A digital platform for Dutch first-line healthcare

A study on trade-offs and openness of the platform architecture

Master Thesis

by

Mats van Hattum

Delft, February 20, 2020

Delft University of Technology

PROMEDICO Beter voor iedereen

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Preface

A drop of sweat splashes on the keyboard as my fingers hit the final keys. As the process of writing this thesis and my academic education are approaching their end, reflections on the past years well up. Thoughts on the program of Complex Systems Engineering & Management (CoSEM). Impressions of countless interesting personalities and innovative projects one encounters every day at Delft University of Technology. Above all, memories on the diversity of people I have got to know over these years. They have become a part of me that I will gladly carry with me into my future life.

From CoSEM, I take to be comfortable with complexity. When the situation seems most illogical or incomprehensible, have confidence that a structured analysis will lead you to find tangible factors to get a grip of the situation. In combination with creativity and teamwork, you will find a way forward in those complex challenges.

From TU Delft, that there are countless smart, inspiring and helpful people always waiting just around the corner. And that together, those individuals make a powerful team that deal with any challenge. Despite (or should I say, *due to*) the differences in personalities, backgrounds and interests, people will find solutions to move forward - if only we have confidence in one another.

From conducting this master thesis, to always have an eye for the lessons to be learned everyday. Whether it is from a person I spoke to, from an analysis I conducted or from just from an ordinary day at work - there is lessons to be learned that can make future challenges better, easier or more joyful. Secondly, to dare to make assumptions and to draw conclusions. This helps finding out whether you are on the right track - in the worst case you can adjust the sails to find a new direction.

Most of all, I remember the people I met along the way. I am happy to be able to express my gratitude here to some of those. From my committee: Mark, your role as a mentor suits you well, you provide clarity, honesty and consolidation to those who are new to the realm of academic research. Geerten, your constructive and honest viewpoint is a valuable asset that can improve any performance. Gijs, your presence is inspiring, you know how to combine short term pragmatism with long term vision. All of you have provided valuable (indirect) leadership to a student on his way to a life as an independent Master of Science.

For the last six months, my academic life was concerned with this master thesis. This period introduced me to the wondrous world of information systems in primary healthcare and gave me a glimpse of academic research in the realm of digital platforms. A complex world indeed, and one full of opportunities and challenges. I hope to have made sense of this world, and to have find out my piece to contribute to the development of this domain. I hope you will enjoy this read, just as I have enjoyed this academic ride.

Mats van Hattum
Delft, February 13, 2020

Summary

Situation

The organization of information systems in first-line healthcare in The Netherlands is complex. There is a high variety of system suppliers and interconnections. This complexity is inefficient as it leads to redundant development work being done and it hinders interoperability between information systems from different suppliers. As a result, there is little innovation in information technology supporting caregivers and patients in first-line healthcare. Innovation in information systems in healthcare is desirable as it can lead to higher patient participation, preventive care and integration of caregivers around a patient – making first-line healthcare more efficient.

Digital platform literature shows a different view on the organization of information systems. Digital platforms are increasingly adopted in all kinds of industries as a way of orchestrating resources and innovation from different contributors. This may also be useful for first-line healthcare. These platforms consist of a stable core codebase that allows additional software-modules to be (de-)coupled to the platform easily, thereby flexibly extending the functionality of the platform. Moreover, platforms can be opened up, allowing external parties to contribute to the platform. By leveraging a network of external contributors through openness, digital platforms show high innovation capacities. This raises the question how an open digital platform in first-line healthcare can be configured.

Complication

Actors that want to develop a digital platform must make design choices prior to platform launch that will affect how the platform develops over the short- and long-term. However, previous studies on digital platforms show limited ex-ante design knowledge on how to develop the socio-technical design for a digital platform. Moreover, effective design of a digital platform depends on the platform's strategy in relation to its context. While some scholars have recently begun to study digital platforms for healthcare, these do not show design knowledge on how a digital platform can be designed for first-line healthcare in The Netherlands. This is a challenge, given previous studies have shown that designing and transforming information system infrastructures in healthcare is complex and often fails. In addition, research on platform openness indicates cautiousness is required with respect to openness: while openness is associated with higher innovation, it also comes with risks of hostile strategies or greater need for coordination.

Question

This master thesis is concerned with answering the question:
What design trade-offs exist that inform the design of an open digital platform architecture in first-line healthcare in The Netherlands?

Approach

A Design Science Research (DSR) approach was used to answer this question. This approach consisted of four steps: In the first stage (*problem awareness*) the current situation and main challenges for information systems in first-line healthcare were described. The approach to the first step was inspired by grounded theory. For the second stage (*suggestion*) a literature review was conducted. The purpose of the review was to identify what platform architectures have been mentioned that could inform the design of a digital platform for first-line healthcare. Moreover, scientific literature was consulted to understand the effects of openness on a digital platform. Third, in the *concept development* stage, a concept artefact

was developed. This artefact shows design options concerning the architecture of a platform. The design options were associated with their implication on platform openness, as reported in literature. Fourth and finally, the concept artefact was *evaluated* with semi-structured interviews with experts in the field of information systems in first-line care. The purpose of the interviews was to identify trade-offs that inform how a platform can be designed in relation to the openness of the architecture.

Results

The following results were obtained concerning the current situation. The existing situation is characterized by low transparency, low openness of information systems, low incentives for innovation and high lock-in of users. Moreover, achieving interoperability between systems from different suppliers is difficult and system suppliers exert strategic behaviour (e.g. long term contracts or willingly failing to comply with data transferring standards) to protect their market position. The current systems are mostly tightly integrated, with limited modularity. On a more promising note, the context seems to be feasible for a platform to emerge, among others given the presence of different sides of users and unexploited niche markets.

From the literature review, design options with different degrees of platform openness were inferred. The design options concerned ten design choices, divided over four design dimensions of the platform architecture. The dimensions were (1) the openness of the core, (2) interoperability between platform cores, (3) openness of the interfaces and (4) stability of the interfaces. These design choices were represented in a chart, together with the effects of these options in relation to platform openness. In the final stage, the chart was discussed in semi-structured interviews with field-experts.

Field-experts in information systems in first-line healthcare predominantly expressed the following trade-offs relating to the openness of the platform architecture. For the core, respondents value openness either through a meta-platform or through resource openness. On the other hand, the platform must ensure ease-of-use and allocation of accountability when complements exert undesired properties. Furthermore, respondents are in favor of a meta-platform to provide critical functionality. On the downside, a meta-platform is considered difficult to implement due to political behaviour of affiliated parties. Concerning the openness of the interfaces, openness is desired to stimulate innovation but it may never come at the cost of control over quality and security of the platform. Interface openness is therefor desired for non-critical functionality, while respondents are reluctant to use open interfaces for critical functionality. For the stability of interfaces, interestingly, compliance to industry-standards is thought to limit innovation as a result of political dynamics. Therefor, stable interfaces are preferred.

These trade-offs led to the following preferred option for the design of an architecture for a digital platform in first-line care. A meta-platform should facilitate the most critical functionality. This is centrally orchestrated for all affiliated parties. The meta-platform is based on an open source strategy, to create incentives to keep improving the meta-platform. For the interfaces, selectively open interfaces are desired as this allows innovation but also control over the quality and security of complements. Finally, concerning the stability of interfaces respondents choose for stable interfaces. Stable interfaces are associated with innovation, while industry-wide interfaces are expected to slow down innovation due to political dynamics.

Next steps

Future steps towards the establishment of a digital platform in first-line healthcare are foremost suggested to focus on designing boundary resources. Boundary resources can ensure control over complements in the ecosystem, while they may also strengthen the relationship between the platform and complements. Research shows limited design knowledge on the design of boundary resources. This direction for future research will both be useful from the perspective of science as from practice.

Contents

1

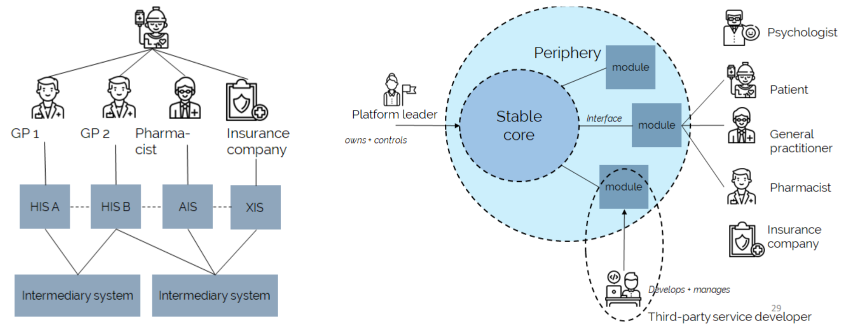
Introduction

1.1. Problem introduction

Information systems (IS) play an important role in Dutch first-line healthcare but the current way they are organized is inefficient. In the present situation, professional caregivers in first-line care are supported by their own type of IS: a general practitioner (GP) has a General Practitioners' Information System (Dutch: Huisarts Informatiesysteem (HIS)), a pharmacist has a Pharmacists' Information System (Dutch: Apothekers Informatiesysteem (AIS)), etc. A first inefficiency is the multitude of system suppliers that develop and supply systems with similar functionality, resulting in redundant development work. As an example, there are an astonishing nine suppliers that develop AISs. Second, this landscape is thus characterized by high heterogeneity in terms of ISs and interconnections. In addition, this multitude of ISs and suppliers makes it difficult to achieve interoperability and information transferring between different systems. Moreover, caregivers in first-line healthcare are reluctant to switch between software suppliers due to long term contracts with IS suppliers. Another inefficiency is caused by strategic behaviour of IS suppliers, who purposefully fail to adopt standards for information exchange in order to protect their own user-base. As a result of this complex organisation of IS, IS vendors experience little competition and there is little urgency for innovation.

This complexity and low rate of innovation in IS is problematic, even more so given the trend of increasing pressure on healthcare. This increase is results from an aging population (CBS Statline, 2019a), escalating costs (CBS Statline, 2019b; CBS.nl, 2018), a declining workforce (CBS, 2019) and a switching burden of disease from short-term illnesses to long-term chronic conditions (European Commission, 2019; McKinsey & Company, 2019). On top of that, technological advancements (such as IoT, big data, blockchain technology and machine learning) offer opportunities to improve healthcare but are not easily incorporated in the current ISs (Idenburg and Dekkers, 2018; The Economist, 2019a). Well-organized information systems, that allow information-exchange across practitioners in first-line care and that stimulate and allow adoption of innovations, may contribute to relieving the pressure on first-line healthcare. Digital platforms show opportunities for more efficient organisation of IS and innovations in first-line healthcare.

