Contact with end user groups	5.07	1.93
Domestic services	4.85	2.15
Marketplace	4.23	1.92

Table 8: Requirements of the platform referring to parents or grandparents (n = 14)

Wellbeing products	6.07	0.92
Wellbeing services	6.07	1
Contact with others	6	0.88

Health services	5.93	1.14
Health products	5.71	1.2
Domestic services	5.64	1.5
Information about local activities	5.43	1.5
Contact with end user groups	5.29	1.38
Domestic products	4,93	1.13
Integration local platforms	4.86	1.88
Integration national platforms	4.71	1.68
Marketplace	4.71	1.68
Information ageing in place	4.64	1.34

III.C - Functional requirements

Taken from Flórez Atehortúa (Flórez Atehortúa, 2015).

Requirement 1: **online community;** the platform shall be an online community for contact, solutions, social wellbeing, interaction with the neighbourhood in the form of social activities/events.

Requirement 2: marketplace; the platform shall offer a digital marketplace for applications in health and wellbeing as well as a marketplace for products and services in the same context, that is an information exchange podium between providers and end-users in the context of health and wellbeing.

Requirement 3: seamless navigation; the artefact shall ensure smooth and simple navigation.

Requirement 4: rating and review mechanism; the platform shall allow reviews of products, products providers, activities and activities providers. A rating system should be in place that allows consumers of products/service give a rating plus a qualitative feedback.

Requirement 5: diary management; the platform shall offer a diary for the end-user- a log in which the user (or someone else on the user's behalf) keeps a daily record of events and experiences shall be in place. The access to such diary should be in as few clicks as possible and always visible from the home page of the platform.

Requirement 6: tasks management; the platform shall offer a task manager mechanism for the end-user, on which the user itself (or someone else on behalf of the user) can introduce and manage tasks related to the health/wellbeing of the user.

Requirement 7: contacts management; the platform shall contain a module for contacts management. These should be divided into two different categories (1) Social Contacts and (2) Special Contacts. A messaging functionality between users should be added as part of the contacts management mechanism.

Requirement 8: text and buttons; the platform shall offer texts/buttons in a size that is readable for levels impaired vision. Buttons for menus shall contain text and image related to the function. Buttons shall contain an audio option that by hovering "speaks out" what it does and displays a text.

Requirement 9: help; the platform shall offer a functionality which can guide the user though the different menus and options. This guided tour through the system is available by default but it is optional. The user may decide to disable it. The help should be offered in text as well as in audio; this is when the help is offered an additional clickable icon is available to hear the text embedded.

Requirement 10: multi-device/platform availability; the artefact shall be available for multi-devices and platforms that are most dominant in the market (web access, IOS, Android).

Requirement 11: news about health and wellbeing; the artefact shall offer a channel or feed of noteworthy information around health and wellbeing targeted to the different groups of end-users, especially the elders.

Requirement 12: search based on key words; the artefact shall offer a type of search that looks for matching elements that contain one or more words specified by the user. In the context of this platform the it shall offer one input box in the main page and allow to retrieve elements like contacts, activities, documents (i.e. insurance policy), products/services.

Requirement 13: virtual helpline and telephone helpdesk; the artefact shall offer a link / contact information to reach out a telephone helpdesk. In addition, the artefact shall offer a live chat functionality that allows the users contact via-chat.

III.D - Navigational map

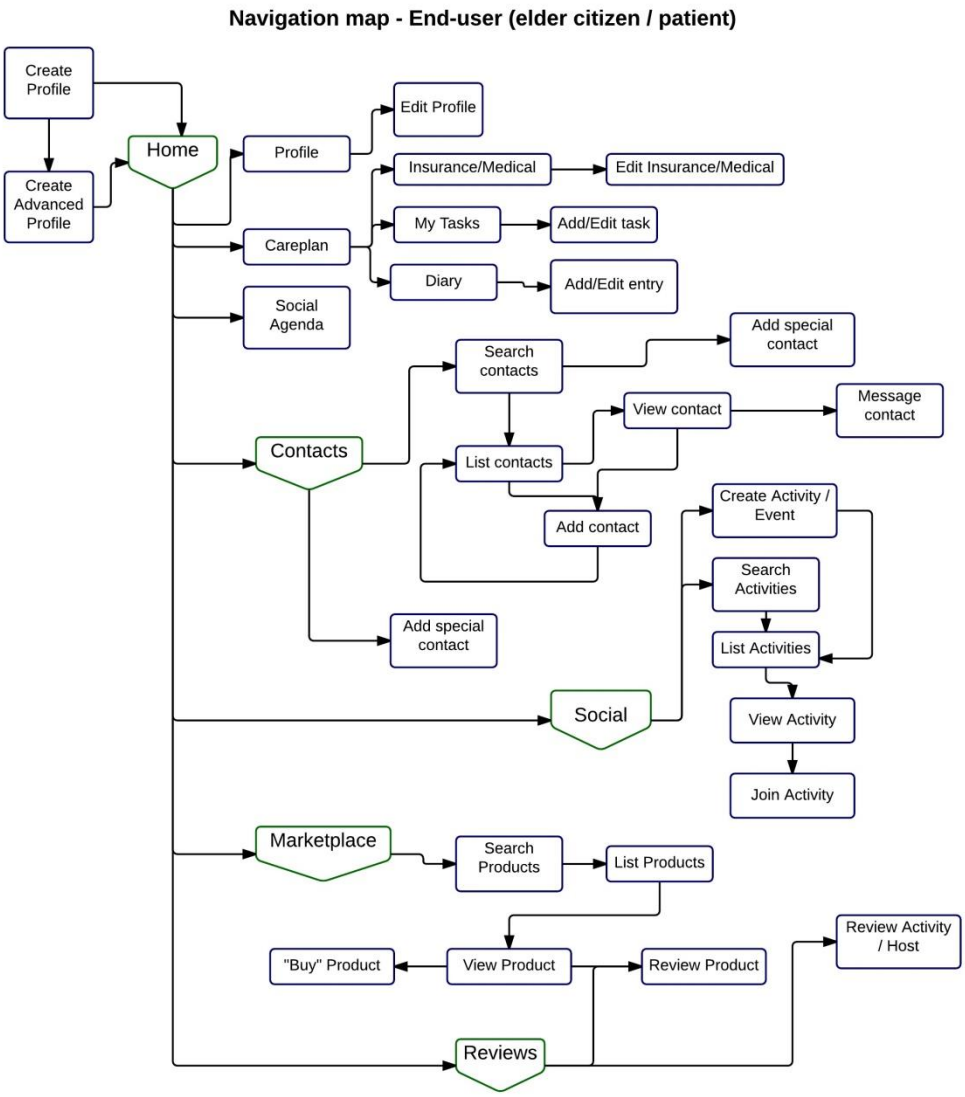


Figure 28: Navigational map

III.E - Clickable model and examples Zo-Dichtbij layout

The clickable model can be found at: https://projects.invisionapp.com/share/434U0BKA8#/screens

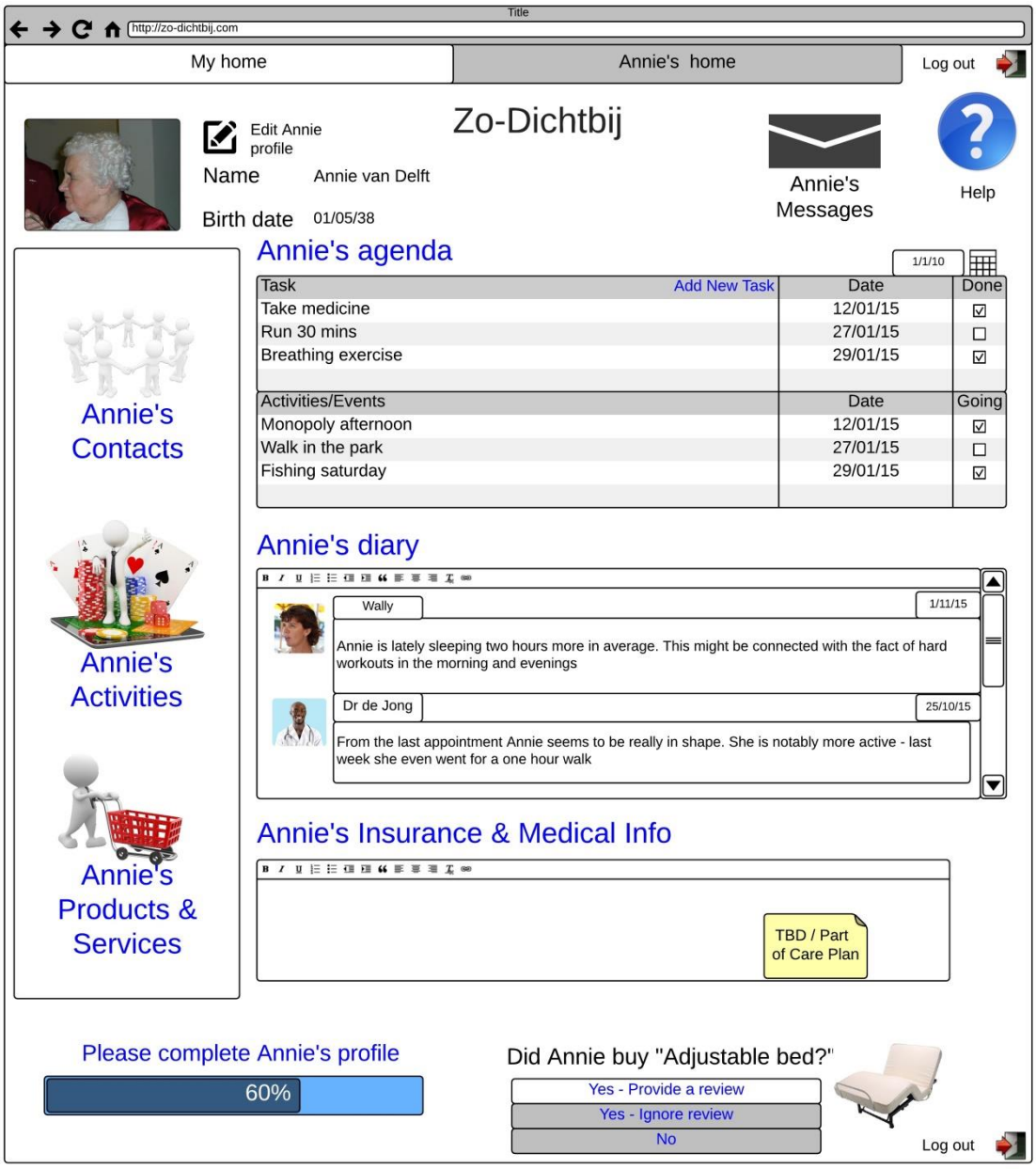


Figure 29: Zo-Dichtbij first overview agenda

Figure 30: Overview clickable model

III.F - High level architecture

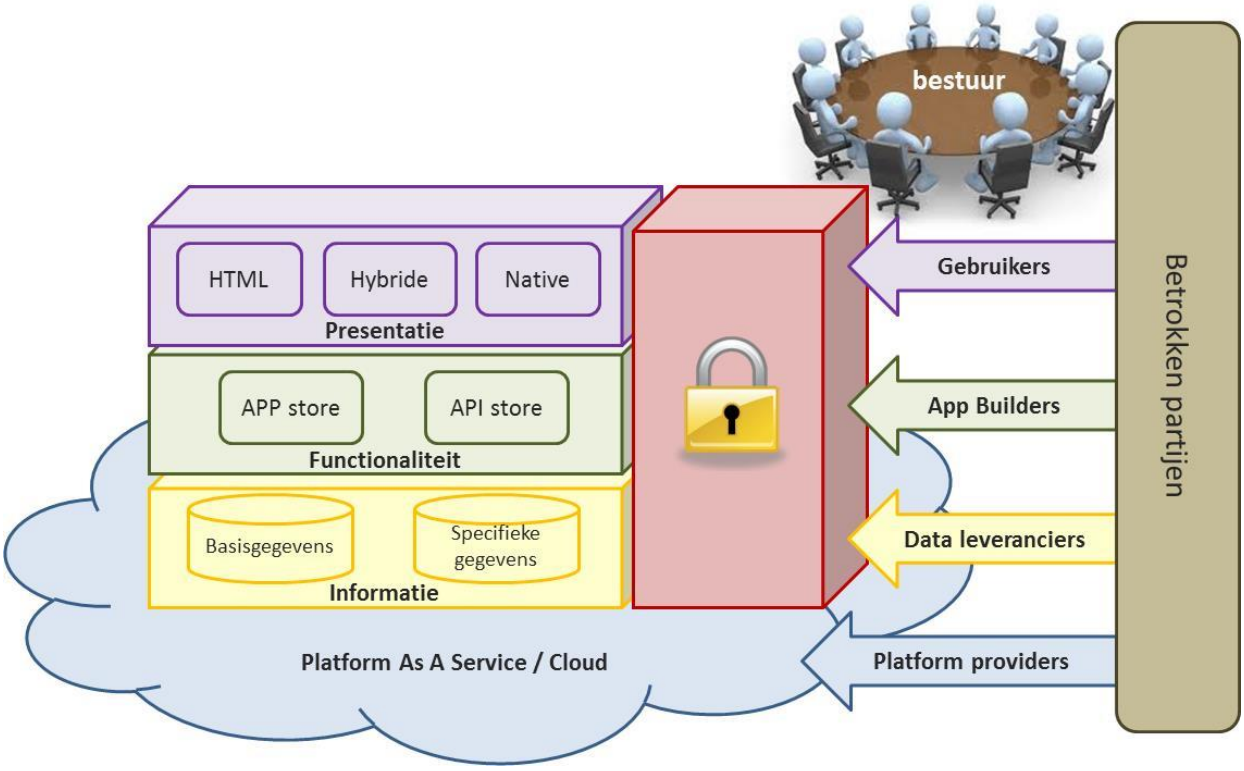


Figure 31: High level architecture Zo-Dichtbij (2015)

III.G - Rest Based Platform

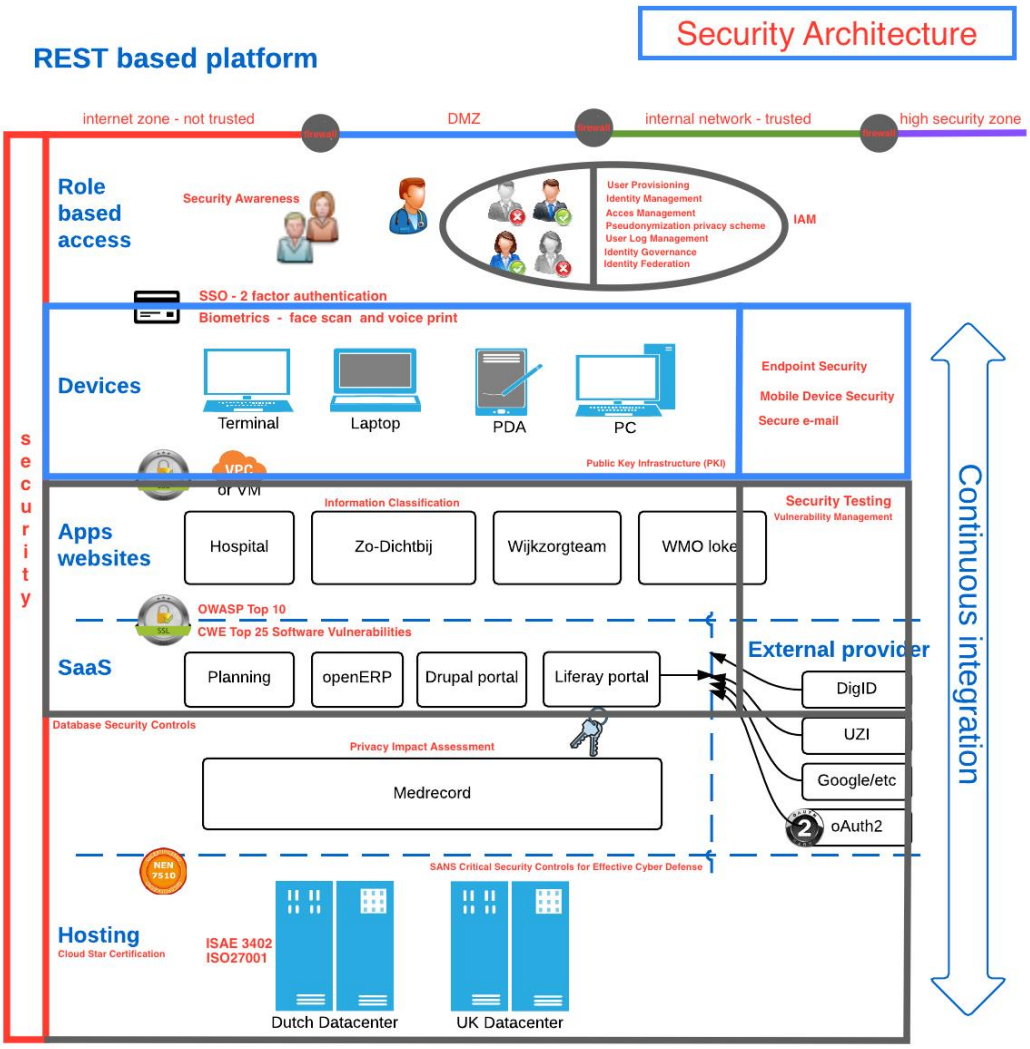


Figure 32: High level rest architecture combined with secuirty advice

IV - Iterative design interviews.

IV.A - First round interviews (summary)

Conclusion of the interview with John Waser (15-03-2016) coded as EA1

- Make sure you can falsify your work.
- Make sure you do a cross-check every so often.
- Use Time Boxing
- Use iterative evaluation steps.
- evaluate your schedule to ensure that each party understands the design.
- There must be an authentication step for both groups of platform actors.
- Let the two interfaces communicate with the intermediary and not directly with the vault or Watson.
- Which data is public and which is private and must be protected. A big concern for privacy
- Design the functionalities in separate services so they can be made separately which then interact with each other as black boxes.

interview with ICTU architect Paul van Raaij (14-03-2016) coded as IA1

- Explain how you chose for these functionalities
- Privacy is of big concern unless the data and actors are anonymous
- Re-write the login of the platform actors
- Role based Log in is a possibility – look at the roles of different users
- Describe the actors more clearly
- Look at the documents IZO-2020
- Determine how you handle Digi-inept users – NORA: AP: other channels
- Use design by privacy. Data restrictions: What is requested from the actor and what can be taken from registers. (information and data models)
- Determine the logging: Who has access to a user's data, who saw that and which is stored.
- Remove duplicates in the system.
- Use the highest category in security
- Flexibility: The platform must be able to adapt and include new functionalities
- Interoperability: Use interfaces which interact with applications, use open standards: XML.

interview with architect ICTU Peter Bergman 17-03-2016 coded as IA2

- Change the arrows in the Archimate schemes.
- Think of how each functionality/service is connected to an application and technology
- Show swimming lanes including: Actors, Business processes, services, applications and technology
- What is the consistency of all the services and what does the information exchange look like?
- Look at privacy by design and Privacy Impact Assessments (PIA)
- Intermediary must be an application not a person/organisation
- Compare the PSA high level architecture with own work
- The vault functionality is a critical design factor (issue)
- Keep in mind that Zo-Dichtbij wants something and the SA must say if it is possible and under which circumstances
- NORA describes more than interoperability and flexibility. Also look at governance
- What kind of instances are hospitals, public or private?

IV.B - Second round interviews (summary)

Interview with Arno Schots Oracle (30-03-2016) coded as EA2

- **Does the platform provide financial applications?**
- Take the developers into account in the actor layer - Defines what the roles are of the developers
- Determine user agreements or that it is necessary, where is this shown in the process?
- How do persons authenticate themselves, or how does the system IAA a person?
- Maybe only place the connection between two users in an interface
- Does the platform provide financial applications?
- What is the main process of the platform? And why offer the additional functionalities?
- Are there also users that just want to use one piece of the functionality such a social but not the rest? How do you realize this?
- Where do the functionalities fit in the business processes? How do you determine the needs of the users?
- Make sure that the Archimate schema is clear and readable for most users. (business architects)

Interview with Jan-Marc Verlinden MedVison (04-04-2016) coded as EA3

- Use NEN 75010-11-12 and NEN13606
- Use rest Architecture: Loosely coupled services
- Website can be used as user interface this is coupled to an API store
- Different platform can communicate through rest and will increase interoperability and flexibility
- Watson is a solution for a problem. Transform into matchmaking assistant
- Make a choice between an open system or a closed system
- Only use input from Zo-Dichtbij
- Actors->business processes->functionalities->Applications->Technologies
- Vault can be Medsafe/medrecord
- API store can realize the functionalities. Matchmaking through assistant
- Relation MVP with total solution?

Interview Peter Bergman ICTU (04-04-2016) coded as IA3

- Elaborate the business processes that the platform actors go through
- What need does an actor have and how does the system find out?
- The functionalities are written as business processes but they are application functions
- Change or explain the function tasks
- Make a function or item that shows what information is available from one user and who has access to it.
- Not all connections – interrelation lines are there, update them
- Think about what realizes what e.g. technology-> application
- Think about how users connect to each other and how does this relate to events?
- Discuss with the Zo-Dichtbij members what functionalities they want and if the current design is okay - focus point: Financial applications
- What facilitates the functionalities? API store check with Jan-Marc

IV.C - Third round interviews (summary)

Interview with Peter Bergman ICTU (25-04-2016) coded as IA4.

- Add standards when the Archimate schematics are finished
- Change business functionalities into application (front-end)
- Add in Governance layer
- Describe the platform management
- Place business processes next to each other in line instead of below each other
- Took a look at the connections made in the Archimate scheme and correct accordingly
- Do the actors have the right names?
- Care providers are users of the platform
- Which functions are accessed and used by which actors?
- Composites in Archimate always have two or more components
- Check the wording used: Functions noun, deeper: Verb
- Place more focus on RBA, improve financial application, tech to third parties
- Write SA in such a way that developers can use it to proceed: write down what needs to be realized under what conditions

Interview with Arno Schots Oracle (25-04-2016) coded as EA4

- Technology is a possible solution to the problem and not of main concern now.
- Write down the decisions, the design choices.
- Open standards or commercial solution? NORA says open
- The design choices must reflect the context and design requirements (costs e.g.)
- The rights of platform actors must be established in terms and agreements
- The rights, roles and authentication must be written down in a contract which the system accesses
- There must be a security check within the system to enforce the role based access
- The role shows to what services a platform actor has access to
- Make a choice: Healthcare providers and end-users reach the platform in the same way?
- Does the platform offer a financial service?
- The need of the platform actors need to be reflected in the business processes, how is this defined?
- Make the business processes consistent with the services of the platform
- Add an end-user for social activities
- Make the architecture understandable for all stakeholders and developers
- Add in governance layer

- Accepts the change of functionality layer from business processes into application
- Something must be designed that operates between API and the platform interfaces
- Change the name of the layers to make it more clear
- Add a security check which functions in line with the role based access, add this in business layer and application layer before the API store
- Determine the technology needs for the API store and other system functions
- Choose if you want to fill the technology layer with third party solutions
- Archimate seems clear

Interview with Jan-Marc Verlinden MedVison (26-04-2016) coded as EA5

- How does this work combine, overlap with the thesis work concerning Watson?
- Archimate v1.6 seems generic and that is good?
- Did we thought about what standards are needed or followed in the design?
- The security check is placed as a front end application but must be a back-end application. How do you solve this?
- What decides the rights of the platform actors? Possible a contract? IAA?
- Look at the BIG laws. It states that a treatment agreement must be established.
- Role based access should always be active: checked via security applications and contract information.
- Seems a clear design also seemed complete
- Third party solutions for technology, determine need do not fill in.
- How do all the application connect? Solution through the API store.
- How do you make the whole role based access line understandable?
- Make it clear and understable but understand that developers often look at pictures but not at the solution architecture document.