Digital platforms are increasingly adopted as a way of orchestrating resources and innovation from different contributors (Parker et al., 2016) and may also be useful for Dutch first-line healthcare. While this trend to digital platforms started in technology-driven industries such as operating systems and search engines (Parker and Van Alstyne, 2018), digital platforms are now impacting and transforming all kinds of industries, from a.o. banking (Deloitte), to education, government services and energy (Mukhopadhyay and Bouwman, 2019; Mukhopadhyay et al., 2019; Tiwana, 2014). Recently, researchers have also begun to address application of digital platforms to the healthcare-industry (e.g. (Bygstad et al., 2015; Fürstenau et al., 2018; Lessard and de Reuver, 2019)). So, what is a digital platform? Put simply, it is a way of organizing independent actors and innovations around a stable core system (Cennamo and Santaló, 2019). The platform is the stable object, on which other parties can develop and offer complementary services and products (Baldwin et al., 2009). Digitality denotes that the platform itself is an extensible codebase (Tiwana et al., 2010) that is editable and reprogrammable (Kallinikos et al., 2013). An important principle of platforms is their modularity, i.e. new functionality can be (de-)coupled from the core platform easily (Tiwana, 2014), thereby extending the functionality of the platform (Brunswicker and Schecter, 2019). Such a platform logic is in contrast with tightly integrated systems, in which functionality cannot be easily modified separately from the IS. This difference between the current organization of IS and a digital platform organization is represented in figures 1.1(a) and 1.1(b).



(a) Simplistic representation of the current situation

(b) Simplistic representation of a platform-based situation

Figure 1.1: Simplified graphic representations of perceptions of the as-is situation and of the platform-based ecosystem situation

Not all digital platforms are organized similarly, and any actor that intends to develop a digital platform must make decisions on how to organize their platform (Blaschke et al., 2019). These decisions for instance include deciding on the platform's launch strategy (De Reuver et al., 2018a), the mode of ownership of the platform (De Reuver and Keijzer-Broers, 2016; Saadatmand et al., 2018) or what functionality is included in the core of the platform (Tiwana, 2014). An overview of design choices found in literature is provided in appendix C. The design decisions are often made at the initial development stage of a digital platform, and may have a big impact on the platform's evolutionary development (Blaschke et al., 2019; Saadatmand et al., 2019; Tiwana et al., 2010). Moreover, these decisions often require platform designers to make trade-offs in balancing paradoxical needs, that are also referred to as tensions (Wareham et al., 2014). One key design decision relates to platforms' *openness* (Parker and Van Alstyne, 2018).

The choice for an open or a closed platform strategy is important because it determines how a platform owner orchestrates external contributors around the platform (Parker and Van Alstyne, 2018). Openness concerns the extent to which external parties can use, develop services on- or commercialize a platform (Benlian et al., 2015; Boudreau and Hagiu, 2009). Some effects associated with platform openness are that it can lead to a higher market potential (Ondrus et al., 2015) and a higher rate of innovation of services (Boudreau, 2010), but also that it requires larger coordination costs and efforts (Eisenmann et al., 2009; Gawer and Cusumano, 2002; Wareham et al., 2014). In the context of first-line healthcare, adoption of external innovations (e.g. smart wearable sensors for patient data collection) can offer opportunities for enhanced patient monitoring and preventive care. Such innovations can lead to enhanced patient engagement, access to care and efficiency of healthcare(Lessard and de Reuver, 2019). Defining a level of openness that suits the needs of the platform owner thus depends on how one aims to balance those consequences associated with platform openness. Besides deciding what level of openness is desired by the platform owner, the owner must also decide how openness can be established (Boudreau, 2010).

In the absence of a digital platform in the current situation, it is needed to design an *architecture* for a digital platform in first-line healthcare - that takes into account platform openness. Platform architecture is defined as the "conceptual blueprint that describes how the ecosystem is partitioned into a relatively stable platform and complementary set of modules that are encouraged to vary, and the design rules binding on both" Tiwana et al. (2010, p.677). The relationship between platform architecture and openness has been addressed by platform researchers (e.g. (Blaschke et al., 2019; Cennamo et al., 2018; Eaton, 2016; Kazan et al., 2018; Saadatmand et al., 2018)). This MSc thesis will study what level of platform openness is desirable for first-line healthcare by studying design *trade-offs* relating to the architecture of a platform.

This remaining part of this first chapter proceeds as follows. First, section 1.2 addresses scientific research related to digital platforms and first-line healthcare and it identifies a gap in literature this thesis aims to solve. Subsequently, section 1.3 explains the scope of the research. Section 1.4 states the goal of this study, followed by the research question in section 1.5. In section 1.6 the approach to answer the research question is described. Section 1.7 explains why this research is relevant for the MSc-program of Complex Systems Engineering at TU Delft. Furthermore, section 1.8 describes the involvement of external parties in this study. Finally, section 1.9 presents how the remainder of this thesis is structured.

1.2. Scientific problem

Over recent years, digital platforms have received an abundance of attention both from academics and from industry. Still, a need exists for gaining a better understanding of the dynamics shaping digital platforms and the environments in which they are embedded. An understanding of platform architectures and design trade-offs relating to openness are necessary for effective design of a digital platform in first-line healthcare in The Netherlands. This section describes some of the knowledge gaps in academic research on digital platforms and how this thesis contributes to filling those gaps.

1.2.1. Scientific problem 1: designing a digital platform in relation to its application domain

This thesis is not the first attempt to apply the paradigm of a digital platform to the context of healthcare. Digital platforms have been mentioned previously to deal with problems of (1) fragmentation of health information systems (Bygstad et al., 2015; Fürstenau et al., 2018) and (2) a lack of innovation (Fürstenau et al., 2018). Both these challenges also seem to be present in Dutch first-line healthcare, with its multitude of systems, types of users and interconnections. It should also be mentioned that research on transformation of information systems in healthcare has shown to be complex and challenging with many examples of failure. This is amongst others because changes in IS in healthcare often transform roles, responsibilities and due to the contextual nature of medical information (Grisot et al., 2018). What can be learned from previous studies on the design of information systems in healthcare?

Firstly, academics have studied how to transform an IT-silo system towards a platform organization in healthcare. In a 2015 research, Bygstad et al. used a digital platform to integrate IT-silos in a hospital context. These silo's denote that there is a specialised IS for each user-group and these are tightly integrated. An advantage of silo's is that they are fairly stable and easy to manage. However, when the context requires cross-organizational functionality or communication, they become a liability. A platform can be used to integrate the silos. However, such a platform has the risk that it may become increasingly difficult to govern due to the involvement of different parties, threatening stability of the system. In a follow up study on how to transform a siloed IT-organization towards a platform-based system, (Bygstad and Hanseth, 2018) find that tightly integrated IS can be transformed to platform-based systems. For this, a platform owner should establish an architecture and governance structure that ensures control over third-parties affiliated with the platform. They suggest that platform owners have a clear conceptual distinction between the core of the platform, and how third-parties are allowed to interact with the core. The platform owner should clearly define how others are allowed to access or use the platform's core.

Another relevant research on the design of platforms in healthcare comes from Fürstenau et al. (2018). They explore the process of designing a platform in healthcare in the U.S.. They come up with a framework of four steps (governance model development, technical architecture design, community building, engaging in ecosystem and environment) that a platform owner must pay attention to for designing a platform in healthcare. They suggest future researchers to study and document the design and development of digital platforms, specifically in healthcare.

Third, Grisot et al. (2018) show that for the effective design of digital platforms, platform owners should carefully consider the socio-technical systems in which they are embedded. The development of digital platforms requires dealing with trade-offs (e.g. choosing between an open and closed system). They argue that platform owners need to be aware of the trade-offs that exist for choosing how to design the platform.

Moreover, there is a need for understanding how digital platforms function within their respective domain (De Reuver et al., 2018b; Helfat and Raubitschek, 2018). In addition, how well a platform will perform, depends on how it responds to changes in its environment (Tiwana et al., 2010). Information on the environment thus seems to be crucial to understanding how a platform can be designed in the context of this thesis research.

Knowledge gap This thesis aims to contribute to understanding what context specific factors inform the design of a digital platform in first-line healthcare in The Netherlands. By explicitly studying what trade-offs inform the design of a digital platform in first-line healthcare, this research contributes to understanding how a platform can be designed with respect to its application domain.

1.2.2. Scientific problem 2: lack of ex-ante design knowledge

Previous research on digital platforms has mostly been concerned with the analysis of digital platforms and their effects on markets in hindsight (De Reuver et al., 2018b). For instance, studying what factors affect the success of a platform (Wan et al., 2017), how a platform develops over time (Eisenmann et al., 2011) and they are often based on comparisons between industry platforms (e.g. (Eaton et al., 2015; Hein et al., 2018; 2016; Ondrus et al., 2015). Far less attention has been paid to studying what choices platform owners face prior to the development of a digital platform (De Reuver and Keijzer-Broers, 2016). Due to the lack of research on the design efforts that shape digital platforms as well as to the secrecy around the establishment of industry platforms, researchers' understanding of design knowledge on digital platforms has been lagging.

Knowledge gap Contrary to the common ex-post analysis of digital platforms, this thesis addresses how the design of platforms can be informed prior to launch. To this end, the study aims to elicit *design trade-offs* that platform owners face, thereby contributing to design knowledge on digital platforms. With this intended contribution, this master thesis responds to a call from De Reuver et al. (2018b) and Schreieck et al. (2016) in expanding design knowledge on digital platforms. Ex-ante design knowledge is considered useful for this thesis research because it enables platform owners to express design-trade-offs based on predefined design choices.

1.2.3. Scientific problem 3: incomplete understanding of relationship between platform architecture and openness

Although platform openness has been addressed by a multitude of researchers, recent studies (De Reuver et al., 2018b; Jacobides et al., 2018) suggest to still develop a greater understanding of the phenomenon of platform openness (De Reuver, 2019). Platforms exert different degrees of openness in the way they open up different parts of their platform (Boudreau, 2010; Ondrus et al., 2015) or to which type of users (Eisenmann et al., 2009). Also, researchers have paid attention to varying consequences of platform openness.

Examples of studies on the effect of platform openness are plenty, for instance: Economides and Katsamakas (2006) study openness in relation to the platform's appropriability, West (2003) examines openness and platform adoption, while Ondrus et al. (2015) are interested in the effects of openness on platform's market shares. Benlian et al. (2015) is interested in finding how the level of openness affects third-parties' willingness to develop complementary functions for a platform. Karhu et al. (2018) even go as far as studying the relationship between platform openness and related risks of hostile strategies by external parties. Despite this substantial research on platform openness, De Reuver and Van der Wielen (2018) find that platform owners have a difficult time deciding on the appropriate level of openness.

In addition to achieving a desired level of platform openness, it is interesting to see *how* platform owners can configure a platform so it aligns with the strategic goals of the platform owner. One stream of scientific literature considers the role of governance for controlling platform openness. Wareham et al. (2014) find trade-offs inherent to platform design (see Table C.1 in appendix C) and argue that governance mechanisms should serve to find a right balance between those paradoxical needs. Similarly, Alves et al. (2018) and Saadatmand et al. (2019) state that the act of balancing platform trade-offs is the goal of governance.