V - Archimate design

V.A - functionalities

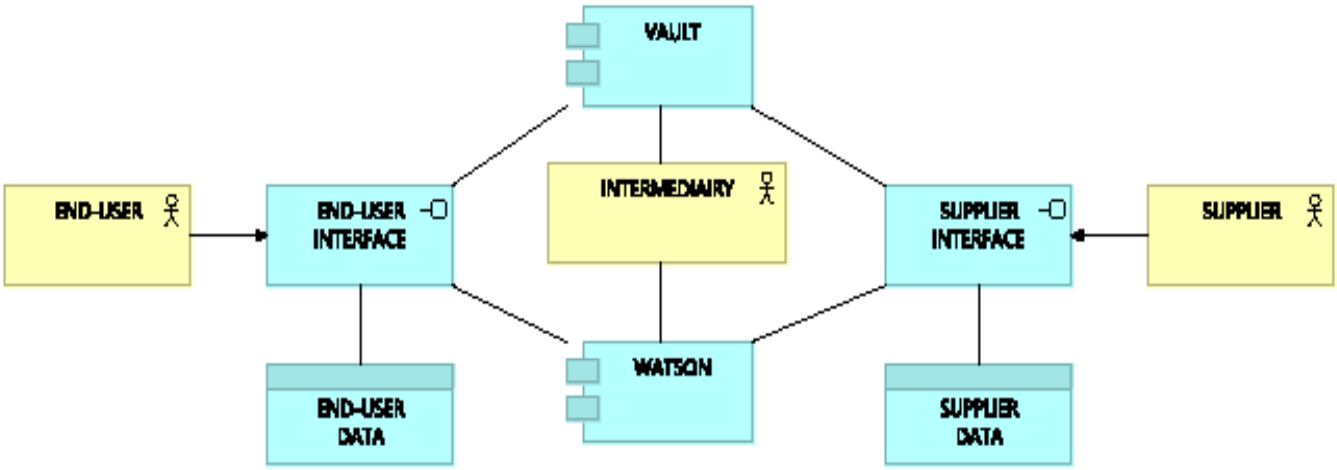


Figure 1: General overview functionalities first sketch

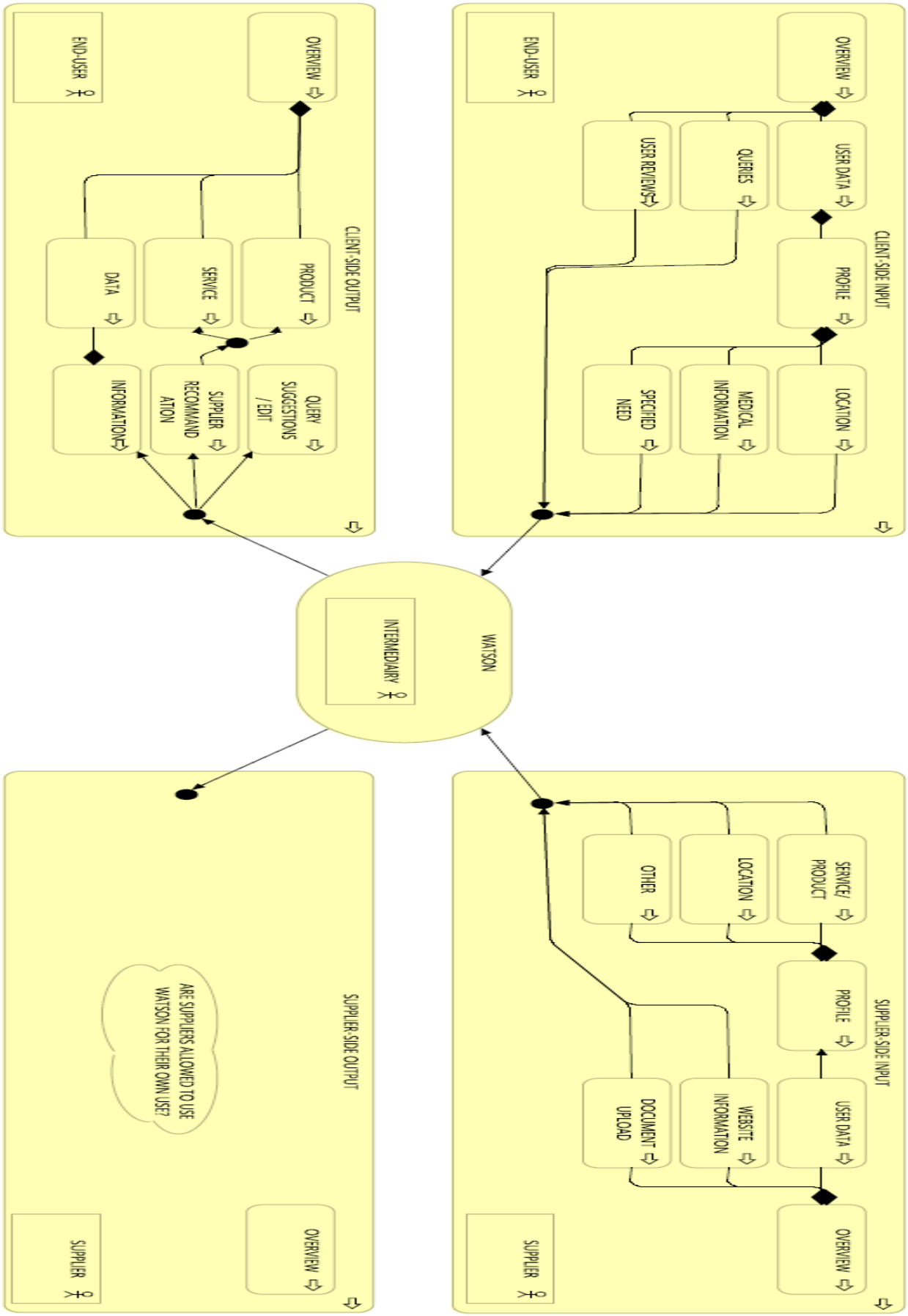


Figure 2: Watson functionality first sketch

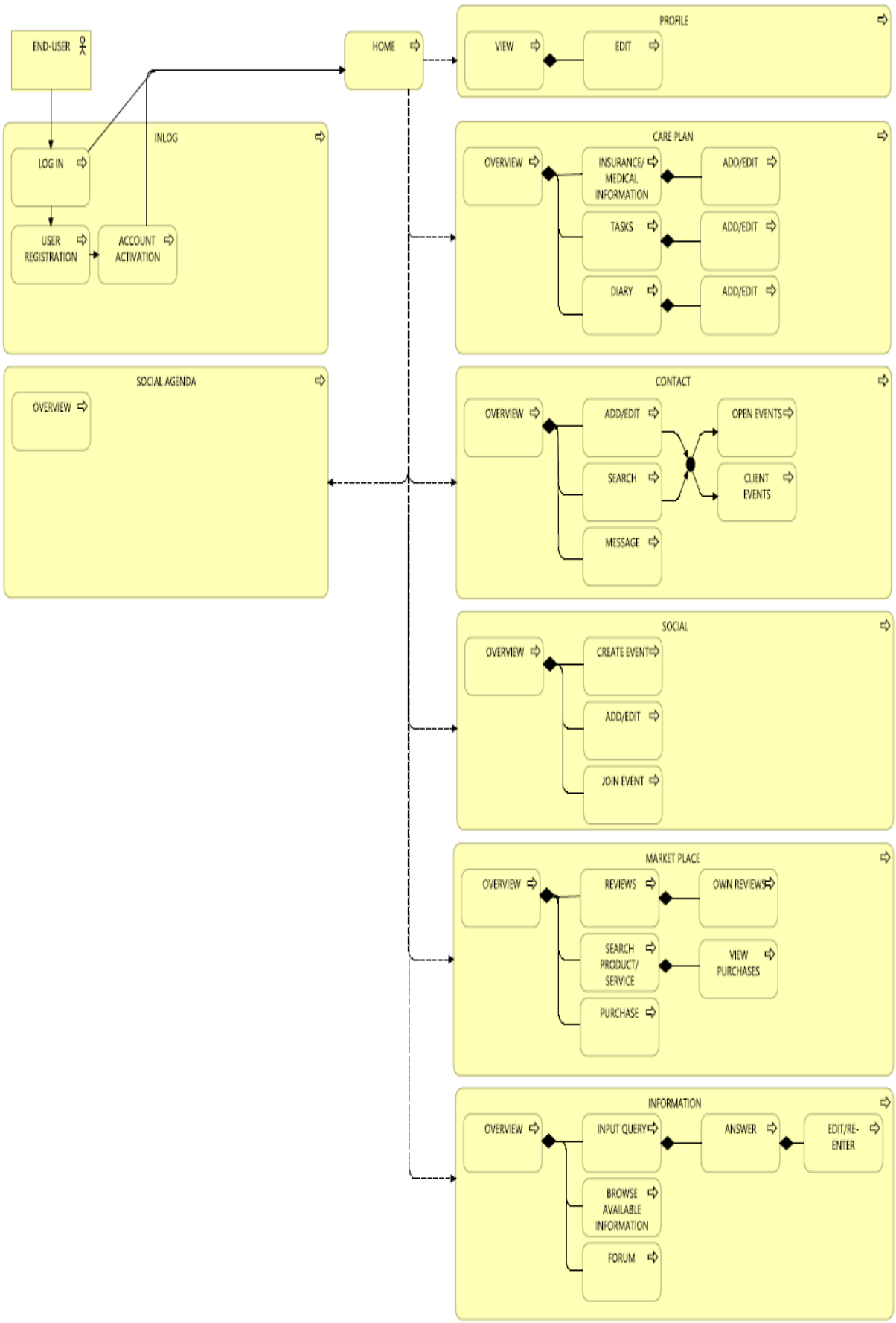


Figure 3: End-User functionalities first sketch

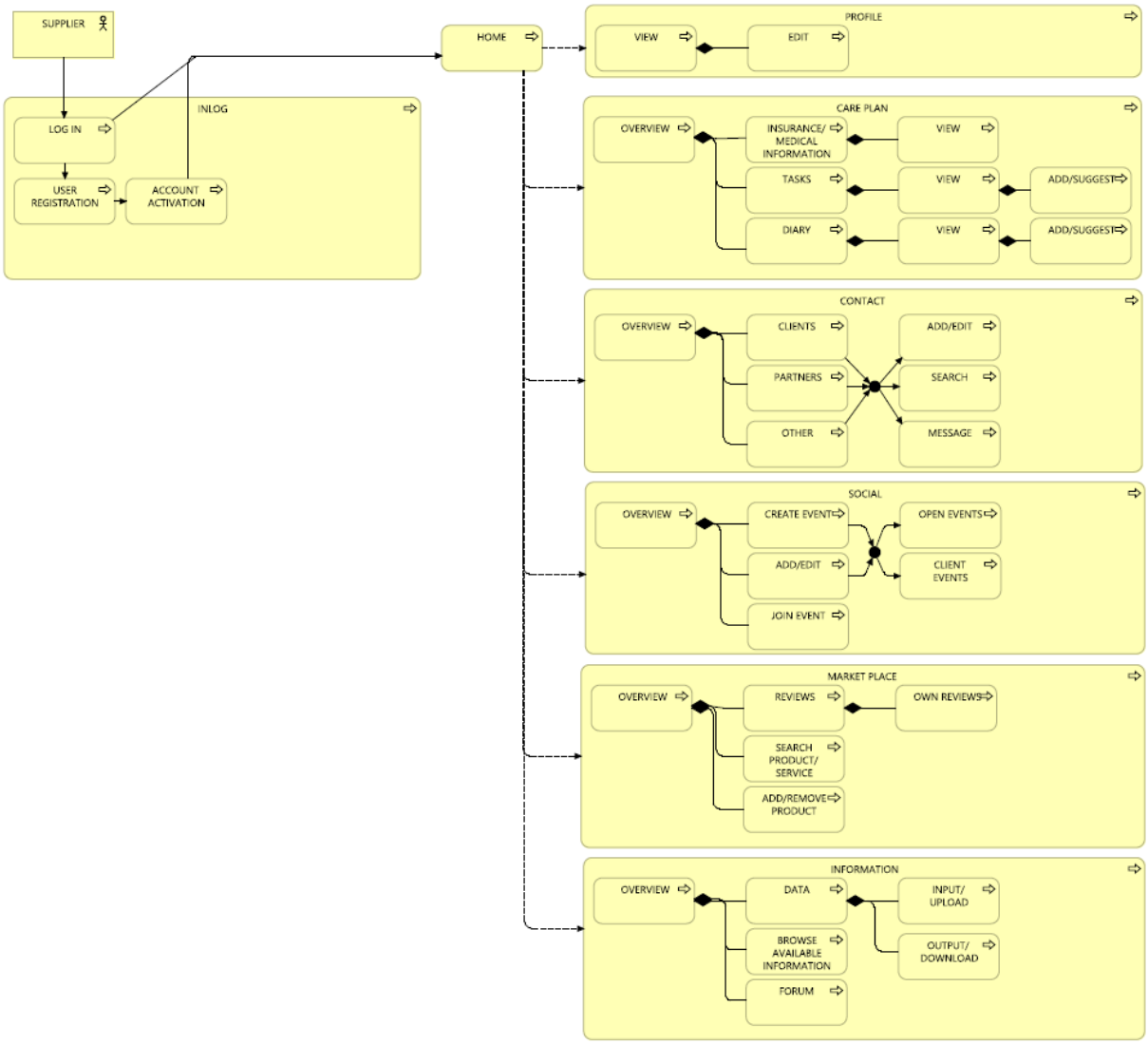


Figure 4: Supplier functionalities first sketch

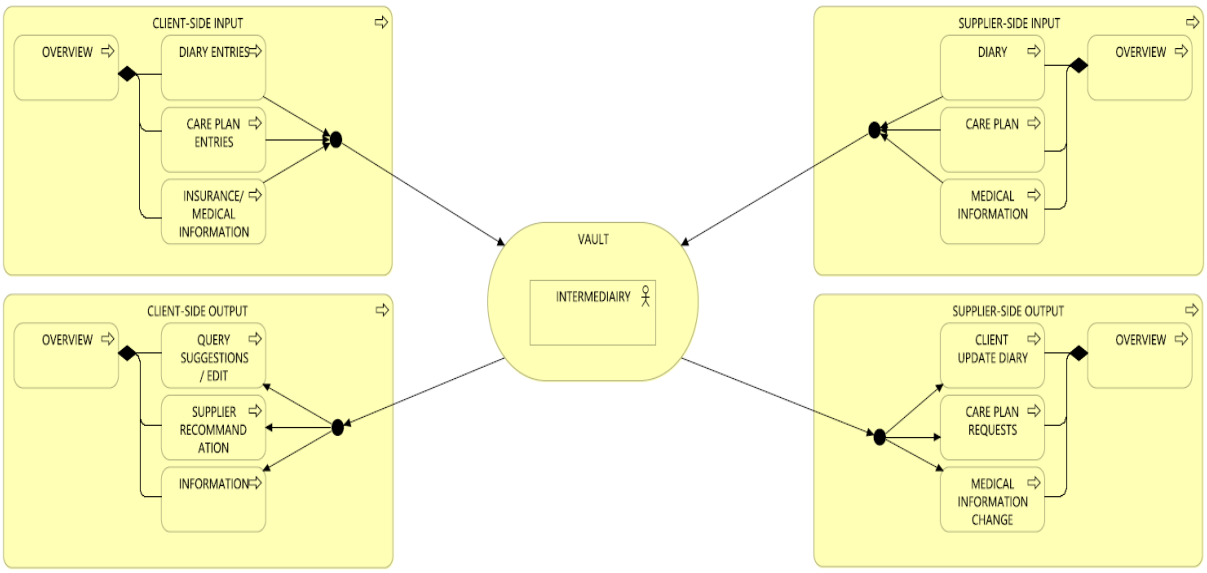


Figure 5: Vault functionality first sketch

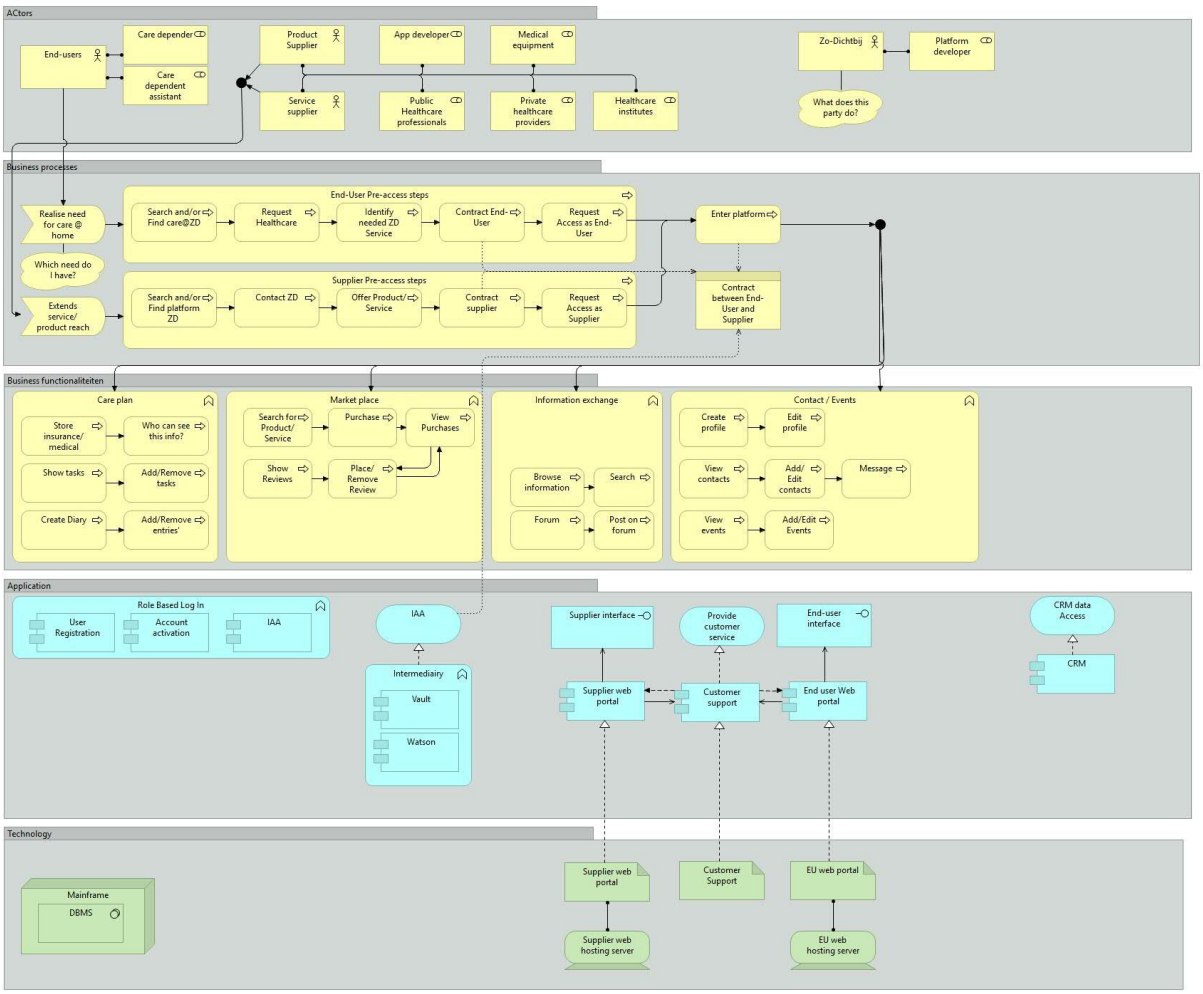


Figure 33: Archimate v1.1

V.B - Iteration Round one results

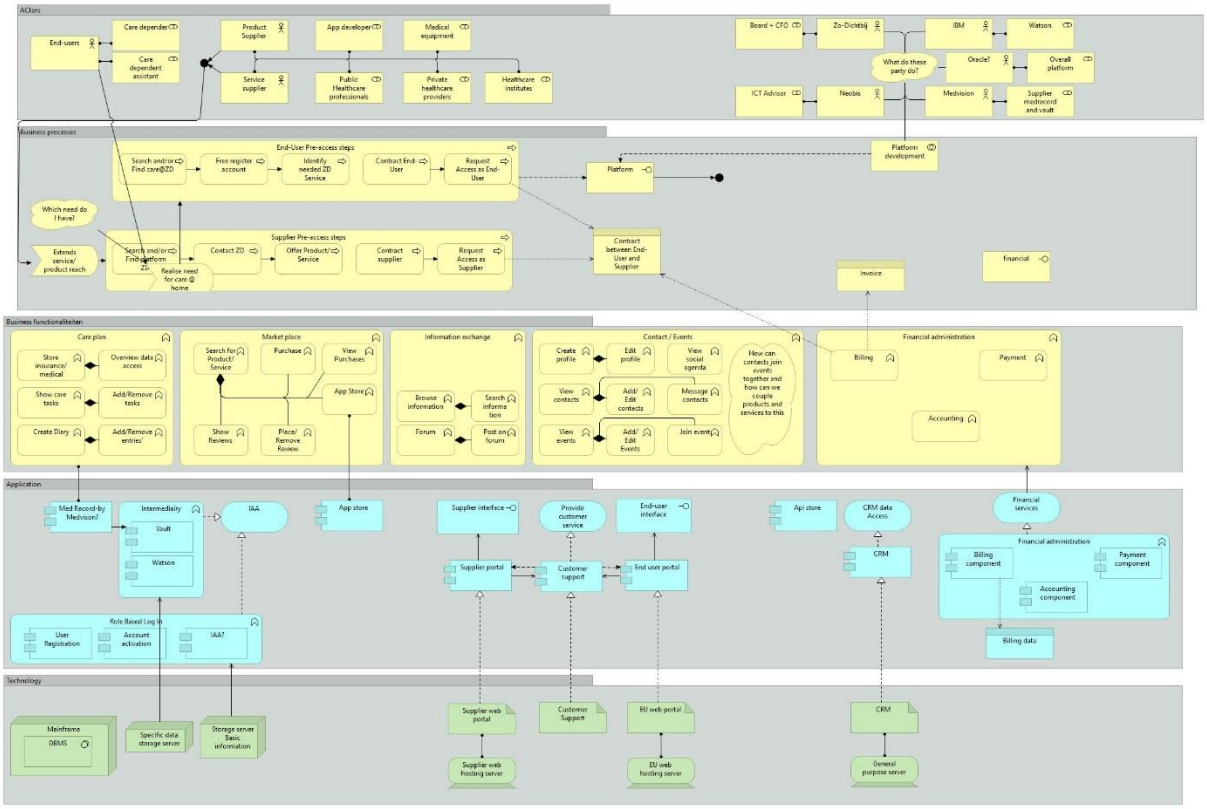


Figure 34: Archimate v1.2

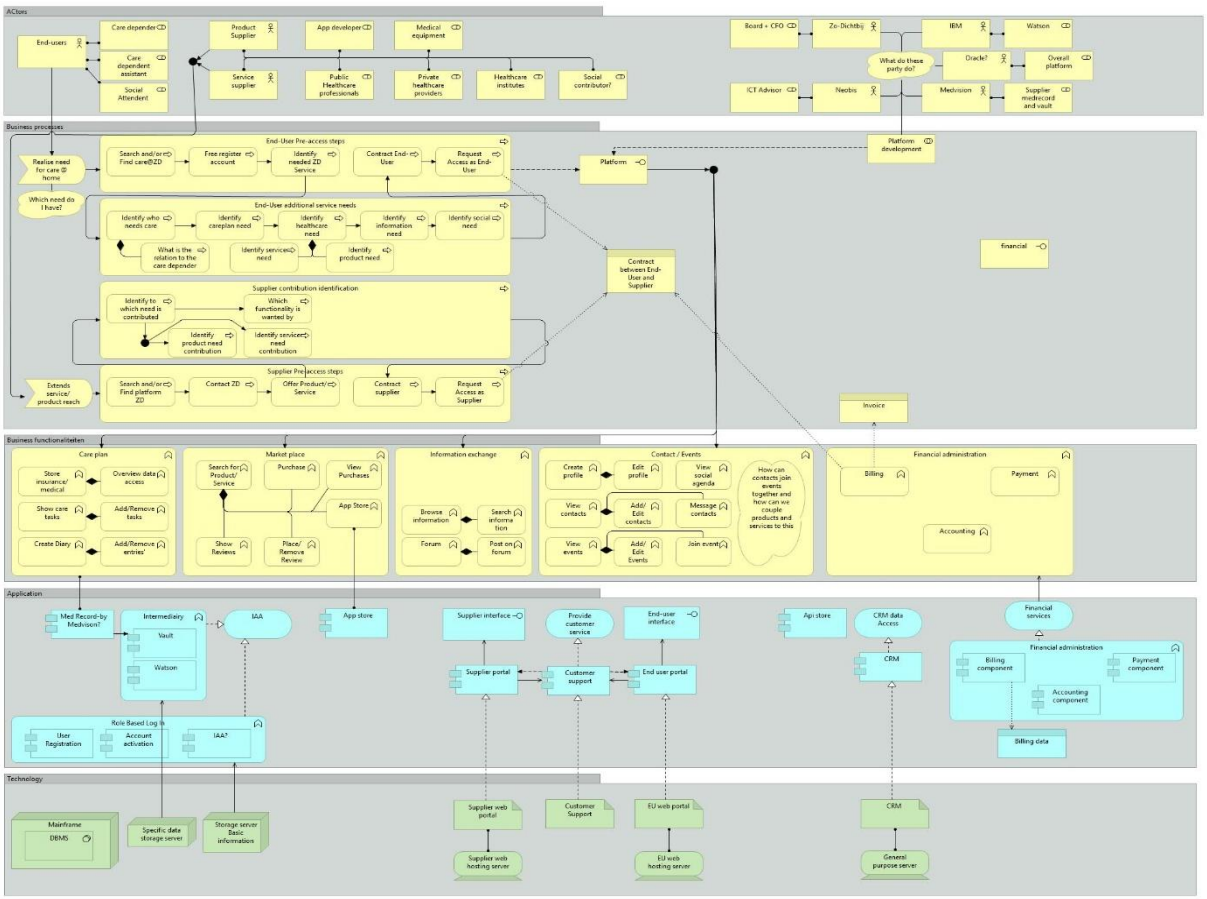


Figure 35: Archimate v1.3

V.C - Iteration Round two results

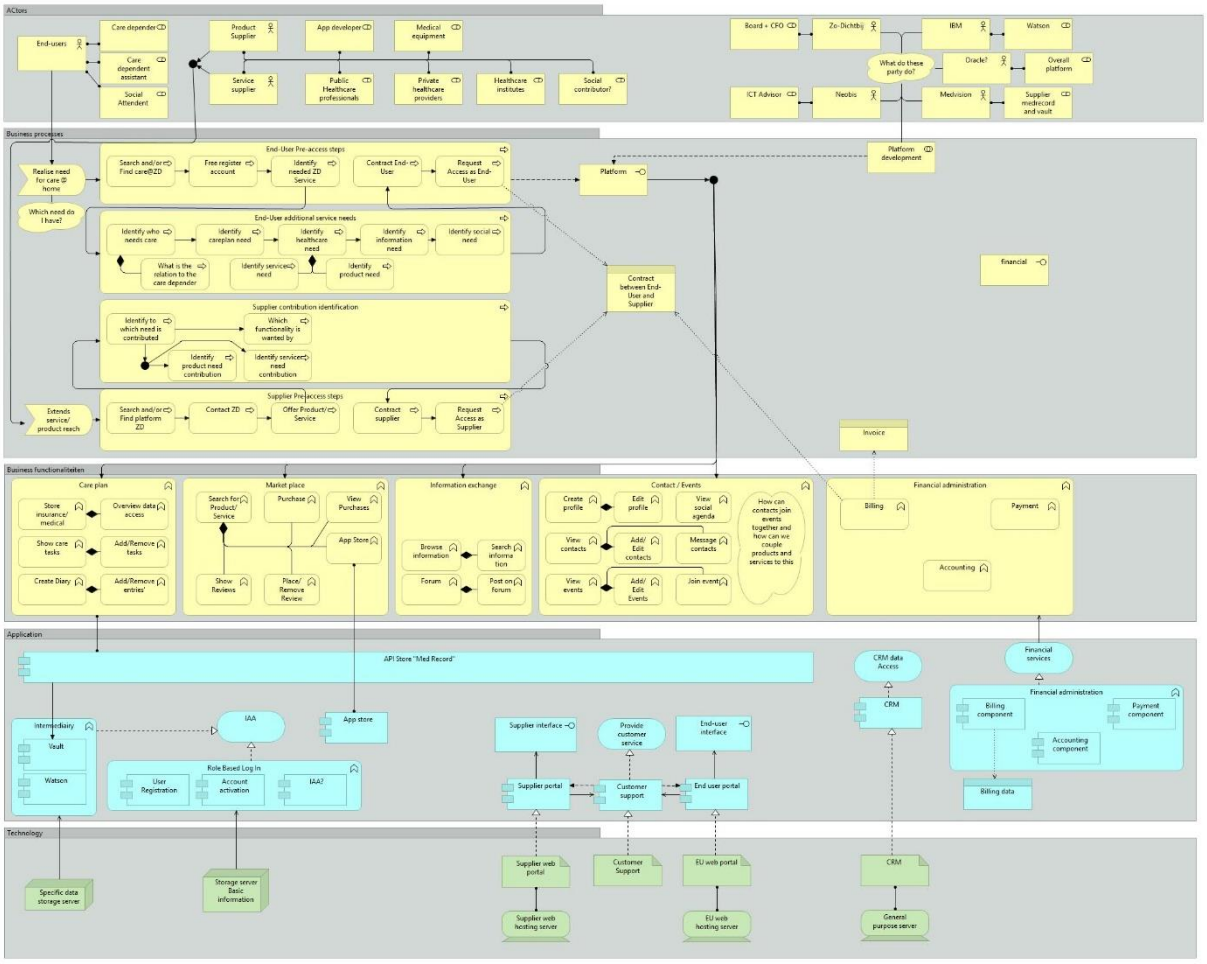


Figure 36 Global Archimate v1.4

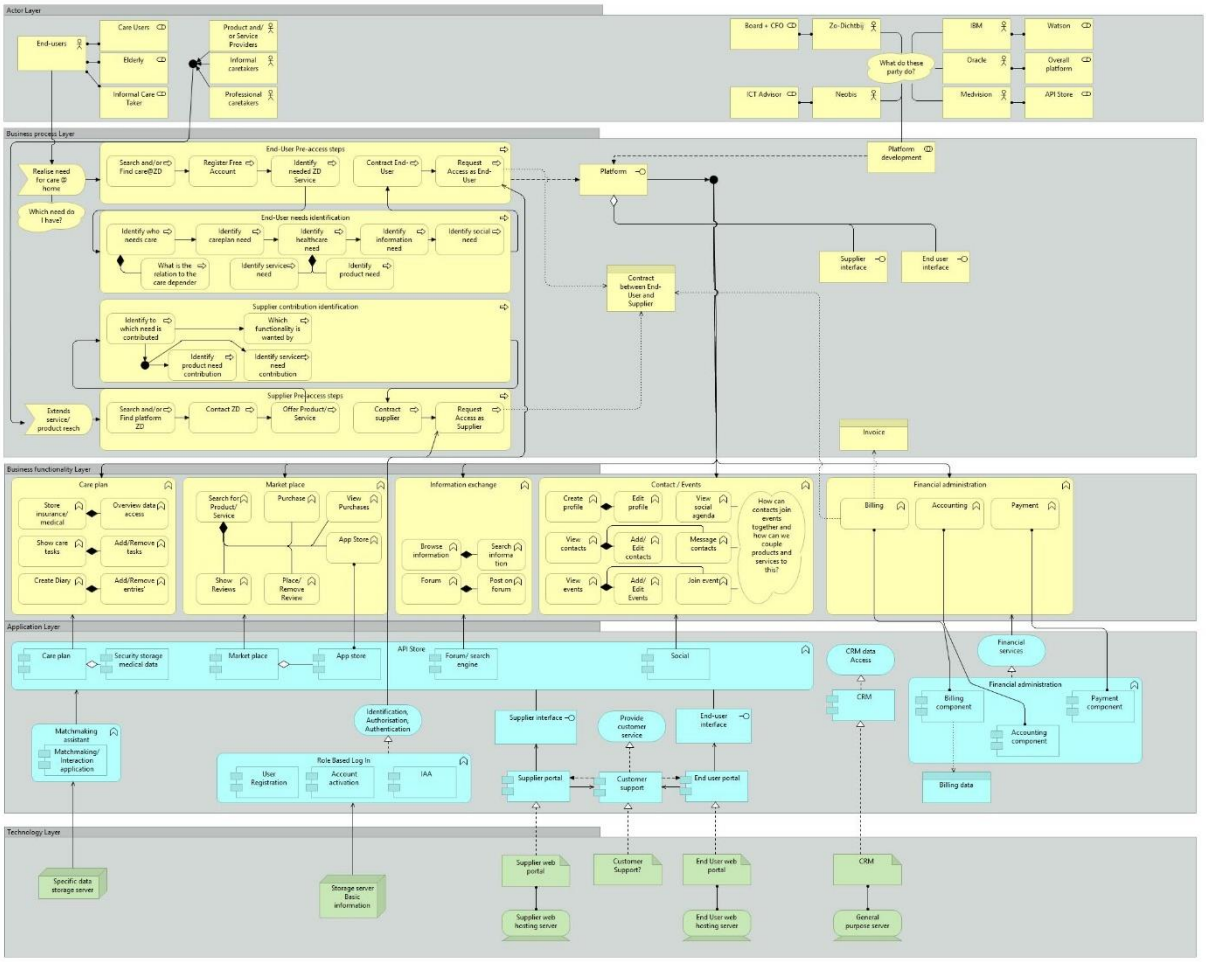


Figure 37: Archimate v1.5

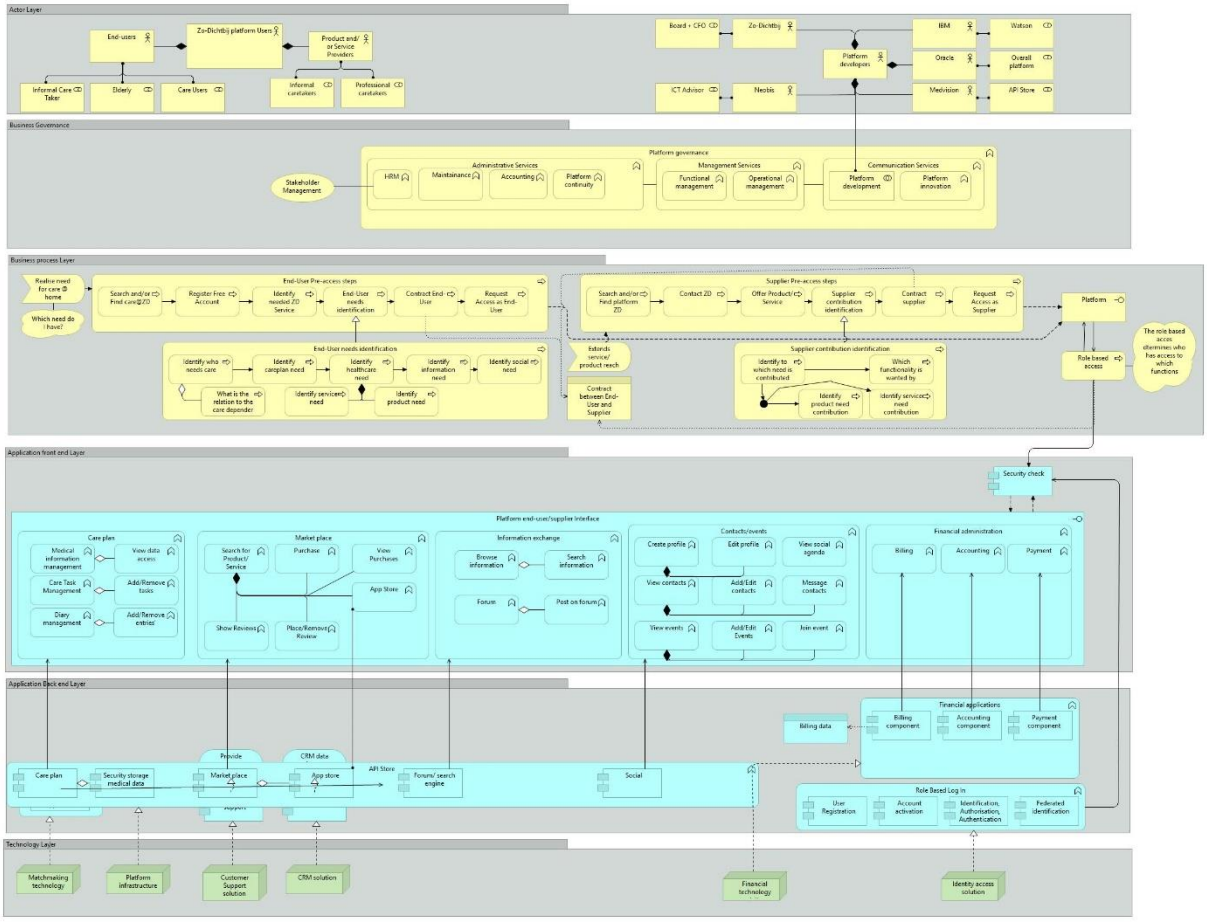


Figure 38: Archimate v1.6

V.D - Iteration round four results

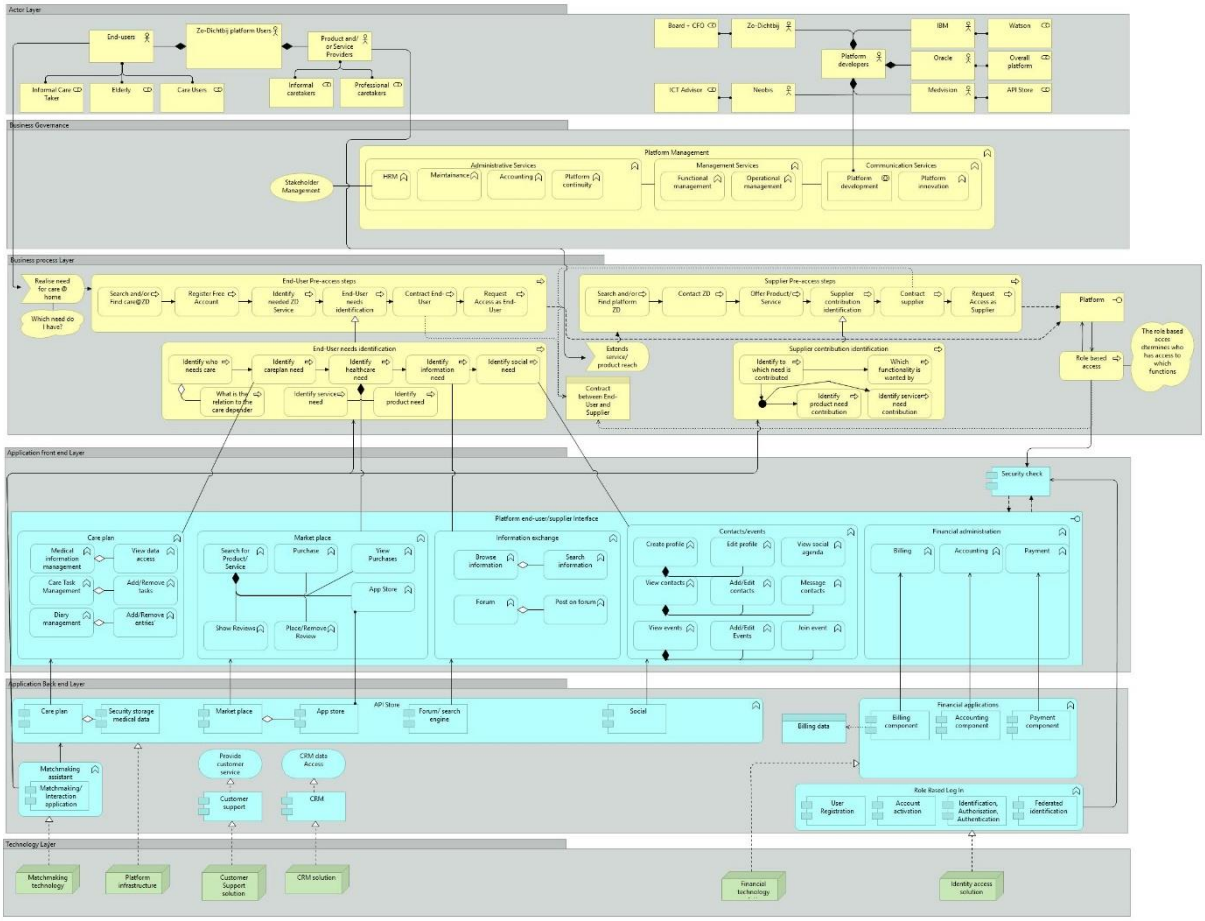


Figure 39: Archimate 1.7

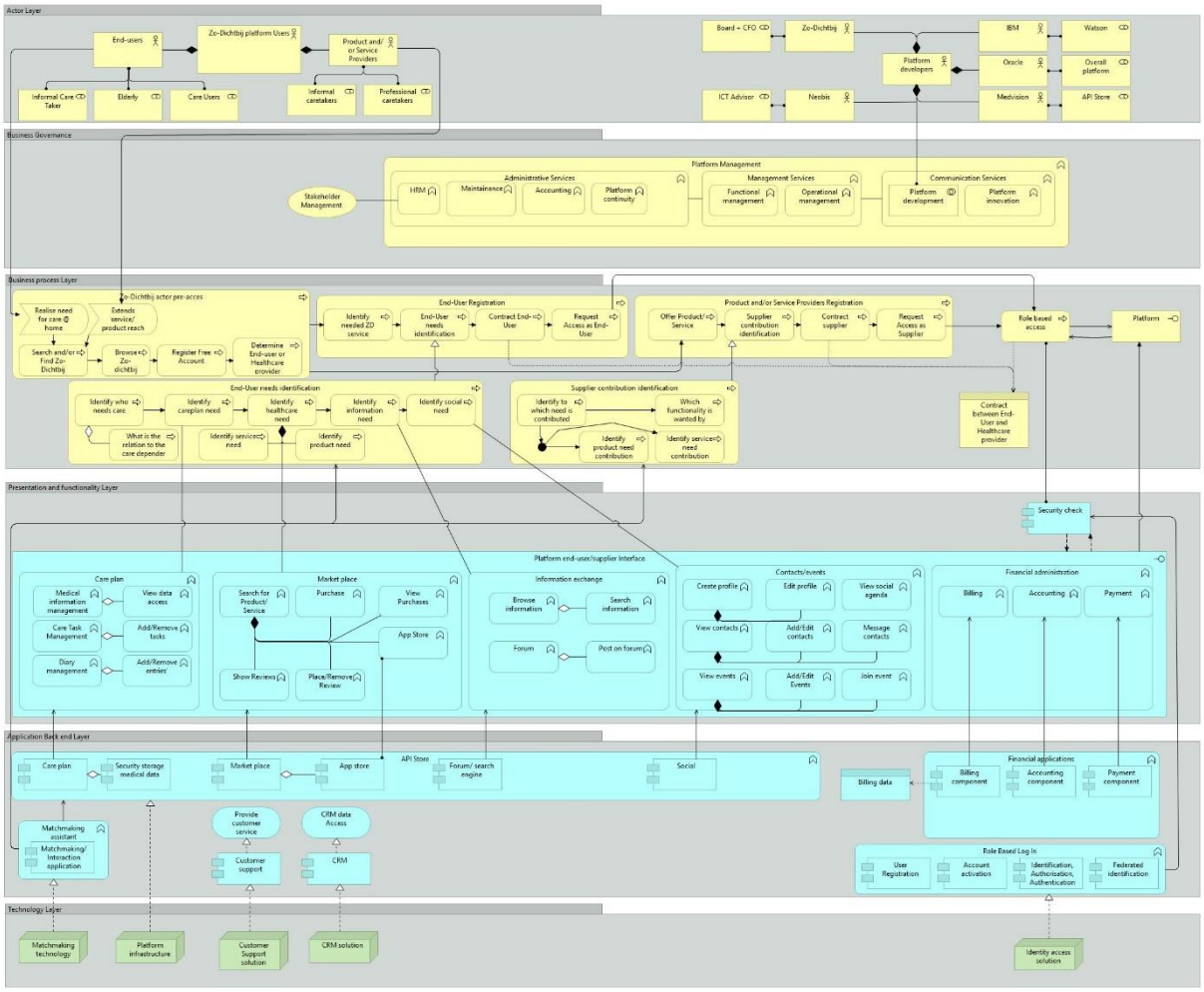


Figure 40: Archimate 1.8 final

VI - Evaluation

VI.A - Questionnaire

The questionnaire in the google format.

Section 1 of 5

NORA review solution architecture Zo-Dichtbij

Beste meneer/mevrouw,

Dit is een eerste review gebaseerd op de toegezonden solution architecture van de private stichting Zo-Dichtbij en hun partners. In dit stadium zijn de oplossingen nog niet toegespitst op de producten die de partners leveren om een algemeen beeld te schetsen. Het ontwerp en mijn onderzoek gebeuren in twee iteratie stappen. Dit is de eerste iteratie waarmee een eerste set vragen wordt beantwoord en het niveau van de solution architectuur naar een hoger niveau wordt getild.

Ik wil u alvast van te voren hartelijk danken voor uw tijd en hulp.

De stichting Zo-Dichtbij wil mensen langer zelfstandig thuis laten wonen door hen informatie te verschaffen over producten in de zorg en het smart living domein. Dit is een koppeling van informatie over diensten en producten tussen afnemers en leveranciers in het publieke/private domein.

De vragen hieronder moeten antwoord geven op de onderzoeksvraag: "Hoe toepasbaar is de NORA voor private partijen die willen communiceren en aansluiten bij de overheid". Ik wil u vragen de onderzoeksvraag in het hoofd te houden tijdens het beantwoorden van de vragen.

De vragenlijst bevat 5 secties: Deze toelichting, persoonsgegevens, solution architectuur, NORA en de afsluiting. Uw antwoorden verzend u op het eind en krijg ik toegestuurd. U kunt deze vragenlijst in uw eigen tijd invullen en er is geen tijdslimiet, het is tenslotte geen toets. Wat ik u zou willen vragen om indien dit mogelijk is, de vragenlijst zo snel mogelijk in te vullen en uiterlijk op 17 juni mij toe te sturen. Mochten er problemen zijn dan hoor ik dat graag, dan ga ik het voor u proberen op te lossen.

Alle vragen staan aangegeven als verplicht. Mocht u het antwoord op een vraag niet weten of niet kunnen invullen naar uw mening, dan wil ik u verzoeken om of de reden op te geven of een - in te vullen. Ik wil u graag vragen om een toelichting te geven bij elke vraag.