Another stream of research pays attention to the role of designing the platform architecture in aligning the platform with strategic goals. Among these studies, Cennamo et al. (2018) refer to finding a balance in a simple versus a more complex architecture (a higher variety in interdependencies and interfaces between the core and complements) and how that affects quantity and the quality of services offered on a platform by third party developers. Kazan et al. (2018) find that architectures can be used to control value creation and delivery between stakeholders in the ecosystem of the platform. Building on the work of Kazan et al. (2018), Blaschke et al. (2019) define high-level taxonomies to discern different types of digital platforms based on the configuration of their architecture.

Knowledge gap Although researchers have thus tried to bring clarity to the relationship between architecture and platform dynamics, there is still a need for better understanding of this phenomenon. As highlighted by Blaschke et al. (2019) and Kazan et al. (2018), we should strive for a better understand how configurations of platform architecture relate to desired platform outcomes. This thesis focuses on this latter hiatus, that is studying the configuration of the platform's architecture in relationship to meeting strategic goals. By clarifying how architecture configurations inform the design of digital platforms, this thesis intends to answer to a call by De Reuver et al. (2018b) to study how platforms can be designed.

1.3. Scope of this thesis

Both from a practical as well as from a scientific perspective it is important to be explicit on what components are included and excluded in this thesis. Digital platforms are complex objects to study due to their impact on complex networks of actors (Yoo, 2012) and "their distributed nature and intertwinement with institutions, markets and technologies" (De Reuver et al., 2018b, p. 124). To advance research on platforms, it is critical to provide clarity on the level of abstraction and on what parts are perceived as part of the context and scope of this study (Adner, 2017; Basole et al., 2015; De Reuver et al., 2018b; Eaton et al., 2015).

This Master Thesis focuses on information and communication systems for the first-line healthcare domain in The Netherlands. The first-line care domain concerns all care providers that a citizen can consult without a need for a prescription (Rijksoverheid, 2019b). It revolves around the working field of, among others: general practitioners, physiotherapists, paramedics, pharmacists, social workers, district nurses, etc. For this thesis report, these care provider are considered under one denominator *healthcare providers* or *caregivers*. Every healthcare provider has his/ her specific information system, for instance to keep track of patients' history or for ordering medication. What is more, these information systems are developed and maintained by a variety of organizations. The scope of this master thesis concerns all parties and information systems that interact in the first-line healthcare domain. When the report mentions *the system*, this entails all information systems and actors that interact in the first-line care domain in The Netherlands. A description of the definitions concerning platform concepts adopted in this thesis is provided in chapter 2.

Another scoping decision concerns how to address the existing information infrastructure, also referred to in research as the *installed base* (Aanestad et al., 2017). Currently, information systems to support the primary care domain are already in place. These systems have evolved over time through policy and/or organizational changes.

Aanestad et al. (2017) provide three ways of dealing with existing information infrastructures (which they call the *installed base*) when transforming towards a new information system solution. The first option is what they call an *installed base-friendly* approach. This approach suggests that a new solution is built upon the existing information infrastructures. In contrast, the second option concerns a *installed base-hostile* approach. In this approach, the new solution competes with the existing infrastructure and may even render the existing infrastructure superfluous. Third and finally, they suggest a *installed base-ignorant* approach. In this ignorant perspective does not take the current system in consideration when designing a new information infrastructure.

This thesis research adopts an installed base-ignorant approach to designing a platform-oriented solution. This entails that an technical architecture and a corresponding governance structure will be designed based on a set of meta-requirements without considering the exiting infrastructure. To examine the implications of the designed artefact for the existing situation, chapter 9 reflects on the findings from this research in light of the existing situation.

It was decided to neglect the role of laws and regulations for this master thesis. While laws and regulations may strongly affect how information systems are designed, they may also severely limit the design space. To keep an open attitude towards the solution space, laws and regulations are not considered within the scope of this master thesis.

1.4. Goal of this thesis

The goal of this master thesis is to understand what trade-offs exist, related to choices of openness of a platform's architecture, for the development of a digital platform in first-line healthcare in The Netherlands. Previous studies have shown that a digital platform can lead to more innovation and integration of IS, but that transforming IS in healthcare is challenging and often fails. The intended outcome of this thesis is a set of design trade-offs and preferences for the openness of a digital platform architecture. These findings are considered a crucial step in learning how a digital platform can effectively be designed in first-line healthcare in The Netherlands.

1.5. Research question

The following question is considered the focal question that this master thesis research sets out to answer:

What design trade-offs exist that inform the design of an open digital platform architecture in first-line healthcare in The Netherlands?

1.6. Research approach

Because this thesis takes interest in identifying trade-offs that arise for the design of a digital platform architecture, a design study is conducted. The presumption is that a platform architecture is not yet in place in first-line healthcare in The Netherlands. Therefor, a design science approach will lead to a set of concept design architectures, that supports in identifying design trade-offs. Moreover, design science is concerned with explicitly identifying what and how the knowledge base and methodologies contribute to the design of an artefact, distinguishing it from routine design (Hevner et al., 2004). The concept artefact for this thesis a set of architecture configurations for digital platforms.

1.6.1. Design science research

Research highlights various approaches to Design Science Research (DSR), this thesis adopts that of Vaishnavi and Kuechler (2004). This approach suggests that researchers should start by gaining awareness of the problem and the context. Furthermore this design cycle explicitly states that theoretical knowledge should be put in the perspective of the relevant circumstances (Kuechler and Vaishnavi, 2012). That this design cycle emphasizes the importance of taking into account the domain in which something is designed, is relevant as this this thesis is interested in designing for first-line healthcare. Another reason why this method is considered useful is that it has a focus on an iterative feedback loop. This loop entails that evaluation of a concept design results in feedback that can be used for subsequent design steps. This feedback loop is important in this thesis, as it clarifies design trade-offs for a digital platform architecture in first-line healthcare. The design cycle of Vaishnavi and Kuechler (2004) is presented in figure 1.2.

Other DSR-approaches considered for this thesis were that of Gregor and Jones (2007) and Peffers et al. (2007). The work of Gregor and Jones (2007) involves eight steps DSR researchers make in designing an artefact, informed by design theories. This approach has a lesser focus on the feedback loop, making it less suitable than the approach of Vaishnavi and Kuechler (2004). Considering the approach of (Peffers et al., 2007), that involves development and demonstration of the artefact which is not considered feasible within the scope of this thesis.

1.6.2. Sub research questions

The research questions supporting the goal of answering the main research question were defined following the steps of the design cycle by Vaishnavi and Kuechler (2004). As with this cycle, this thesis evolves along *awareness of the problem*, to *suggestions*, *development*, *evaluation* and, finally, *conclusion*. The following set of sub questions is defined:

- Sub research question 1 *What does the existing landscape of information systems in the Dutch first-line healthcare look like?*
- Sub research question 2 *What configurations of digital platform architectures allowing varying degrees of platform openness have been reported in scientific literature?*
- Sub research question 3 *What concept design can be used to identify trade-offs for choosing openness of the platform's architecture?*
- Sub research question 4 *What trade-offs relating to openness exist in the Dutch first-line healthcare domain that inform a decision for a platform architecture?*

How these sub questions relate to the overall research approach is conceptually visualized in figures 1.2 and 1.3 at the end of this section. Below, the approach to the sub questions are briefly explained. These methods used in this study are discussed in-depth in chapter 3.

Sub question 1: Understanding the current situation

The first stage of the design cycle is concerned with gaining an *awareness of the problem*, i.e. understanding the system, its environment and the design challenge. Because an unambiguous description of the current situation of information systems in the domain under study is lacking, it was considered useful to firstly try to describe the existing situation. The approach taken to develop an understanding of the existing situation was inspired by grounded theory (based on (Corbin and Strauss, 1990) and (Charmaz, 2008)). As a part of this approach, this stage of the thesis involved (1) interviews with experts in the field (developers of IT-systems) and (2) desk research.

The outcome of this stage is fourfold: first, a description of the context of first-line healthcare in The Netherlands. Second, a conceptual representation of how IS are positioned within this domain. Third, an analysis of important stakeholders. Fourth, what implications are derived from this analysis that may impact the design of a digital platform in first-line healthcare.

Sub question 2: Suggestions from previous studies

The second stage relates to the *suggestion*-step in the cycle of Vaishnavi and Kuechler (2004). The purpose of this step is to research what theoretical concepts can inform the design of the artefact (Kuechler and Vaishnavi, 2012). In this thesis, this concerns developing an understanding of platform architectures and platform openness for application in first-line healthcare. The goal was to identify what conceptualizations of platform architectures are reported in scientific literature that may inform the design of a digital platform. To this end, a review of academic literature was conducted.

The outcome of this study is an overview of how various researchers have defined platform openness and what configurations of architectures are mentioned in academic publications to realize a desired level of platform openness.

Sub question 3: Design and development of concept artefact

The third sub question corresponds to the third step (*development*) in the design cycle, that is the development of an artefact. The artefact, in the context of this study, is a conceptual design for deciding on an appropriate architecture for the primary healthcare domain. A first step in the development of a conceptual artefact is to combine the findings of the first two sub questions. This step will interpret the theoretical concepts found from sub question 2 and translate them to application to the primary healthcare domain in The Netherlands.

The outcome for this step of the research is a comprehensive overview of design options that platform owners can choose from to select a desired level of openness. This overview of design options should be suitable to present to field experts in the domain of IS in primary healthcare in order for them to express their perspectives on a feasible platform architecture for the domain under study.

Sub question 4: Evaluation

Finally, related to the *evaluation*-step, the artefact of design choices will be validated and evaluated with field-experts. This evaluation has two goals. First and foremost, the purpose of validating the design choices is to identify what trade-offs field-experts express for an open digital platform in primary healthcare. To this end, semi-structured interviews were conducted with field experts in IS in first-line care.

The outcome of this part of the research is a description of trade-offs experienced by field experts and how these trade-offs relate to different configurations of the platform architecture, as presented in the conceptual model of design choices (see sub question 3). These findings will contribute to practice by eliciting what configuration of a digital platform would be beneficial for a better organization of information systems supporting the Dutch first-line healthcare domain.

The second purpose of this sub question is *evaluation* and *iteration* of the concept design of the artefact. This evaluation is also done through the semi-structured interviews. Iteration considers the elicitation of feedback from semi-structured interviews to serve as input for subsequent design steps. This iteration

’loop’ is also part of the design cycle from Vaishnavi and Kuechler (2004). Based on the outcome of the semi-structured interviews, the conceptual design is adjusted. Presumably, this does not result in a detailed design but it will rather result in recommendations for digital platform research.