Als u nog verdere vragen heeft kunt u mij bereiken op rubenjan.greve@ictu.nl en 06-21561417.

Met vriendelijke groet,
Ruben Greve Student MOT - TU Delft

Figure 41: Questionnaire part one

Section 2 of 5

Persoonsgegevens

Dit deel gaat over uw persoon, zodat de informatie in context te plaatsen is. Daarnaast maakt dit het contact makkelijker zodat ik uw mogelijke vragen kan beantwoorden of voor mij om navraag te doen.

Wat is uw naam? *

Long-answer text

Wat is uw functie? *

Long-answer text

Wat is uw deskundigheid omtrent architectuur? *

Long-answer text

Bent u werkzaam in het publieke of private domein? *

- Publiek
- Privaat
- Other...

Bij welke instantie ben u betrokken? *

- Zo-dichtbij
- ICTU
- Other...

Geeft u toestemming om uw antwoorden te gebruiken in het onderzoek? *

- Ja, met naam
- Ja, anoniem
- Nee

Figure 42: Questionnaire parttwo

Section 3 of 5

Solution architecture

Dit deel gaat over de solution architecture zelf.

Wat is uw eerste indruk van de solution architectuur? *

Dit gaat over de gehele architectuur in zijn algemeenheid.

Long-answer text

Mist u iets in de beschreven architectuur views naast de aangegeven limitaties? *

Long-answer text

Vindt u dat de architectuur overeen komt met de wensen van de actoren en waarom vindt u dat? *

Long-answer text

Wat kunt u zeggen over de opbouw van de hoofdstukken? *

Volgen de hoofdstukken logisch op elkaar of had u een andere volgorde gebruikt?

Long-answer text

Als u de context in H1.4 in het achterhoofd houdt, volgt het ontwerp dan de context en kunt u uitleggen waarom wel of niet? *

De context legt de situatie uit waarin zich een probleem voordoet en of de voorgestelde oplossing dit oplost.

Long-answer text

Figure 43: Questionnaire part three A

In welke mate is de semantiek, de syntax beschrijving, eenduidig en helder? *

U kunt dit vinden in 5.3 – Information needs and semantics.

Long-answer text

Wat vindt u van het niveau van beveiliging? *

U kunt dit vinden in H6 en H7.

Long-answer text

Zou u de mate van robuustheid kunnen beschrijven dit platform ten opzichte van het wegvallen van het systeem? *

Deze vraag gaat over de gehele architectuur.

Long-answer text

In welke mate zouden de diensten, waaruit de totale architectuur is opgebouwd, los van het platform kunnen draaien? *

Zijn alle diensten los te ontwerpen en te realizeren?

Long-answer text

Verwacht u dat de ontworpen architectuur oplossing de opschaling naar nationaal niveau mogelijk maakt? *

Het minimum viable product wordt ontworpen in samenwerking met de gemeente Rotterdam. Deze architectuur oplossing beschrijft echter opschaling naar nationaal niveau.

Long-answer text

Wat zijn uw verwachtingen omtrent de interoperabiliteit van de architectuur? *

Long-answer text

Wat is er nodig om de privacy van de Zo-Dichtbij actoren (end-users en product and/or service providers) te beschermen en denkt u dat dit al voldoende gedaan is? *

Dit kunt u vinden in het door het hele document heen en met name in H7.

Long-answer text

Figure 44: Questionnaire part three B

Section 4 of 5

NORA

Dit deel gaat over de NORA zelf. Hoe deze toepasbaar is voor private partijen die willen aansluiten en communiceren bij bijvoorbeeld het ministerie van volksgezondheid. U kunt de solution architecture gebruiken als casus.

Wat is uw eerste indruk omtrent de toepassing van de NORA? *

De NORA principes zijn door het hele document toegepast maar een overzichtstabel vindt u in appendix IV.

Long-answer text

In hoeverre zijn er voor deze solution architecture ontoepasbare NORA-principes en waarom? *

De NORA principes zijn door het hele document toegepast maar een overzichtstabel vindt u in appendix IV.

Long-answer text

Wat kunt u zeggen over het toepassen van de GDI bouwstenen, die de NORA voorschrijft, in deze solution architecture? *

Dit kunt u vinden in H3.6. Missen hier nog toepasbare bouwstenen? Dit betreft met name AP07.

Long-answer text

Hoe vind u dat de Pas-Toe-of-Leg-Uit standaarden zijn toegepast en missen er nog standaarden? *

Dit kunt u vinden in appendix V.

Long-answer text

In welke hoedanigheid is de solution architectuur voor u NORA-compliant? *

Dit is een vraag naar uw mening. Voldoet de solution architecture aan alle NORA principes?

Long-answer text

Zijn er verder nog voor- of nadelen van de NORA voor private partijen die nu nog niet zijn besproken? *

Figure 45: Questionnaire part four A

Denkt u dat het toepassen van de NORA ervoor heeft gezorgd dat de beveiliging van het systeem is gewaarborgd? *

Dit kunt u voornamelijk vinden in H6 en H7.

Long-answer text

Zorgt de toepassing van de NORA in deze solution architecture dat het systeem robuust is? *

Deze vraag gaat over de gehele architectuur.

Long-answer text

Maakt deze toepassing van de NORA in de solution architecture het platform opschaalbaar naar nationaal niveau? *

Dit gaat over de hele architectuur.

Long-answer text

Is het NORA-compliant zijn van een private partij (Zo-Dichtbij) een probleem voor andere organisaties die willen aansluiten bij deze partij (Zo-Dichtbij) en welke niet NORA-compliant zijn? *

Zo-Dichtbij wil een matchmaker zijn die zorg- gebruikers en -leveranciers aan elkaar verbindt. Zijn er mogelijke problemen voor partijen die later ook diensten willen aanbieden via bijvoorbeeld de API-store?

Long-answer text

Heeft de toepassing van de NORA gevolgen gehad voor het niveau van interoperabiliteit? *

Dit gaat over de gehele architectuur.

Long-answer text

Heeft de toepassing van de NORA gevolgen gehad voor het niveau van flexibiliteit? *

Deze vraag gaat over de gehele architectuur.

Long-answer text

Denkt u dat het toepassen van de NORA ervoor heeft gezorgd dat Zo-Dichtbij kan samenwerken met de overheid? *

Dit is een vraag naar uw mening op basis van het meegestuurde werk en de NORA. Zou u deze kunnen toelichten en aangeven waar u mogelijke problemen ziet?

Long-answer text

Figure 46: Questionnaire part four B

Section 5 of 5

Overige

Dit is het laatste deel van de vragenlijst. Hartelijk bedankt voor uw tijd!

Mist u nog iets? *

U kunt vragen missen cruciaal voor het onderzoek of anders deze ruimte gebruiken om een algemeen commentaar te plaatsen.

Long-answer text

Bent u bereid tot een verdiepend interview om uw antwoorden toe te lichten en vragen te beantwoorden? *

- Ja
- Nee

Figure 47: Questionnaire part five

VI.B - Evaluation criteria combined with questions

Table 9: Evaluation criteria matched with question s“Are you building the right thing?”

Validatie criteria: Voldoet de solution architecture aan de user requirements (Zo-Dichtbij requirements)	Question
Completeness	Wat is uw eerste indruk van de solution architectuur?

Completeness	Mist u iets in de beschreven architectuur views naast de aangegeven limitaties?
Functional requirements	Vindt u dat de architectuur overeen met de wensen van de actoren en waarom vindt u dat?
Consistency	Wat kunt u zeggen over de opbouw van de hoofdstukken?
Consistency	Als u de context in H1.4 in het achterhoofd houdt, volgt het ontwerp dan de context en kunt u uitleggen waarom wel of niet?
Consistency	In welke mate is de semantiek, de syntax beschrijving, eenduidig en helder?
Security	Wat vindt u van het niveau van beveliging?
Robustness	Zou u de mate van robuustheid kunnen beschrijven dit platform ten opzichte van het wegvallen van het systeem?
Scalability	In welke mate zouden de diensten, waaruit de totale architectuur is opgebouwd, los van het platform kunnen draaien?
Scalability	Verwacht u dat de ontworpen architectuur oplossing de opschaling mogelijk maakt?
Interoperability	Wat zijn uw verwachtingen omtrent de interoperabiliteit van de architectuur?
Flexibility	Met de solution architectuur in ogenschouw, hoe beoordeelt u dan de flexibiliteit van het systeem en heeft u tips?
Privacy	Wat is er nodig om de privacy van de Zo-Dichtbij actoren (end-users en product and/or service providers) te beschermen en denkt u dat dit al voldoende gedaan is?

VI.C - Verification criteria combined with questions

Table 10: Verification criteria with questions “Are you building it right?"

Verificatie criteria: De beoordeling of het ontwerp voldoet aan een wettelijke eis, specificatie, of opgelegde voorwaarde (NORA).	**Question**
Completeness	Wat is uw eerste indruk omtrent de toepassing van de NORA?
Completeness	In hoeverre zijn er voor deze solution architecture ontoepasbare NORA-principes en waarom?
Completeness	Wat kunt u zeggen over het toepassen van de GDI bouwstenen, die de NORA voorschrijft, in deze solution architecture?
Completeness	Hoe vind u dat de Pas-Toe-of-Leg-Uit standaarden zijn toegepast en missen er nog standaarden?
Consistency	In welke hoedanigheid is de solution architectuur voor u NORA-compliant?
Consistency	Zijn er verder nog voor- of nadelen of voordelen van de NORA voor private partijen die nu nog niet zijn besproken?
Security	Denkt u dat het toepassen van de NORA ervoor heeft gezorgd dat de beveiliging van het systeem is gewaarborgd?
Robustness	Zorgt de toepassing van de NORA in deze solution architecture dat het systeem robuust is?
Scalability	Maakt deze toepassing van de NORA in de solution architecture het platform opschaalbaar naar nationaal niveau?
Interoperability	Is het NORA-compliant zijn van Zo-Dichtbij een probleem voor andere organisaties die willen aansluiten bij Zo-Dichtbij en welke niet NORA-compliant zijn?

Interoperability	Heeft de toepassing van de NORA gevolgen gehad voor het niveau van interoperabiliteit?
Flexibility	Heeft de toepassing van de NORA een positief of negatief effect gehad voor het niveau van flexibiliteit?
Interoperability	Denkt u dat het toepassen van de NORA ervoor heeft gezorgt dat Zo-Dichtbij kan samenwerken met de overheid?

VII - NORA table results

Table 11: The NORA principles discussed with the platform developers in 2015 and actualized in 2016. Red is 2015 PSA, Blue is 2016 SA.

ID	Description	Application/effect	Relevance
AP01	Services are reusable (The service is designed so that other organizations can reuse them in private services)	What are potentially reusable services / facilities Zo-Dichtbij? Who could be interested in using it? https://www.logius.nl/diensten/samenwerkende-catalogi/ This AP is not applicable. Unless Zo-Dichtbij wants to openly share their information and systems this AP does not hold in terms of competition. If Zo-Dichtbij wants to share The use of the API store will enhance this principle and because the functionalities are designed as separate services. The service should use open standards, but cannot be registered in a national service register. The services are designed in a general way and the Zo-Dichtbij specification is minimized.	2
AP02	Uncoupling with services (The steps in the service process are opened up as a service)	Zo-Dichtbij is not (yet) put down as a service process. There are as of now no definite process steps. That makes this principle irrelevant for the time being. The main service is Zo-Dichtbij is the matchmaking between end-users and healthcare providers.	0
AP03	Services complement each other (The service complements other services to and does not overlap)	What role Zo-Dichtbij therein (compete, connect, ...) and how Zo-Dichtbij fills that role than (in terms of architecture, but also in terms of communication). Are the target groups of the various initiatives under or not? The internal process steps are meant to be unique in this system. Between external systems this is logical for marketing concepts. The smart living area is underpopulated and therefore Zo-Dichtbij seems to fit. The combination of the	0

		matchmaking assistant and the API store make Zo-Dichtbij unique. The actors of the system are also clearly described.	
AP04	Position of the service (The service is clearly positioned in the offerings)	Also, look at AP03. Describe and communicate Zo-Dichtbij as a service in context of broader social and / or public service. This seems logical in terms of marketing. Integration of services is the core concept of Zo-Dichtbij. This is realized by the Matchmaking assistant and the services are clearly described in the SA. The positioning of the entire platform is market research and done previously.	2
AP05	Accurate service description (The service is accurately described)	Someone of the foundation Zo-Dichtbij has to take this up This is taken into account during the SA design. The services are described in general and what the expected functions are. In the process description is stated who does what, and what the result is of the function. The service description forms the basis of the quality baseline but this has not been made yet. SLAs are mentioned in the information security layer.	2
AP06	Use standard solutions (The service uses standard solutions)	What are the relevant standards? It is difficult to use standard solutions and building blocks because of competition. This is different for private parties compared to the government. The use of standard solutions such as XML however is possible. What are standard solution that Zo-Dichtbij can use? RBAC is used as well as standard solutions for IAA. The semantic model is based upon the care dictionary of Dutch healthcare. How do the developers use standard solutions?	2
AP07	Use the national building blocks (The service uses the nationwide building blocks of e-Government)	This involves building blocks designed for government organizations or for communication with government organizations. http://www.noraonline.nl/wiki/Bouwstenen. Most of the building blocks are not available for private organisations and is therefore not applicable. When new developments arrive which couples the government building blocks to private ones, this might come into relevance again.	1
AP08	Use open standards (The service uses open standards)	This principle does not only mean the use of open standards, but also prohibits the use of closed (proprietary) standards. Open standards prevent vendor lock-in (dependence from a supplier) and increase the flexibility of information and the interchangeability of information between different parties. A list can be found at: https://www.forumstandaardisatie.nl/open-standaarden/lijsten-met-open-standaarden/ The list of open standards is noted above. A selection must be made.	2