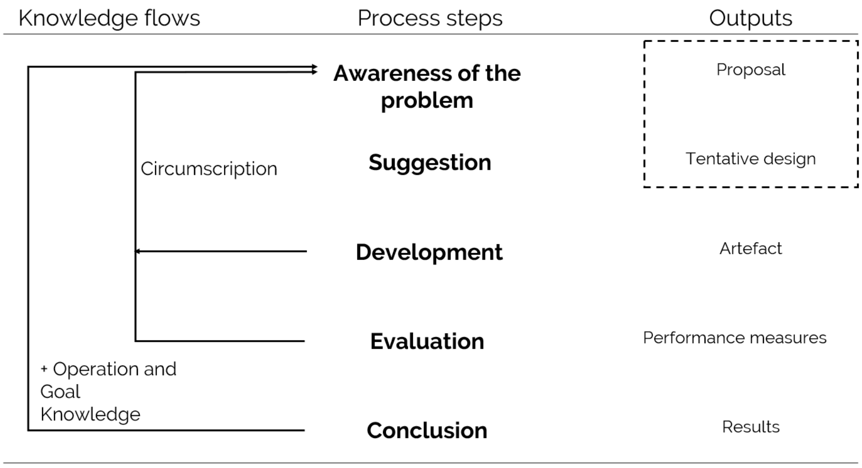


Figure 1.2: The design as described cycle by Vaishnavi and Kuechler (2004)

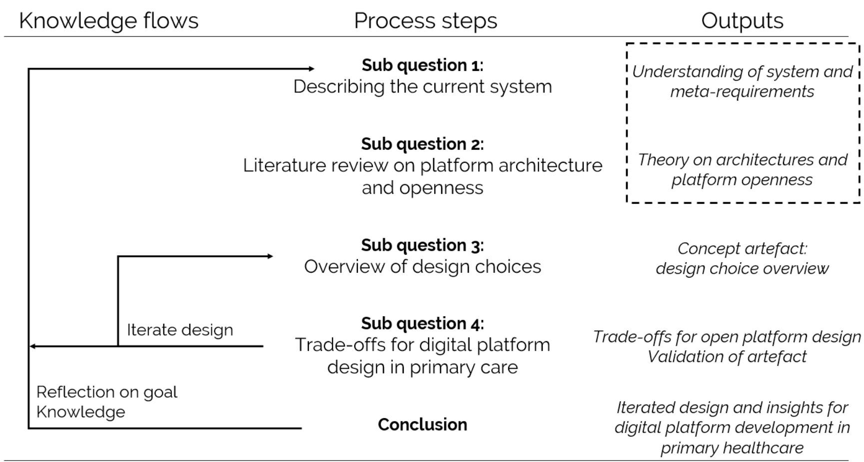


Figure 1.3: The research approach to this thesis, inspired by the design cycle of Vaishnavi and Kuechler (2004)

1.7. Relevance to MSc programme

The proposed research is in line with the MSc program Complex Systems Engineering and Management, as it deals with designing an intervention in a complex socio-technical environment. The proposed research touches upon several relevant concepts from the CoSEM-program, ranging from dealing with complexity in terms of a multi-stakeholder environment and eliciting trade-offs in the design of architectures of large-scale information technology systems.

1.8. Involvement of external parties in this thesis

This thesis was conducted in the context of a research internship at Promedico Groep. Promedico is a Dutch company that develops and supplies information systems for general practitioners and pharmacists in The Netherlands.

The external stakeholders that have participated in this research (either in informal discussions or in semi-structured interviews) were either employed at or at affiliated institutions. All worked for organizations supplying digital services for the Dutch first-line healthcare market.

At no point during this thesis, Promedico or any other institutions has interfered with this research.

1.9. Reading guide for this thesis

The remainder of this report is organized as following, and as represented in figure 1.4. Chapter 2 explains key concepts used throughout this report. It defines different perspectives researchers take on studying digital platforms and how this thesis can be positioned in light of these perspectives.

Chapter 3 of this report explains the methodologies used and the data sources that were consulted for answering all sub research questions and the main research question. It explains why these methods are deemed appropriate and what pitfalls need to be accounted for prior to conducting this research.

Chapter 4 describes the first research question of this thesis, that is gaining an awareness of the current situation of information systems in the first-line care domain and understanding what challenges this domain faces. This chapter describes the system under study and it presents an analysis of the relevant stakeholders to be considered. After describing the system, some of the most prominent reflections are the state-of-affairs are described.

Chapter 5 presents the finding from two literature reviews, related to sub research question 2. First, it explains what findings were derived from academic literature on the descriptions of digital platform architectures. Subsequently, the chapter discusses what factors are reported in literature that determine whether platforms are open or closed. Altogether, this answers sub research question 2.

In chapter 6, the findings from chapters 4 and 5 are merged. This convergence leads to the design and development of a concept artefact, a design table that describes platform architecture configurations and their relation towards platform openness (answering sub research question 3).

Chapter 7 concerns answering sub research question 4. evaluation was done by means of conducting semi-structured interviews to validate the concept design but also to identify trade-offs relating to platform openness in first-line healthcare. The results to the interviews and analysis are provided, answering sub research question 4.

Chapter 8 gives the conclusion to the research questions that were described in section 1.5 and section 1.6 of this introduction.

Finally, this thesis is concluded by reflecting on the limitations to this study and on possible directions for future work in chapter 9.

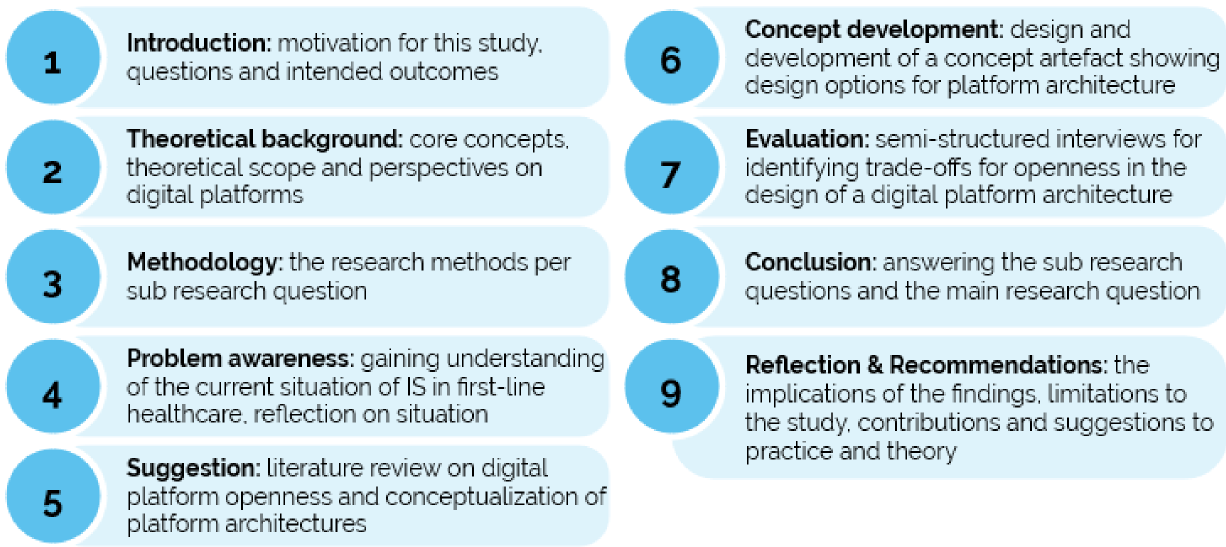


Figure 1.4: Reading guide

2

Theoretical background

Over recent years digital platforms have been studied extensively but researches have also been scattered. Not only have digital platforms been studied in different industries but also from different perspectives (De Reuver et al., 2018b; Gawer, 2014). Moreover, digital platforms are challenging objects to study because of their intertwinement with different users and technology and possibly even overlap with other platform ecosystems (De Reuver et al., 2018b). Because of this and the dynamic nature of platforms, it is difficult to construct theory around digital platforms. For the purpose of clarity and to be able to compare findings in platform research to other digital platforms, it is important to be clear on the scope of digital platform research, what perspective the researchers take and to state what definitions are used throughout the research (De Reuver et al., 2018b).

The purpose of this to explain relevant concepts and theories to understand the position of this research in the context of digital platform research. For this, first key concepts in digital platform research are explained (section 2.1). Secondly, different perspectives on digital platforms and how this thesis is positioned in research on digital platforms is discussed in section 2.2.

2.1. Key concepts of digital platforms

The explanation of key concepts is discussed in two parts. First, subsection 2.1.2 describes the components that constitute a digital platform. In addition, digital platforms are dynamic in the sense that they may evolve over time and interact within an environment. Section 2.1.3 describes concepts relating to this dynamic nature of digital platforms.

2.1.1. (Digital) platforms

A 2018 literature review on the state-of-affairs of digital platform research by De Reuver et al. explains the similarities and differences between *non-digital platforms* and *digital platforms*. This thesis also uses this distinction to specify what is defined as a digital platform and to substantiate how this thesis perceives a digital platform for the primary healthcare domain.

Non-digital platforms

Platforms are in general considered as ”foundations upon which actors can offer complementary services and products” (Gawer, 2009, p.2). Furthermore, platforms typically act as entities that intermediate between different user groups (for instance between complement suppliers and users) (Rochet and Tirole, 2003). Others describe platforms as some stable core that allows other actors to develop complements that offer additional services that add functionality to the core (Baldwin et al., 2009). Teece (2018, p. 1376) adds to this definition of platforms as "a hub around which companies and users can, jointly or separately, innovate and attract users". This thesis finds these definitions not to be mutually exclusive, but rather as complementary.

Within these definitions, some properties are implicit. For one, platforms are characterized by *modularity*. Modularity can be understood as the possibility to add components to the core system, those components can be coupled and decoupled to add functionality of the overall system (Schilling, 2013). Another property of platforms is that they can mediate between different users, e.g. buyers and sellers. When a platform brings together two types of users, it is considered a *two-sided platform*. A platform can also mediate multiple user groups, i.e. a *multi-sided platform* (Boudreau and Hagiu, 2009). This multi-sidedness may be useful for the primary healthcare domain because it may for instance allow mediation between software suppliers, patients and different caregivers.

Digital platforms

This master thesis refers to Ghazawneh and Henfridsson (2015, p. 201) (inspired by Tiwana et al. (2010, p. 675)) for defining digital platforms as "software-based external platforms consisting of the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate".

Platform architecture

For this thesis, the platform architecture is defined as "A conceptual blueprint that describes how the ecosystem is partitioned into a relatively stable platform and a complementary set of apps that are encouraged to vary, and the design rules binding on both" (Tiwana, 2014, p. 7).

Platform openness

For the remainder of this thesis, platform openness is defined as the extent to which external parties are allowed to use, develop services on- or commercialize a platform (Benlian et al., 2015; Boudreau and Hagiu, 2009).

2.1.2. Digital platform components

This section deals with discussing components that constitute a digital platform.

Modules and applications

In the context of digital platforms, *modules* are defined as software modules that can be added to the core of the platform (Tiwana et al., 2010), often in the form of applications that are provided by external developers (De Reuver et al., 2018b). *Applications* are "executable pieces of software that are offered as applications, services or systems to end-users" (Ghazawneh and Henfridsson, 2013, p. 275). For this thesis, the definition as described above by Tiwana et al. (2010) is used. Furthermore, the term 'modules' is used, but modules and applications are considered similar and interchangeable.

Interfaces

Interfaces are the specification of how modules interact with the core of the platform (Tiwana, 2014). They provide specifications to ensure the technical interoperability between the modules and the platform (Baldwin et al., 2009). These interfaces and loose coupling of modules allow that platforms are open for introducing new products, services and capabilities after the establishment of the platform (Yoo et al., 2010). Interfaces can for instance be APIs (Application Programming Interfaces), that specify how to couple a module to the core platform.

Platforms and ecosystems

Over recent years, there has been increasing interest in the concept of *ecosystems*, which in its most basic form can be seen as a group of interacting firms that are interdependent (Jacobides et al., 2018; Nambisan, 2018) and together create value (Hannah and Eisenhardt, 2018). There are different sorts of ecosystems, such as business ecosystems (Valkokari, 2015), innovation ecosystems (Clarysse et al., 2014) but also platform-based ecosystems (Isckia et al., 2018; Parker et al., 2017; Tiwana, 2014). The latter is relevant to this thesis.

For the definition of platform-based ecosystems in this thesis, two definitions from literature were used. The first definition is that of Tiwana (2014, p. 6): ”The collection of the platform and apps that interoperate with it represents the platform's ecosystem”. The second comes from Cennamo and Santaló (2019): ”Platform-based technology ecosystems are new forms of organizing independent actors' innovations around a stable product system”. The inclusion of the second definition is relevant because it stresses the fact that an ecosystem can involve interaction of independent actors around the platform. Concluding, this thesis defines digital-platform based ecosystem as ”the collection of the platform, the apps and the organization of independent actor's innovations surrounding the platform”. Whenever this thesis refers to an *ecosystem*, this denotes a platform-based ecosystem.

2.1.3. Digital platform dynamics

This section explains dynamics concerning digital platforms relevant to this thesis.

Platform ownership

It should also be mentioned that in platform-based ecosystems there is often a *platform owner* or a *keystone firm* (Iansiti and Levien, 2004), i.e. the ”lead firm responsible for the platform” (Tiwana, 2014, p. 5). While most studies discuss the perspective of a single firm as platform owner, ownership does not necessarily focus on one party (Teece, 2018; Tiwana, 2014). Instead, multiple firms can be at the centre of a platform-based ecosystem and may organize control or financing related to the platform.

Roles

In addition to the platform owner, platform-based ecosystems typically attract at least two groups, clients (or partner) (Isckia et al., 2018) and users (Aulkemeier et al., 2019). Often, three groups of actors are represented in platform-based ecosystems, i.e. *users*, *owners* (or platform provider) and *complementors* (or clients) (Aulkemeier et al., 2019; Tiwana, 2014).

A clear description comes from Eisenmann et al. (2009), who describe four roles present in digital platforms. *Demand-side users* are the end-users of the platform. *Supply-side users*, or *complementors* are those users that develop complements to expand the functionality of the platform. *Platform providers* manage and control the day-to-day operations of the platform. Finally, *platform sponsors* are the lead party that determines the platform's ownership, control and strategy.

Generativity

Generativity refers to the concept that platforms can facilitate unforeseen product offerings without the need for active participation by the provider of the platform (Tilson et al., 2010; Zittrain, 2008). The modularity-principle allows that new applications can be added to the platform also after the platform-configuration has been determined. This characteristic flexibility for complementors to develop previously unknown applications or services that can be coupled to the platform and add value to the platform. Generativity is thus closely related to the creativity and innovative characteristics of digital platforms.

Network effects

Network effects or *network externalities* are a property of platform based systems that ”every additional user makes it more valuable to every other user on the same side (*same-side network effects*) or on the other side (*cross-side network effects*) "(Tiwana, 2014, p. 25). These cross-side network effects are also referred to as *indirect network effects* (Song et al., 2018). Various researchers have studied the role of network effects in the adoption and scaling of platforms (Constantinides et al., 2018; Parker et al., 2017). The self-reinforcing effect of network effects enhance the value of platforms. Higher adoption of a platform may also foster innovation, as it becomes more attractive for complementors to innovate on the platform. Likewise, when there is a lack of network effects, the platform owner or sponsor needs to invest to grow the platform. Instead, *openness* of a platform can enhance the attractiveness of a platform, as will be described in chapter 5.

Competitive dynamics

It has been recognized that ecosystems of platforms have introduced a new perception on competition as compared to former 'value-chain' based economies. In platforms, competition occurs *between platforms*, for instance in attracting users and attracting complementors (De Reuver et al., 2018b). It also occurs *among complementors*, that is what complementary offerings are adopted at the cost of the adoption of other complements (Adner, 2017). Additionally, Teece (2018) finds that forms of competition may also occur *between the platform and the partners*, for instance in the appropriation of rents from the sales of complements through the platform.

Winner-takes-all dynamics

Due to network effects, platforms that attract a large pool of users tend to increasingly become valuable for complementors and users, resulting in a self-reinforcing effect that may lead to a winner-takes-all situation in which one platform becomes the dominant market standard (Inoue, 2019). As a result, the variety of platforms gets smaller and the monopolistic platform gets more powerful. This can lead to undesirable market dynamics, for instance leaving people with little options but to comply to the platform's terms (Boudreau and Hagiu, 2009). Arguably, such winner-takes-all dynamics are undesirable for the primary care domain as they can lead to loss of efficiency in terms of quality services at low costs.

One way to deal with these dynamics is by deploying an appropriate governance structure. For instance, by enforcing interoperability or standardization (Zhu and Iansiti, 2007) or data-sharing (The Economist, 2019b), regulatory bodies can create market dynamics that allow for competition between platform owners and between complementors.

2.2. Perspectives on digital platforms

Researchers of digital platforms have had different perspectives on digital platforms (De Reuver et al., 2018b; Gawer, 2014). While some are interested in platforms as enablers of transactions between multiple parties others focus on the role of platforms as a catalyst for innovation. Subsection 2.2.1 describes the perspectives on digital platforms described in platform literature, subsection 2.2.2 describes the perspective adopted for this research.

2.2.1. Perspectives on digital platforms

Digital platform researchers recognize that digital platforms are studied from various perspectives (De Reuver et al., 2018b; Stolwijk et al., 2019). However, they are not unequivocal in their choice and description for the perspectives on platforms. While all these perspectives acknowledge that a platform consists a core entity, with loosely affiliated components, they take a different focus on the role of a platform within its ecosystem. Because it is yet uncertain how a digital platform may be designed to support the primary care domain, a description of the perspectives can help to gain a better understanding of the function that a platform fulfills within its application domain.

The *economics perspective* on digital platforms views platforms as multi-sided entities that facilitate interactions between different user groups. This type of platform is sometimes called *business platforms* (Stolwijk et al., 2019). One example to explain this perspective is how Uber works, it couples users who seek a ride from location A to B with users that offer a ride. Another example is how Facebook attracts for instance end-users, advertisers and widget developers (Boudreau and Hagiu, 2009). Facebook creates value by coupling these user-groups and giving them access to a large group of affiliated users. Important topics in this stream of research are the dynamics of competition and network effects. Literature in this field for instance studies how and why platforms succeed at establishing a user base

The *industrial engineering perspective* sees platforms as a stable core, comprising functionality that is shared by the modules that are affiliated with the platform. Gawer (2009) defines platforms from this perspective as a core "building block" that provides essential functionality "to a technological system – which acts as a foundation upon which other firms, loosely organized in an innovation ecosystem, can develop complementary products, technologies or services". This structure stimulates innovation of novel services and products through the platform. An example of this perspective is the Windows operating system. This operating system provides core functionality (a.o. a user interface, managing memory and executing applications) on which additional complementor providers (e.g. music streaming service Spotify) can offer their service to users.

A different type of platforms are *data platforms*. Data platforms are platforms that gather and combine information from different data sources to exchange and link data (Stolwijk et al., 2019). These platforms create value to affiliated users by sharing data from different sources. Openness is also important in relation to data platforms. 'Open' denotes that third parties have rights and possibilities to be "used, modified, and shared by anyone for any purpose" (Open Knowledge Foundation, 2019). Open data platforms aim to foster transparency of data and they can be used as a means to foster innovation through the development of new services and products (Athanasopoulou et al., 2016; Janssen, 2011). Information technology and systems supporting the healthcare industry can be expected to generate huge amounts of data, the perspective of a data platform can shed a light on how to deal with openness of data in this domain. Standards for data transferring and interoperability of different data sources plays an important role in the development of data platforms (Stolwijk et al., 2019).

2.2.2. Positioning this thesis in scientific research

What sets this thesis apart from the economic and industrial engineering perspective on digital platform research, is that these perspectives take an ex-post perspective while this thesis examines the design of a digital platform 'from scratch'. The conceptual description of the different perspectives is helpful for breaking down the dynamics that shape digital platforms. Rather than choosing a perspective, this thesis incorporates both market dynamics (economic perspectives) as well as architectures that stimulate innovation (industrial engineering perspective). In discussing the findings of the research, the outcomes will be addressed in light of these two perspectives.

As for the data platform perspective, the application of a data platform view on a platform in primary healthcare is considered an interesting topic to study but was not covered in this thesis.

3 Research methodology

This chapter discusses the methods used in this thesis, how data that is gathered and analyzed to draw conclusions on the research questions. Figure 3.1 below shows an overview of the methods, tools and outputs that are involved with the steps in this study.