AP09	Preferred Channel: Internet (The service can be requested via the Internet)	This is a principle of Zo-Dichtbij The current state of the architecture does not have major limitations for website use. How this is realized in the technology layer is the responsibility of Zo-Dichtbij and its developers.	2
AP10	Additional channel (The service can, except via internet, be accessed through at least one other channel for personal contact)	The service aims to connect end-users and healthcare providers. This service is delivered completely over the internet. The further contact (and therefore channels) between end-user and healthcare provider is not responsible for this service. The internet will be the main channel for Zo-Dichtbij.	0
AP11	Similar results regardless of channel (The result of the service is similar, regardless of the channel through which the service is requested or delivered)	Also look up, AP10 This principle is not applicable for Zo-Dichtbij No changes from 2015	0
AP12	One-time query (Customers are not asked for information already known)	To what extent does Zo-Dichtbij query data e.g. registering suppliers and / or customers in question, which have already been registered in another context in a (government) organization? Is such data reusable (legal, semantic and technical feasibility)? When the basic registers of the government cannot be used, Zo-Dichtbij must store data itself. This also places constrains on the IAA of the users. This also places constrains on costs and design of the platform. The information flows are modelled. The main sources of information storage and generation are modelled in the information flow model. The semantic model describes what information goes through the system. Is all the data accounted for and does this have to be checked with the government(non -private AP)?	2
AP13	Source Registrations are leading (All the information objects are derived from source registrations)	See AP12 This seems logical in terms of marketing. (geldt ook voor bedrijven: basis bedrijfsproducten/prijzencatalogus) Is the information model compleet? Are there any information objects missing?	2

AP14	Reporting back to source holder (The service reports doubts about the accuracy of information on the source)	If Zo-Dichtbij as a source registrant is in possession of certain information, Zo-Dichtbij must offer a service which allows the reporting and restoration of false registration. If Zo-Dichtbij is a user of source data, the question is whether Zo-Dichtbij is able to detect errors and whether it is the right party to report back this. What are quality requirements for these records? The government basic registers can be helpful if they can be used. If not than Zo-Dichtbij must determine how to use IAA for their actor data.	0
AP15	Target Binding (The purpose for which information is (re-)used is compatible with the purpose for which it was collected)	This point is essential for the (re-)use of personal data. These use of this data requires a (mandatory) Privacy Impact Analysis. With every information request that the community will have, has to be seen to what extent the purpose of accessing that data coincides with the goal of the data when it was registered. Therefore, meta-information about the source data should provide sufficient understanding of the purpose of registering and provide (legal) possibilities for reuse. This will have to be done in the technology layer. The addition of the Care Plan makes the information person bound and contains very sensitive information. Therefore, the information must be well secured. A privacy impact analysis is advised as well to take privacy by design into account in further development. In the SA it is accounted for where data is generated and where it comes from.	2
AP16	Identification information objects (All the information objects are uniquely identified)	This is important because cooperating parties exchange information. Zo-Dichtbij must figure out what data is shared with other parties through and over the platform and it should figure out what the semantics and syntax should be. Unique identification is necessary in order to be able to use the same information within a variety of sources (for example, in co-operation in chains) unambiguously. It is of importance that data can be identified in only one way. This can be done through the use of shared semantics as seen in the semantic model or by using basic government registers if this is possible (KVK, BSN). This AP is difficult for Zo-Dichtbij as communication with competitors is difficult and will need to determine with the MVP what data is generated and shared with other parties. How data is used and named can be agreed upon in the contract, but this shouldn't exclude the majority of providers.	2
AP17	Information Objects described systematically (All the information objects are	Make information models and describe them. see AP16 Collaboration is only possible if those involved understand unequivocally what the relevant information objects are and are	2

	described systematically)	able to use them. This requires a systematic description. Such description should provide an understanding of: - The goal, the context and the significance of the information object - The ability to re-use objects within (legal) frameworks - The traceability, identification, accessibility and exchangeability Information objects are determined as well as meta-data. This is done using the care dictionary http://www.thesauruszorgenwelzijn.nl/ and an example SA LRZa. The government is taken as the source for relating the semantics as this is the goal of the SA (national level, VWS) but it is not known what the effect is to connect to other parties.	
AP18	Spatial Information by Location (The service provides access to spatial information, location-wise)	This can certainly be relevant (e.g.cards with districts where district teams are active, or cards that show a particular concern or general density dependence) This depends on the question of the customer. The customer indicates whether the response should be presented as a spreadsheet, a geographic map, or otherwise. This data is stored during the registration process and allows the matchmaking assistant to offer services and product and/or service providers on basis of that information.	2
AP19	Customer perspective (The service is designed from the perspective of the customer)	This is an essential principle, because (part of) the target can still be something Digi inept. How Zo-Dichtbij going to handle this? Which groups are targeted and how does architecture play a role? This is described in the actor analysis in the business architecture. The end-user is taken as main actor during design.	2
AP20	Personal approach (The service approaches identified customers in a personal way)	This principle can be very relevant, but the questions are what is legally feasible and what is actually desirable. The customer must be able to indicate that personally (opt-in and permanent means to opt-out). This seems logical in terms of marketing. The Personal approach means that the platform offers the possibility to store personal preferences of a recipient. In the process of intake of an information request there is room for a dialogue with the customer on the exact question and the expected results. Herein lies the personal approach taken. The matchmaking assistant is used for this if the platform actor agrees to share the information (however, this sharing is crucial). Are there any jurisdictional matters connected to this?	2
AP21	Bundling of Services (The service is bundled with	Closely related to AP03 and AP04. See there.	1

	related services so that they can be requested together with one request)	Previous Zo-Dichtbij research has determined what platform actors want. The bundling of supply and demand is the main function of the platform. The collaboration between developers offers a bundling of services but is more a realization of Zo-Dichtbij services. From a competition perspective Zo-Dichtbij acts alone at first sight.	
AP22	No wrong door (Government offices / services link directly to the service)	ZED is in itself a service counter or portal that refers to services. It is of interest that the information is targeted and that the communication is done in the right form. All information is clearly stated and interaction design will help guiding the user to the right location. This is also researched by TUD parties connected to Zo-Dichtbij. There will be only one website so all connections must guide to this website. The platform of Zo-Dichtbij cannot be found in the government catalogus.	1
AP23	Automatic service (The service is provided automatically after certain signals)	See AP20 An information request may have a repetitive character. This means that one and the same question is answered periodically. For example, a monthly overview of treatments per customer or supplier. If a customer asks for a repetitive service. It must come automatically.	2
AP24	Proactive offering (The service supports proactivity of services inside and outside the organization)	See AP20, Importantly, the behaviour that can be provoked by Zo-Dichtbij. Zo-Dichtbij will often not offer services automatic or proactively. Often, it will be initiated by the connected healthcare providers using information via Zo-Dichtbij. It is therefore important that Zo-Dichtbij and healthcare providers make very clear agreements about the opt-in principle as described in AP20. Suppliers who do not comply with these regulations, cannot join the platform. This AP is taken into account in the contract of the Zo-Dichtbij actors. All actors should provide clear information about their services through the registration services combined with the matchmaking assistant to help steer the information requests. Signals that activate a certain process are taken into account in the management section of the business architecture.	2
AP25	Transparent services (The customer is informed about the state of affairs of the service requested)	This is particularly important when providing services with transactions. To what extent is Zo-Dichtbij intermediary, or even supplier? Can Zo-Dichtbij as intermediary also provide this principle or does the responsibility lie at the original supplier? Zo-Dichtbij is designed to be a matchmaker and will primarily connect end-users and providers. This is made transparent in the review system and a clear contract between end-user, Zo-Dichtbij and provider. The financial system is a wish for the future when memberships with additional functionalities are offered.	2

		The website needs to be online 24/7. All platform actors actions can be traced back to thatactor.	
AP26	Customer has access (The customer has access to the personal information and the use of that data)	The important question here is which data is recorded by Zo-Dichtbij and what information they connect to that data. When this implies personal data, this principle is always applicable. This is especially relevant in the recording of process data regarding information requests by stakeholders. The contract and user data are insightful for the platform actors. The process is automated, and when actual persons are involved this must be recorded. (this can be done in the diary).	2
AP27	A responsible organization (One organization is responsible for the service)	This principle comes into effect during the following questions: - Which services are the responsibility of Zo-Dichtbij and in which services is Zo-Dichtbij only an intermediary? - How do we ensure a clear responsibility (accountability) on Zo-Dichtbij? For problems with a service (for example, providing false information to an end-user) not all parties can be responsible at the same time. This must be agreed upon in the contract. On the other hand, rejecting responsibilities through the use of a disclaimer seem unwise. The success of the platform stands or falls with the quality of service and the responsibility that goes with it. This goes hand in hand with clear communication through a communication plan that must be made.	2
AP28	Established agreements (Service provider and recipient have established agreements on the provision of the service)	See AP05. It is important that the recipient knows exactly what service he / she receives from whom and under what conditions. This AP calls for the contract named in AP 26 and 27. Another fact is that there must be terms and conditions and perhaps a disclaimer, see AP27. These agreements have effects on the amount of security.	2
AP29	The service complies with the norm (The service provider shall bear the consequences if the service is different from agreements and standards)	This principle comes into effect especially in chains or other forms of cooperation. It is important that it is perfectly clear what standards and other agreements are made between Zo-Dichtbij and cooperating parties. Parties which do not conform to those agreements or standards provide a suitable solution themselves. Preconditions for quality service are optimal availability and accessibility of data sources. To facilitate this, the platform makes agreements with suppliers on which methods and standards to use. The responsibility to commit these agreements lie with the parties participating in the platform.	2
AP30	Accounting for services delivery is possible	See AP25 If Zo-Dichtbij registers data, the following must be at least clear	2

	(The way in which the service is provided, can be accounted for)	from the record: - Which Information questions are asked and by whom? - Who handled the information request and when? - Which data sources have been approached and used? - What conditions are taken into account before the action (e.g. privacy impact analysis)? - To what extent did quality issues arose for source data? - To what extent was the question owner satisfied with the result? On the basis of such information can Zo-Dichtbij justify its services. These questions must be answered in the information and technology(data) view. This is also taken into account in the semantics. A audit trail must be made. This must also done in accordance to the information and semantics model.	
AP31	PDCA cycle in quality control (The quality of the service is controlled on the basis of cyclic feedback).	Zo-Dichtbij must evaluate on a structural basis and act upon those results. See AP27. The quality of answering information requests is a critical success factor for Zo-Dichtbij when it comes to confidential patient information. Zo-Dichtbij shall use the registration of the service process for controlling quality. A quality and review plan must be written. The complaints are handled through the information and communication section in the business architecture.	2
AP32	Quality control at the highest level (Control on the quality of the service is anchored at the highest level of the organization)	See AP27. Zo-Dichtbij will take care of the management of the system while The developers of the system will deliver and build and maintain what is delivered. What service contracts will be offered by the developers?	2
AP33	Baseline quality services (The service meets the baseline quality)	A baseline quality services does not seem relevant to Zo-Dichtbij in the first instance. If the platform is scaled to a national level (with a suitable organizational structure), it may become relevant. The baseline is especially important if multiple parties work together in chains or networks. Zo-Dichtbij could apply such a grouping for multiple healthcare suppliers when those parties use each other's data or services. A baseline describes the manner in which, with the use of the methods, standards and means, a baseline must be created to make sure that the security and quality level of services is maintained. This creates uniformity in the approach to the services provided by the various participants. From that uniform baseline the platform has better control over the quality of its service.	1

AP34	Accountability of the control on quality (The service provider accounts for the degree of control, in consultation with the customer)	See AP31, AP32 and AP 33 It is important that during the development an improvement plan is taken into account. This forms a basis. When the platform is actually running the data generated could be used to improve the plan. How does the management account for responsibilities? Implement the PDCA-cycle?	1
AP35	Continuity of the service (The delivery of the service is continuously guaranteed)	To make sure that the services of the platform Zo-Dichtbij are continuous, clear agreements must be made with all users. For the services, where Zo-Dichtbij is an intermediary, it should be clear that continuity falls under the responsibility of the healthcare provider. How will Zo-Dichtbij handle disappearance of a service? The technical continuity falls under the responsibility of the platform developers Ch. 6.; this has to be concluded in a contract. The financial continuity falls under the responsibility of the platform management; this is also seen in section 4.3.3.	2
AP36	Restoration of a service (In case of failure to provide a service, the initial situation is restored)	This is particularly relevant services trades. See also AP25. This is very important when considering the functionalities offered by the API store, especially the care plan and the market place. The platform maintenance will be the responsible party to handle restoration and communication and information will handle the messaging.	2
AP37	Identification, authentication and authorization (Service provider and customer are authenticated when the service is of a confidential nature)	Where there is a service offered based on personal information, IAA is necessary. Additionally, a PIA is required. It depends on the supplied services whether one factor authentication is sufficient, or whether a two factor is needed. Zo-Dichtbij might possibly use data from different sources registrations. Those sources might contain confidential medical information. The manner of identifying, authenticating and authorizing of the service requires explicit attention. To facilitate this general authentication rules can be used (e.g. Multi-factor authentication, DigiD with SMS code) in addition to general and specific authorization rules, if necessary, depending on the particular source. This is taken into account seen in the role based access and the security check. Especially the care plan places great constrains concerning the security protocols. PIA is very important here as well as PBD. The passwords are in the category of Pass Phrases.	2

AP38	Information security through zoning and filtering (The relevant facilities are separated into zones)	Information security measures such as zoning and filtering, should be made clear in the agreements with the platform healthcare providers. The demands on information security are stricter when healthcare providers need data from other each other. Think of: - Assess risks and possible consequences. Then take appropriate measures. - Using widely accepted security standards (ISO27001 / ISO27002) - Regularly monitor and evaluate services with information security in mind. This AP is considered in the design of the role based access. The number of security measures could be increased as of now. Zoning between physical and technical infrastructure must be established.	1
AP39	Control on accuracy, completeness and timeliness (The controller systems check information objects for accuracy, completeness and timeliness)	Data from source records are in principle correct. On re-utilized data Zo-Dichtbij does not need to carry out any checks. Private registrations should be of course controlled using semantic- and syntactic agreements. An additional check on data must be done, if possible through the government basic registers. If this is not possible how is the data going to be checked?	0
AP40	Exchange messages are refutable (The message exchange is irrefutable)	See ZP36 and AP25. For financial transactions a party such as iDEAL could be used. The messages must be refutable according to the semantics. the jurisdictional responsibility must be determined by the Zo-Dichtbij foundation. What messages need to be refutable?	2

VIII - Interviews after the questionnaire

VIII.A - Interview with Jeroen Neerincx ICTU architect

Coded as Follow up Interview 1: FI1, credentials are A3 see Table 5. The questions are **bold.**

You have filled in the questionnaire and you have read the document?