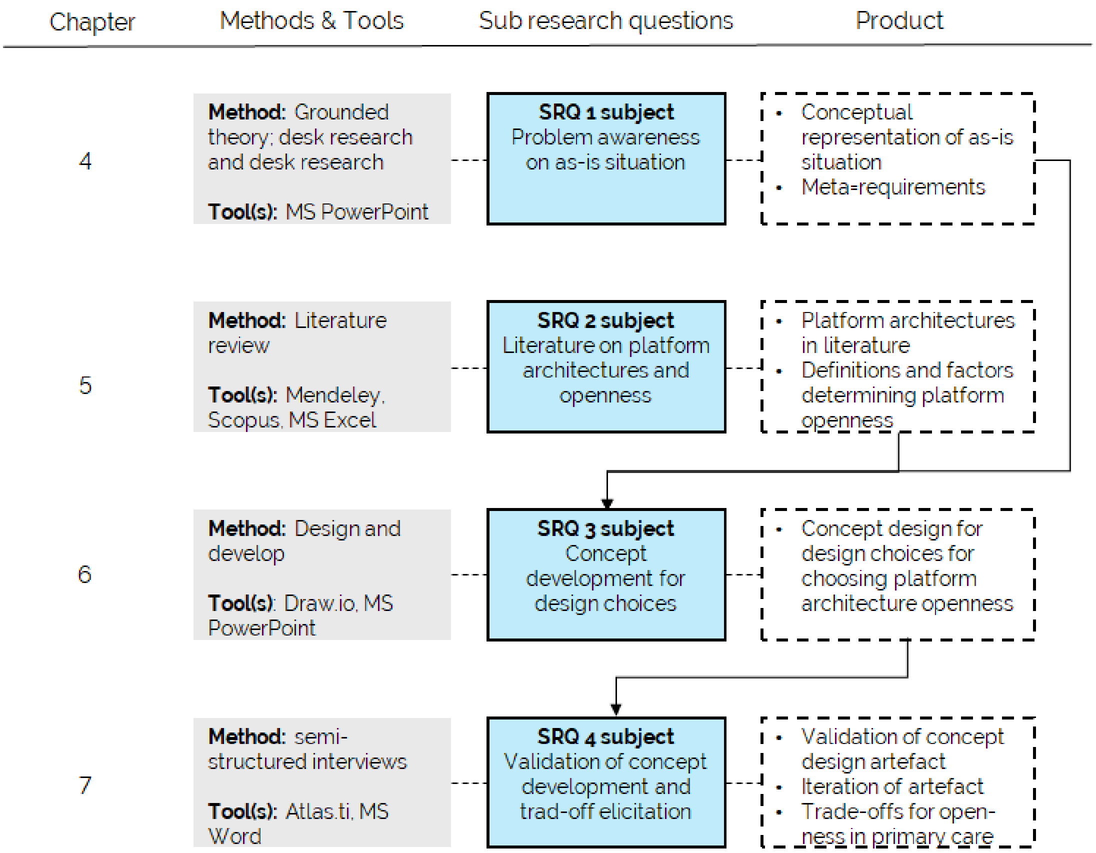


Figure 3.1: Overview of the tools, methods and outcomes for each step of this research and where they are described in this thesis

3.1. Approach to sub research question 1

The goal of the first step of this research is to develop awareness of the context and the problem. This stage is grounded in the perception that a DSR project should aim to solve a real-world problem (Hevner et al., 2004; Kuechler and Vaishnavi, 2008). However, currently, an unambiguous description of the existing situation of information systems supporting Dutch first-line healthcare is lacking. A first step in understanding how a digital platform may be designed in first-line healthcare, is developing an understanding of what the existing landscape looks like.

3.1.1. Intended outcome for this stage

To 'develop an unambiguous understanding of the landscape of information systems in first-line healthcare' remains a fairly broad goal. What deliverable must this stage yield? Previous work from DSR and information systems in healthcare show several insights for the first stage of this study.

In terms of the DSR approach followed in this study, Vaishnavi and Kuechler (2004) suggest that researchers should map 'soft context information' about the system. This is "information about the operational context of a system or process" (Kuechler and Vaishnavi, 2008, p. 492). This type of information has two properties: (1) it often entails information concerning the organization or social structures that is difficult to objectify, and (2) this information typically provides criteria for selecting between design decisions (Kuechler and Vaishnavi, 2008). To further specify this stage's goal, other studies on information systems in healthcare were consulted.

Researchers studying IS in healthcare acknowledge that previous attempts at reforming information infrastructures in the healthcare domain in Europe have involved great complexity. This complexity was attributed to involvement of different parties with diverging interests and high fragmentation in terms of information systems and suppliers (Aanestad et al., 2017; Agarwal et al., 2010). Moreover, alterations in either technology or organizational structures may have reciprocal effects on involved technologies and stakeholders. Consequently, successful design of information systems for healthcare-related information systems requires a thorough understanding of the characteristics of the situation (Aanestad et al., 2017).

Based on the DSR approach and insights from researchers in IS in healthcare, the first stage of this research intends to describe:

- A high level description of how first-line healthcare is organized in The Netherlands;
- How IS are organized in this domain;
- An analysis of the stakeholders involved;
- What implications result from this description to the overall goal of this thesis research.

3.1.2. Method for this stage

The approach used to develop insight in the current landscape of IS in the first-line care domain was inspired by *Grounded Theory*. Grounded theory is a qualitative inquiry method designed to explain and describe concepts and phenomenon under study (Corbin and Strauss, 1990). This theory is useful in exploratory research when researchers start off with little information concerning the topic under study (Creswell et al., 2007), hence its relevancy for this sub research question. Grounded theory academics have different perceptions on the method's use. The perception of thesis mostly resembles that of *constructionist* approach Charmaz (2008). This approach sees grounded theory as a method to describe the world as the researcher constructs it.

Justification

Grounded theory is in particular useful for uncovering dynamic interplay of actors within a system. Moreover, this method keeps an open attitude to phenomena that may seem relevant only later in the research that were not addressed earlier. This is considered a useful property as limited knowledge is available on the landscape of IS in the first-line care domain from the start, so the opportunity to add concepts that weren't previously considered may be needed.

A critique to grounded theory is that it is dependent on the researchers interpretation of findings and data by the researcher (Timonen et al., 2018). To mitigate this negative consequence of the theory, this research clearly describes how the theory during this stage was developed.

Data usage

In grounded theory research, data collection and data analysis are interrelated. As opposed to common methods where data is collected first and later analyzed, with grounded theory the analysis is required right from the start and this analysis is used as input for the following interviews or observations (Corbin and Strauss, 1990). This way, theory gradually evolves as research progresses. What is more, data can be collected from various sources, e.g. interviews, observations, government documents, etc. - anything that might bring to light anything relevant to describe the subject of the research. Still, a structured approach is imperative for thoroughly drawing conclusions on the state-of-affairs of the current system under study.

Two data sources were used:

- **Desk research** - An initial understanding of the landscape of information systems in the first-line healthcare sector was developed through consultation of publications from this domain. These publications included works from Idenburg and Dekkers (2018), Idenburg and Phillipens (2018), Kuijpers and Bakas (2017), Bus et al. (2019) and Van Gelder and Zebregs (2015) and the web resources `https://www.nictiz.nl/` and `https://www.vzvz.nl/`. These resources cover the trends that are observed concerning IT that supports the first-line care domain. Furthermore, they provide an overview of historical developments that have shaped the current landscape of the system under study.
- **Discussions with field experts** - Kuechler and Vaishnavi (2012) incorporate 'tacit theory' as an input to information systems design efforts. This refers to "insights or evidence/experience-based justification for pursuing a novel design" (Kuechler and Vaishnavi, 2012, p. 404). Experts' insights are therefor deemed a useful source for gaining an understanding of the problem and its context. These insights were gathered through conversations with field experts in IS in first-line healthcare.

  Over a period of four weeks, eight one-on-one (and once a one-on-two) discussions were organized with field experts. These experts all worked at companies that develop information systems for first-line care providers. The approach to these discussions are described in appendix subsection B.1.2. The results of are presented in the corresponding chapter 4.

Analysis approach

The approach to this part of the study is graphically represented in Figure 3.2. Information collected from desk research was conceptually represented using a slides presentation. These conceptual figures (e.g. Figure 4.1 and Figure 4.3) were showed to domain experts. After each discussion with a domain experts, the information from the slides was iterated until domain experts had no suggestions for further adjustments. An overview of these talks is presented in chapter 4, table 4.1.

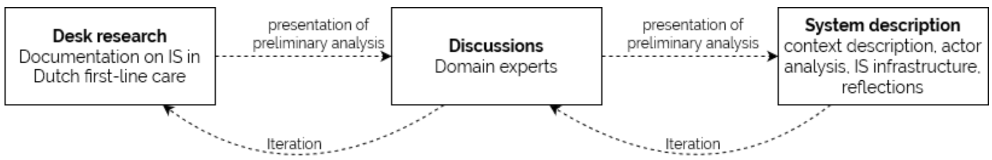


Figure 3.2: Overview of the approach to sub research question 1, inspired by grounded theory

Tools
Microsoft Office PowerPoint was used to develop a slide show that could be presented to subjects to develop a shared understanding of the as-is situation of information systems in the first-line care domain.

3.2. Approach to sub research question 2
Inspired by the *suggestion*-phase in the design science methodology by Vaishnavi and Kuechler (2004), this phase sets out to find what (1) platform architecture configurations and (2) what trade-offs relating to platform openness have been reported in scientific literature. Previous researchers have studied differences in existing configurations for digital applications based on the intended goal of a system (e.g. Ondrus et al. (2015) and Kazan et al. (2018)). By examining architecture configurations that have been described by researchers in the digital platform domain, this thesis aims to describe the variety in architectures and the motives that underlie these different configurations. Moreover, this thesis aims to understand how openness can be achieved for a platform in first-line care. Therefor, platform architectures should be described together with their implications on the openness of the platform. Ultimately, by examining the possible configurations it should become clear what architectures can be interesting to pursue for Dutch first-line care.

3.2.1. Intended outcome for this stage
The intended outcome from this phase is an overview of design choices that platform owners have concerning the design of their architecture core. These choices for differences in platform architectures should relate to different degrees of openness of the platform.

3.2.2. Method for this stage
A literature review was conducted, with two focuses: (1) platform *architectures* and (2) platform *openness*.

Justification
As indicated by Wee and Banister (2016), literature studies can be conducted for several purposes. One of these purposes is to understand what theories and studies are available to inform the design of a real-world situation. Similarly, for this thesis the goal is to understand what knowledge previous studies on platform architectures and openness have revealed that may be of value for application to a digital platform in first-line healthcare. As also indicated by Wee and Banister (2016), it is important to describe the approach taken for the literature study. Section B.2 reports what approach has been taken in this regard.

Data usage
The data gathered for this step are scholarly publications. To enhance the quality of the academic literature that was used, only articles were used that could be found in the database of Scopus. All publications in Scopus have been subject to peer-review processes.

Analysis approach
The methodology for how the literature review was conducted, is included in appendix section B.2.

Tools
Mendeley was used as a means for managing references. Microsoft Office Excel was used for keeping track of relevant information found in the academic publications.

3.3. Approach to sub research question 3
Next, the information from the previous steps must be converged in a way that allows field experts to express trade-offs relating to the openness of a digital platform in first-line healthcare.

3.3.1. Intended outcome for this stage

The intended outcome is a concept design that shows the design choices that platform owners have for choosing platform architectures with different degrees of openness. Based on this design, field-experts should be able to express their perception of what platform architecture will be suitable for first-line healthcare. Their motivation for choosing design options is expected to highlight design trade-offs.

3.3.2. Method for this stage

A combination of methods was used to guide the development of a concept artefact. Firstly, following DSR-suggestions by Johannesson and Perjons (2014) and Peffers et al. (2007), the purpose and intended outcome of the artefact is made explicit, with the intention of defining the requirements the artefact must meet. Secondly, brainstorming took place to develop ideas for the artefact (inspired by an approach from Johannesson and Perjons (2014)). For brainstorming, the outputs of sub research question 2 were used for inspiration. The ideas for the artefact were assessed, after which a design has been selected and built. An explanation of these steps is provided in chapter 6. Third, sketches were made concerning the design choices platform owners face for the platform architecture and openness. These sketches are included in chapter 6. Finally, the sketches for the design artefact have been assessed. In this stage, the sketches and ideas for the concept artefact are assessed and selected (Johannesson and Perjons, 2014).

Justification

Brainstorming is an established means for the generation of new ideas (Johannesson and Perjons, 2014). It can be executed both in groups or by individuals (Isaksen et al., 1998). For this research it done solely by the researcher.

The purpose of sketching, is to clarify the thinking about the artefact. Sketches are useful for communicating the concept artefact to actors and to gather feedback on the concept artefact (Johannesson and Perjons, 2014).

Data usage

All data that served as input for the artefact, was already gathered in previous steps of the research (in chapters 4 and 5. The only data that has been considered in addition, were scholarly publications on platform design as inspiration for the design of the artefact.

Analysis approach

Concept design artefacts were sketched, assessed and selected. For selection between concept designs, several criteria were used. First, one of the goals of the artefact is to identify design trade-offs. For this, we are interested in how domain-experts respond to the theories underlying different design choices for a platform architecture. This corresponds with one of the goals of evaluating a concept design, according to Johannesson and Perjons (2014). A relating criteria is that respondents must be able to express their feedback on the theories underlying the concept design. Second, the artefact should provide a concise and holistic overview of the design options. If the artefact is too elaborate, it may be difficult for respondents to express their reflections on the artefact. Third, this thesis takes a neutral standpoint on a digital platform for first-line healthcare. Likewise, the concept design artefact should take an objective stance in explaining design choices on the architecture and openness of a digital platform.

With these criteria in mind, two designs options have been considered for the artefact. Both artefacts have been included in the *design and develop*, *sketch* and *assess* phase:

- **Option 1: Conceptual model denoting influence-relationships**

  A conceptual model can reveal influence relationships between factors, for instance: *an increase in A causes an increase in B while simultaneously leading to a decrease of C.* This method has been used for the establishing theories on relationships between factors for instance by Nikayin et al. (2013).

For studying architectural design options for platform openness, such an artefact would highlight interrelationships of driving forces and consequences of platform openness.

- **Option 2: Design configuration table**

  A table provides a structured way for highlighting choices that platform owners need to deal with on different dimensions. It allows for pragmatic comparison of concepts in relation to one another. The development of a table as a design artefact to highlight different configurations has been inspired by the work of Nickerson et al. (2013), who develop a structured way for developing taxonomies through design science research.

  Using a table to denote different configurations for digital platforms has also been done by De Reuver and Keijzer-Broers (2016), Blaschke et al. (2019) and Mukhopadhyay and Bouwman (2019).

Assessment of the two models resulted in selecting the *design configuration table* as a suitable artefact for this study. This table is presented in chapter 6. This option was considered to have several advantages over option 1. First, it proved to be difficult to objectively sketch certain factors and consequences using the first model without taking a biased perspective. For instance, the effect of design choices is dependent on the viewpoint one takes or ones role in the platform ecosystem. Since this image aims to take a neutral standpoint, this introduced complications. The design table allowed for a more objective description of the consequences and factors related to openness. A second advantage of the design table over the influence diagram is that it allowed more easily to include all design options in one comprehensive overview. The influence diagram required to sketch multiple diagrams for the various design options of the architecture.

Tools

Draw.io and Microsoft PowerPoint were used as tools to sketch ideas for the design of the concept artefact.

3.4. Approach to sub research question 4

This final step deals with *evaluation*, *iteration* and the elicitation of design trade-offs for openness of architectures. Iteration in DSR considers the elicitation of feedback on the concept design to serve as input for subsequent design steps. This iteration 'loop' is also included in the design cycle from Vaishnavi and Kuechler (2004). For this thesis, the purpose of evaluation and validation is to gain understanding of the trade-offs that field-experts make when deciding on platform openness in this domain.

3.4.1. Intended outcome for this stage

The intended outcome is a substantiated list of trade-offs related to choices for openness of a platform architecture for a digital platform in first-line healthcare.

3.4.2. Method for this stage

Semi-structured interviews with domain-experts were conducted to elicitate trade-offs relating to openness of a platform architecture for the domain under study. Semi-structured interviews are interviews based on a predefined set of questions but with flexibility in terms of the order and the openness of questions. This way, they give respondents room to answer questions in their own wordings (Johannesson and Perjons, 2014). A detailed description of the set-up for the semi-structured interviews, including the protocol used and the selection of respondents, is provided in appendix section B.3.

Justification

Semi-structured interviews are considered a suitable method for the intended purpose because they can be used to developing understanding of the attitudes and perspectives respondents have towards the concept design (Johannesson and Perjons, 2014). Moreover, this method is useful because it allows for additional insights to emerge that were not foreseen by the researcher. In addition, they "provide a way of capturing the knowledge of practitioners and experts within a specific research domain", while keeping "an open mind towards discovering new insights that were not made explicit prior to the collection of the empirical data" (De Reuver and Haaker, 2009, p. 224). Furthermore, this method is considered useful in clarifying user needs and objectives (Wilson, 2013). The method has the advantage over *structured interviews*, when the subject of the interview entail complex ideas or systems (Johannesson and Perjons, 2014). In semi-structured interviews, the respondents have more freedom in expressing their opinions and ideas.

Downsides of this technique are that the efficiency of the method depends on the expertise of the respondents and it is rather time-consuming (Johannesson and Perjons, 2014). The selection of interview-respondents is selected to minimize this disadvantageous property. The selection of respondents is discussed in subsection 3.4.3. What is more, the open character of a semi-structured interview has the disadvantage that the researcher has to interpret the responses (Johannesson and Perjons, 2014). Another criticism on semi-structured interviews relates to its qualitative nature. It has been said that qualitative research suffers a lack of transparency and it requires interpretation of the data by the researchers, possibly jeopardizing objectivity (Ward et al., 2013). For the purpose of transparency, the approach to the semi-structured interviews has been described clearly in appendix E.

Data usage

The data collected and analyzed in this stage involves the transcripts from the semi-structured interviews.

3.4.3. Analysis approach

This subsection explains the how the semi-structured interviews were approached. The goal of using semi-structured interviews to understand trade-offs relating to the openness of the platform architecture. For an in-depth understanding, the interviews were designed to capture the broad range of trade-offs that exist for this domain as well as to understand what trade-offs weigh more heavily than others. The selection of interview candidates was made with the purpose of involving different roles in the field as to include varying views on the topic of this study. The interview protocol was used to develop a sense of what consequences and trade-offs are valued over others. The respondents and the protocol for the semi-structured interviews are discussed below. A description of the execution of the interviews is included in section 7.1.

The interviews were transcribed and coded. Transcripts were first printed and hand-coded twice to develop an initial impression of the responses. For this, an open coding approach was used. No prior codes were defined. The coding was informed by the interview transcripts and the with the end goal of identifying trade-offs and preferences relating to the openness of a platform architecture in mind.

Hereafter, the transcripts were included in the software Atlas.ti. In Atlas.ti, the interviews were examined for each dimension of the design table, that is: the dimensions were discussed separately, the transcripts for these parts were also analyzed separately. This approach was taken for the purpose of structuring the analysis.

Tools

The semi-structured interviews were recorded (with consent of the respondents, see appendix I). The recordings were transcribed, using web-based tool Otranscribe (`https://otranscribe.com/`) and anonymized. Subsequently, Atlas.ti (version 8) was used to analyze the transcribed interviews. The argument for using a software is that it contributes to a more objective and systematic way of analysing and interpreting the transcripts (Barry, 1998). Also, it enhances the transparency of the analysis, as long as the researcher provides a clear description of the conducted analysis (Paulus et al., 2017).

Selection of respondents

The selection of the respondents is an important step for effective usage of semi-structured interviews because the quality of the feedback depends on the knowledge of the respondents. For this reason, a selection of interviewees was made, based on their experience and roles in the domain of information systems in the Dutch first-line care domain. The subjects were elected to cover a broad range of perspectives on information systems in the domain under study. The following fields of expertise were chosen to be included in the interviews:

- field-experts with affinity with the multi-actor dynamics with respect to decision-making processes and policy-interventions in the first-line care domain. This group is denoted with a *P*, denoting *policy* in Table 3.1;
- developers of IT-applications for the first-line healthcare domain, for their technical knowledge on the development of healthcare applications. This group is denoted with a *T* for *technology* in the table below;
- c-level managers of IS suppliers in the first-line healthcare domain, for their strategic perspective on positioning IS in the domain under study. This group is denoted by the *M* for *management*;
- healthcare practitioners, these are caregivers that have a demonstrated affinity with information technology. Those are denoted by the *H*, standing for *healthcare*.

Table 3.1 shows an (anonymized) overview of the respondents. The *I* stands for *interviewee*. To protect the respondents' confidentiality, it was decided to use codes to denote the interviewees.

Table 3.1: Overview of the respondents of the semi-structured interviews

Code	**Organization type**	**Role**	**Other relevant experience(s)**	**#years in first-line healthcare**
PI1	IS vendor; Interest group for IS developers in healthcare	Manager business development; board member	Similar functions at other IS developers for first-line care; national board for supporting cooperation of IS suppliers in first-line care	>20
PI2	Interest group for IS developers in healthcare	Director	Representative for interest organization for health insurance companies	15-20
TI1	IS vendor in first-line healthcare	Head of IS products	Similar position at other IS vendors	>20
TI2	IS vendor in first-line healthcare	IT-architect	10 years as software architect	2-5
TI3	IS vendor in first-line healthcare	Product (application) owner	n/a	2-5
MI1	Supplier of webpages for caregivers and personal digital health environments	Director	n/a	>20
MI2	Information system supplier in the Dutch first-line care domain	Director	15+ years experience in management rolls, mainly in banking and IT and healthcare and IT	2-5
HI1	Combined practice for general practitioner and pharmacy	Pharmacy doctor	Active role in providing feedback on the quality and operations of information systems in first-line healthcare	15-20

Interview protocol

The goal of the interview was to elicit trade-offs relating to the openness of the platform architecture. The output of the third step of the research (sub research question 3) were used to design an interview protocol. A protocol was used to enhance the comparability of the feedback and insights provided by the respondents. The protocol consisted of a set of questions that were developed in advance. The researcher was allowed to deviate from this protocol when relevant new insights emerged during the discussion. The protocol can be found in appendix B.3.1.

A few days in advance of the interview, the respondents received a document, explaining the scope and purpose of this thesis research. This document also stated the goal of the semi-structured interviews. This information document explained that the interview would involve discussing configurations for architecture openness, but it did not show any information concerning the concept artefact.

The interviews were supported by a PowerPoint presentation. The motivation for using a slide presentation to substantiate the discussion, was to provide all respondents with similar information. If all information would have been sent in advance, a risk loomed that some respondents could become biased or misinterpreted some of the information related to the concept artefact. These slides have been included in this thesis in appendix H.

During the first interview, the interviewee mentioned that slide 12 (the interface standards-dimension) was somewhat confusing. It was suggested to show an additional platform in the image explaining option 2 (the middle image in Figure 6.5). This suggestion was included and this image has been adjusted before the following interview.