J1: Yes, I did only fill in the second part about the NORA but if I have time I fill in the rest too.

First impression:

J2: Seems a good and clear story. Does not always seem to go in depth enough for a SA. there are a number of questions still open and they need to be answered before the SA is final. This is logical since you cannot do it all yourself. There are a number of open ends as of now. Is the platform responsible for the quality of the service or is it just a broker? Privacy and Security are not good enough yet. PIA must be done and Stork levels must be determined.

R: Who performs a PIA?

J3: Zo-Dichtbij must perform it.

R: Are there choices depend on the PIA?

J4: Yes, to make it complete. The results of the PIA are a condition to continue.

R: Wishes of the Actor?

J5: Don't know them well enough, hard question.

R: What do you think about the build-up of the chapters?

J6: Needed to get used to. Target of architecture seemed target of platform. Sometimes the context of the project seems to be intertwined with the rest. On the other hand, overall it looked good. Take the project out of the rest of the story and keep it to the introduction

R: Does the design provide the solution which is requested from the context, problem statement in H1.4?

J7: Yes, it is a solution, not THE solution but a solution.

R: Did you have a look at the semantic model?

J8: seems rudimentary, for just a broker it seems fine. But if it stores all kinds of data then it needs to be expanded much more. IF this is possible within the knowledge and time constrain

R: What do you think of the robustness of the design?

J9: flexible, scalability. Depends on definition. so it is a very difficult question.

R: Ruben explains his definition

J: Robustness is mainly about the technical architecture so that is not something you can answer. Also depends on a central or decentral solution. The more decentralized it is the higher the robustness.

R: Can the services that the platform delivers, be separated and still be functional?

J10: Are that the services of the providers or the matchmaking?

R: Matchmaking, but also the other services such as care plan?

J11: The care plan has to be expanded much more before you can say anything about that.

R: Can a API Store realize this?

J12: Yes, I think an API Store can realize that.

R: Did the NORA help in providing scalability?

J13: Difficult question because if the NORA would not be applied what architecture principles would have been applied. Scaling in national level is determined mostly with the application of Standards in my opinion. NORA building blocks cannot be applied so we mainly go to principles.

R: Do you think you need the NORA to scale up to a national level?

J14: Yes, it can be helpful but only if you don't know or use any other architectural principles. It still mainly depends on the standards that are used in public organisations. Then it becomes easier.

R: What is your opinion on the level of Flexibility?

J15: Mainly on building blocks and standards.

R: Security?

J16: Stork levels must be determined and a PIA must be performed

R: What is your opinion on how the NORA principles are applied?

J17: It looked good. I did not go through all principles. Principles about reuse of building blocks or decoupling of services can't be applied. Especially AP07. Maybe there is still another. The principle that says that services need to be complemented or that only one services can be developed. This is impossible from a market perspective.

R: So it is mainly determined if you use the principles purely internally or within a market outside the organization?

J18: A example is within the entire government. So you need to apply them within your domain or within a company. So some principles can be applied when only within one company but become more difficult when used as a domain reference architecture in a certain market.

R: So it mainly depends on the scope of applicability?

J19: Yes, sometimes you have to explain why you use a certain principle or not. That is not a bad thing. You can't just use the NORA you need to put time into it and it is not a simple check list

R: What about the building blocks?

J20: You just can't use those. They are for internal use of the government.

R: What about the EID building block?

J21: Well that will be available for the government and the market. It is not just a building block but also a collection of agreements

R: What about the explain or use standards?

J22: Well that depends mainly on the technical architecture which is not really a part of this SA and it is not really my specialty.

R: And what if we apply them in a later stadium?

J23: Well then some are always applicable but not all.

R: Is the SA in your opinion Nora compliant?

J24: It depends. When you are NORA compliant it will be easier to exchange information with the public organizations. but you can always exchange information with the government.

R: But if we can always exchange information with the government what is the use?

J25: Well it makes it easier.

R: In what way?

J26: Using the same semantics, apply the same standards, principles are mostly focussed of the digital service providing and that is mostly for the government because that is more on a tactical level. It doesn't mean necessarily that the systems can exchange information more easily.

So concluding. partly yes. A bit through standards and partly because of the principles concerning security and privacy. Those you need to comply with and the rest are mainly common sense.

R: Question of conscience: Do you always use all the principles?

J27: I normally work with just PSAs. and your work also seems to be in this area as well. And i have made PSAs many times before and then through my experience I look at the project and then select the most important principles. 40 principles are just a lot. You have noticed this too. You need to adjust your PSA for the target audience and then you have around 6-8 pages which simply cannot state all the principles and their effects.

R: Has a client ever complained about not using all principles?

J28: Yes, and then I explain where they are and why I have made this particular selection. Time constrain is the main reason as well as the length of pages.

R: Would you then apply the NORA more in a PSA than a SA?

J29: Architecture principles can be used in both, but the most important is the PSA where you write down which principles are mainly applicable and then you can write down the implications in the Sa

R: Are there any pro's or cons regarding the application of the Nora for private parties?

J30: Well the principles are just a guideline so there cannot be any cons. only places a time constrain. The quality of the system will only be influenced in a positive way when you implement them. standards only lead to positive effects. Building blocks can be the big problem. even for some smaller public organisations it is very hard to use those building blocks because they can be very expensive.

R: So it can be useful but it just costs a lot of time to use?

J31: You should use common sense when applying the NORA principles. it can lead to 2-3 weeks of extra time. But yes it can help

R: What do you think the NORA has for an effect on the security of the system?

J32: In principle yes, with the necessary linking of the principles to standards and such.

R: Does the NORA have an effect on the information exchange between private and public parties?

J33: Well you can always exchange information between them but it becomes much easier. it not a yes or no question but it becomes easier and it has a positive effect on the scalability

R: Is being Nora compliant a problem for other parties that are not Nora compliant?

J34: How the Nora is applied in the way it is now, it doesn't lead to a problem. the smart usage of the principles would bother any company. Unless we start talking again about the building blocks and certain standards. in my opinion. and not including the principles which are not applicable because of market competition

R: What is your opinion about the Interoperability and flexibility of the system?

J35: Mainly influenced by the application of standards. Governmental standards probably not but especially the open standards should be used but that is common sense.

R: Can Zo-Dichtbij collaborate with the government if the NORA is applied?

J36: A organisation can always collaborate with the government. Using the NORA just makes it easier.

R: Do you have experience with private organisations?

J37: Yes, for several years.

R: Did you hear about the Nora then?

J38: Yes, I think so

R: What is your general opinion about the Nora? Would you want to change anything?

J39: Yes, some things can be improved. The Nora has been improved as compared to a year ago. but I'm not really putting any time into this area.

R: Anything to improve?

J40: Hard to answer at this moment.

R: Do you think that public organizations will applaud a private organization because they are Nora compliant?

J41: I think that depends.

R: On what does this depend?

J42: Depends on the sector and the person/architect you are talking to. Some public organisations don't use the Nora because they use their own system.

R: Thank you.

VIII.B - Interview with anonymous Architect ICTU

Coded as Follow up Interview 2: FI2, credentials are A1 see Table 5. The questions are **bold.**

Introduction, business architect: **W**

Ruben student: **R**

R: Who do you need to complete a solution architecture?

W1: Business architects, information architects and software architects.

R: So it is hard to make this alone?

W2: For a solution architecture that goes into more detail, it asks for a certain kind of expertise that is hardly found in one person. For example, the PSA which is more high level that could be made by each architect.

R: What is your first impression and did you read it?

W3: I did read it globally. It is not as concrete as it could be, which I understand and I understand it is a guide for further development of the project start architecture to a solution architecture. I like the use of Archimate, but I doubt if all the figures are Archimate proof. It should be Archimate proof, because otherwise the figures deliver more questions than it gives answers.

R: It was not possible in my time to be 100% completely Archimate trained. Not all the figures are 100% Archimate proof and this is written in the document.

W4: That is okay but you need to put in the disclaimer. Because otherwise it generates more questions than in gives answers.

R: But you did state it seemed complete.

W5: Looking at the index, all the chapters which I think are necessary are there, you even included a security chapter. I have read it globally

R: You didn't understand information flow model?

W6: This is mainly because of the Archimate you have used. It seems wrong, but then it's mainly because of the figures used. And because it is a solution architecture I also expected a data model.

R: That is not possible because of my background.

W7: I understand that, but what is then the goal of this document?

R: that I make an expansion from the PSA to a SA or SA intermediate, the first steps towards a SA

W8: So how should I evaluate this then? With your limitations or as a fully functional SA? I miss this disclaimer.

R9: See this as a first attempt to the full SA, with the given limitations
Ruben explains how he wrote the document

W10: Okay that disclaimer would make it much clearer to go through a next time.

R: So what would you name this document? So this isn't concrete enough for a SA?

W11: Well I didn't say that, but what I miss: It isn't concrete enough for a developer.

R: Except from the information model, do you think anything else is wrong?

W12: Well the information and functionality layer is a weird combination. In TOGAF this is completely different

R: Well I did study TOGAF and used its ideas in a general way but it is not completely 100% TOGAF.

W13: Secondly, it would be nice to go one level deeper, take for example the function billing and explain how it works according TOGAF. and then explain that this is an example for the rest of the work.

R: Okay so back to the information model, what would you have expected?

W14: Well the relationships between the sections and the hierarchy between them and the interfaces which are there. You can use TOGAF for this as well.

R: Okay but I made this figure purely to give an overview, but you say that this is wrong?

W15: Well its very confusing for people who are Archimate enthusiasts.

R: Miss anything else?

W16: I miss the relation with the ISO norms

R: They are stated in the appendix and were derived from NICTIZ which is an organization that developed a domain architecture.

W17: Okay I see them, but it is a list and I don't see the implications?

R: That is true it needs to be determined later during the development. How can I find out what they are if I cannot design the technical architecture?

W18: And what about the CIA rating? Because I'm sure that the NEN7510 mentions the CIA rating

R: I purely made a list so that the next developer knows where to look and what is necessary. And other architects did not mention the CIA rating but an A&K analysis.

W19: What is that?

R: Exactly that is the problem, what do we need to use.

W20: And what about the security advice?

R: This was based on a document written by a college student that wrote an advice on the security or Zo-Dichtbij so it remains fairly high level.

W21: Well the CIA rating IS high level.

R: This also stems because I only had one example of an SA and there is not a lot of information in the literature that states what should go in there. So you can tell me that it has to be in here, but you are the first one to tell me. So this relates back to what you expect what should go in a solution architecture.

W22: Well to say something useful about the security, I need to see a data model. This is very important to start with because the measures taken here have effects throughout the document. So the security part can go a detail level deeper.

R: Okay but then I see this more as an advice document instead of the full blown SA. So we see that a common problem is to define the SA and what should go in it and what this document then is.

W23: Well this depends to which school you belong, depending on that, this document could be too much or too less.

R: So what would you name this?

W24: According to TOGAF this would be an architecture description. One step before the solution architecture.

R: So this is an intermediate from TOGAF?

W25: No TOGAF does not even has a solution architecture.

R: Okay let's continue with the NORA principles. What is your first impression about the application of the NORA?

W26: All the principles are taken into account and it seems like you have tried to apply them throughout the document. Seems good. What is relevance?

R: That was added by the Zo-Dichtbij members and it's a rating they determined.

W27: I would suggest a fourth lane: conformity, to describe to what level you could have conformed to the principle.

R: Are there inapplicable principles?

W28: For example, the principles for interfacing and privacy and security show the most use but for inapplicability: it seems that many of the service principles are meant for providing services to civilians.

R: But aren't the users of Zo-Dichtbij civilians?

W29: AP the government only delivers the services which are necessary, AP the services complement each other is not applicable because you only have these specific functionalities.

R: Are there standards only used by the government and what about open standards?

W30: NORA standards are to my opinion not usable by private initiatives, and there are also some open standards only for the government/public parties.

R: To define the question better: are there any parts of the NORA that are not usable for private organisations.

W311: Added value is mainly found in the security and privacy and interfaces. and for the negatives many principles are less important such as AP No Wrong door, because there is only one door: internet. AP38 is not usable anymore it old and outdated! I would say that that the AP Geo location is not useful.

R: But it seems useful to me, since we couple requests and needs of end-users on basis of their location. for example, to show the nearest three care providers.

R: You did not have an opinion about the Use-Or-Explain standards?

W32: I didn't really look at them, but now you ask I'd say that they are purely usable by governments. NORA is a reference architecture for the Dutch government right? So what would you use that for a private organisation?

R: Well because we want to use the RA to connect public and private organizations.

W33: well if you look at information sharing than the two parties just need to state what standards they use and to which the private organisation must comply with. They must perform a requirement analysis even deeper and more specified.

R: Does this application of the NORA make ZD NORA-compliant?

W34: I cannot say anything about this until you add the compliancy lane to the NORA table.

R: Are there any pros or cons by applying the NORA for a private organisation?

W35: Well somethings are not relevant and before you know that, you have to go through all of the NORA which takes a lot of time. It would be helpful to state at each principle if it is government only.

R: Does the government/NORA/ICTU want that?

W36: Of course to show which points is relevant for private organisations is very useful. This can increase the impact within and outside of the government. Doing this is useful for private organisations because it saves a lot of time.

R: Anything else?

W37: Well I don't like that the NORA is just usable for the government.

R: Do you think applying the NORA to scale up to national level?

W38: Yes, it would make it easier, but all the organisations would also need to use the NORA and not all organisations do this, even some public organisations.

R: Yes, I have heard this before and find it very strange. It is weird that I do research about private organisations that want to be NORA compliant and then it appears that many public organisations are not NORA compliant. When public organisations don't need to be NORA compliant why would private organisations be compliant?

W39: Well that is their freedom or choice.

R: Being NORA compliant is a problem between private organisations?

W40: No I don't think so, there is always a certain distance and differences between two organisations, but it should always be easier if the two are NORA compliant.

R: Any effects on the flexibility?
Ruben explains flexibility

W41: Yes, I think it has a positive effect. because services will be designed separately.

R: Can the application of the NORA make collaboration with the government better?

W42: Yes, I think so because of the for mentioned reasons.

R: What is your general opinion of the NORA?

W43: Sometimes not complete enough while this could be possible. Parts are outdated, for example missing IoT, I miss the implications of all the NORA principles, and when they are there they are very abstract and unrealistic. Clarity.

R: Thank you