Moreover, it was found during multiple discussions that respondents were really interested in 'what functionality it was that was included in the core'. This question was previously identified as one of the key trade-offs needed to be made by a platform owner prior to the launch of a platform (see Table C.1). It was decided to make take an example that could consistently be used in all interviews; the core comprised treatment logging, authentication and identification.

On recording and consent

All discussions were audio-recorded and transcribed. After transcription the recordings were deleted and the transcripts were sent to the interviewees for them to provide feedback or agreement on the transcripts.

The participants were explicitly asked for their consent for their participation and for the audio-recording of the interviews. The consent form was constructed based on the template provided by TU Delft. This document is attached in appendix I.

4

Problem awareness - Current situation

A digital platform cannot be designed without an understanding of the context to which it applies. A thorough understanding of the 'as-is situation' and the problem and context in which an information system operates is crucial to successful design efforts. DSR researchers agree that gaining an understanding of the 'environment' or 'problem identification and motivation' are essential to understand the complexity of the system (Gregor and Jones, 2007; Hevner et al., 2004; Kuechler and Vaishnavi, 2008; Peffers et al., 2007; Vaishnavi and Kuechler, 2004). Therefor, this step is a prerequisite for further design steps. The approach to gaining an understanding was described in section 3.1. The outputs of this stage are discussed in this chapter.

This chapter is organized as follows. A high-level overview of the first-line healthcare domain is provided in section 4.1. Subsequently, section 4.2 describes the outcomes of the analysis of the stakeholders that interact in IS in first-line healthcare. This is followed by a description of how IS in this domain are organized in section 4.3. Finally, section 4.4 gives a reflection on the challenges that IS in first-line healthcare in The Netherlands face, and its implications for the design of a digital platform in this domain.

4.1. Context description of first-line healthcare

In The Netherlands, professional healthcare is divided in four layers, 'zero-line healthcare', 'first-line healthcare', 'second-line healthcare' and 'third-line healthcare' (Nictiz, 2019b). The zero-line healthcare involves preventive care measures and healthcare research (Nictiz, 2019b). The first-line care domain concerns all care providers that a citizen can consult without a need for a prescription (e.g., general practitioners, dentists, physiotherapists, etc.) (Rijksoverheid, 2019b). Second-line domain involves specialized care, which in essence is all care taking place in hospitals. The final layer, the third-line, deals with highly specialized care demands. This layer constitutes of specialized health clinics.

For clarity purposes, the interactions in the domain of information systems in the first-line care domain are dissected over three different 'layers', a *policy* layer, a *healthcare* layer and an *information systems* layer. This layered distinction has no formal foundation, it is a distinction that, in the talks with domain experts, proved to be a useful way to describe the interaction of actors within this system and was inspired by their suggestions. Figure 4.1 gives a visual and conceptual overview of how the most important stakeholders interact. Additionally, it should be noted that the description of the system includes the actors (with corresponding characteristics) that came forward most prominently in expert interviews and desk research. Although this overview is not exhaustive, it is assumed to take into account all relevant dynamics of the stakeholders and systems within the scope of this research.

On policy

How first-line healthcare has been organized in The Netherlands has changed over recent decades. Up untill 2006, the ministry of Health Welfare & Sports (HW&S) arranged care centrally through the so-called 'Ziekenfonds'. This system ensured all Dutch citizens had equal access to care. In addition, citizens could choose to buy additional care support through private insurance policies. These private insurance companies were more lucrative for healthcare providers compared to the Ziekenfonds. As a result, this system had the perverse incentive that those who could pay the most, had access to the best care. In general, healthcare for less wealthy citizens slowly became neglected. Therefor, in 2006, HW&S introduced a new arrangement. The ministry decided that healthcare should be arranged through insurance policies. Every citizen is obliged to take out a health insurance and is subsidized to do so. The ministry purchases insurance policies. Insurance companies in turn, must 'purchase' care at healthcare providers. This system is targeted at giving insurance companies the incentive to compete on the quality and the costs of care - ideally, resulting in the most efficient care for citizens. These developments have shaped the roles and interactions that shape first-line healthcare.

First of all, the ministry of HW&S is responsible for ensuring Dutch citizens have access to care. This organization of care involves trading-off a 'social responsibility' and an 'economical responsibility'. The first one being ensuring that everyone can have access to care, the latter to relying on market forces to provide high quality care at the lowest possible costs. In addition to the system described above, the ministry of HW&S has delegated certain types of care (elderly care, youth care and chronically ill) to municipalities (Rijksoverheid, 2019a). The ministry funds municipalities, the municipalities themselves are responsible for organizing these types of care within their area.

Secondly, insurance companies have a large role in the system. Insurance companies determine what care support and medications can be reimbursed. Furthermore, on behalf of their clients (patients), they pay for professional care support. Through this structure, they have a large role in determining how patients interact with caregivers. Moreover, in case innovations change the interactions between patients and caregivers (e.g. more focus on preventive care or patients are enpowered to organize self-care) this can have consequences for the role of insurance companies. The other way around, insurance companies may fund innovations that can improve healthcare support.

Another party that can affect the organization of healthcare is the European Union. An example of this is their directive for nations to maintain a registry of all medication that is available and has been prescribed to prevent medicine-fraud. Also, European legislation may affect how information systems in this domain evolve, for instance the General Data Protection Regulation (GDPR) is a European legislation that all system suppliers must adhere to. Similarly, in banking, the Payments Services Directive 2, has forced banks to open up their information systems to outside developers. Although EU's intervention in member states' healthcare systems have thus far been limited, in the future the EU's influence in this context may increase.

Finally, a party that has a regulating influence on the healthcare domain in The Netherlands is that of the wholesale industry. Wholesale refers to the suppliers of medicine. Insurance companies determine what medications can be reimbursed. Wholesalers in turn, can control what medications they supply to pharmacists and thus indirectly affect the system as a whole.

On healthcare execution

The healthcare layer concerns all actors that play a part in the interactions between healthcare providers and patients. Central to this layer is the interaction of care providers that perform healthcare support and give advice to patients. The first-line care domain constitutes of a set of care providers that all serve the patient. As indicated by the arrows in Figure 4.1, both the patient as well as the care providers receive financial support from the municipality and insurance companies for their healthcare.

Figure 4.1 shows a dotted line within the first-line healthcare. This denotes two groups. One is a *care group* (Nl: zorggroep). A care group is a collaboration of, often in the same geographical region located, care organizations that are centrally controlled. The care group has a guiding role, connected care providers are not restricted to the care group's advice, though following their advice is recommended. For instance, a care group can advice the adoption of information applications because that will lead to greater alignment of healthcare information technology within the care group. The second group is *care centers*. Care centers are groups of care providers located at the same location. Again, this does not imply that the care providers within a care center necessarily have to use the same applications (or application providers), but often the providers within a care center choose to adopt the same solution to information applications. Finally, as with the insurance companies, there is an interest group (Dutch: belangenvereniging) for patients that represents and protects the interest of the patients.

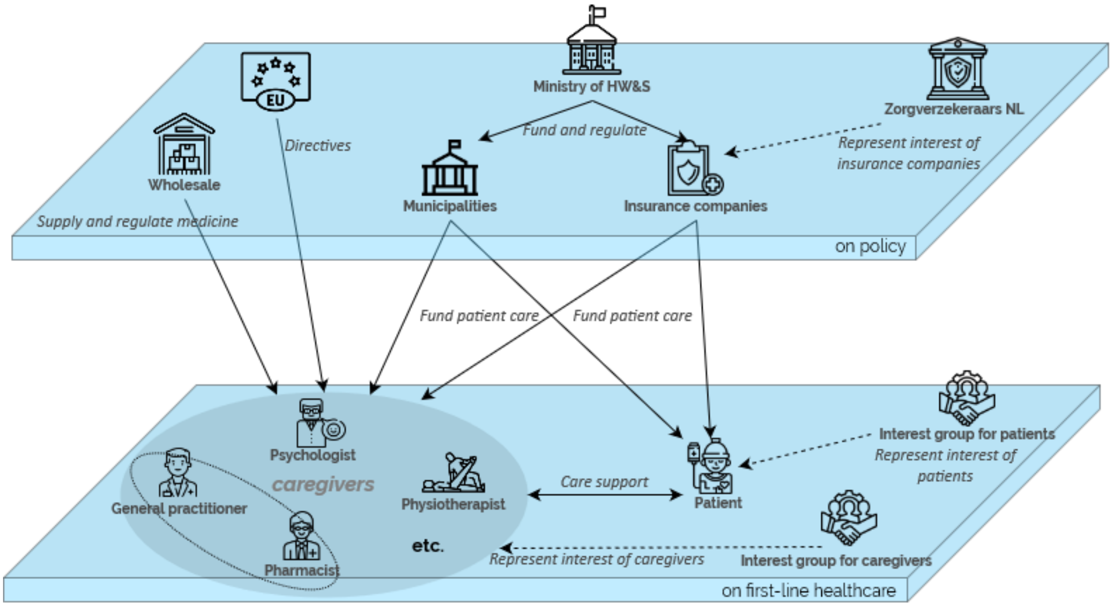


Figure 4.1: Visual representation of context, actors and interactions in primary healthcare

4.2. Stakeholder analysis

Gaining insight in the dynamics of stakeholders is relevant because it clarifies what stakeholders need to be involved when transforming the information infrastructure in first-line healthcare. Due to the means stakeholders have to adopt or discard a novel IS solution, they influence the feasibility of such innovation. Also, the interest that stakeholders have towards an innovation can affect whether an innovative attempt to change the IS infrastructure turns out to be a success or not. A detailed overview of the involved stakeholders, their means, their interest and their power and interest towards organizing information systems in the primary healthcare domain is provided in a stakeholder analysis reported in appendix D. Following an approach proposed by Bryson (2004), the stakeholders are discerned into four categories. Appendix D shows a detailed analysis of the stakeholders. This section reports a concise overview of this analysis.

Most important to notice is that there is a small set of stakeholders that have both the resources and an interest to influence the organization of IS in the system under study. These parties are denoted as *players* in figure 4.2. Their power position can be either negative or positive towards intended change. In case that a stakeholder has a positive attitude towards the suggested change they may help enforcing the proposed changes. When they have a negative attitude, on the other hand, they may hinder attempts to innovate. To understand how to approach an actor that holds a high power position, one can turn to the actor's interest.

It can be assumed that an actor may play a favorable role when an innovation serves his/her best interest. These parties that have large power and a large interest should be addressed with the highest priority when searching for support for transforming the IS infrastructure.

The number of stakeholders with less interest but still a high power position is small. Stakeholders in this group are called *context setters* in Figure 4.2. While these parties may have less interest in the discussion at hand, they may still be very influential -possibly even indispensable. Similar to the attitude towards 'players', attempts to enforce intended innovations should consider the interest of the 'context setters' because their support or resistance may determine the innovation's adoption.

Thirdly, there are those with a high interest in the IS infrastructure but who have little means of influencing the outcome. This category is called the *subjects*. Although these parties may be heavily interested in the developments in IS infrastructures in the primary care domain, they typically have limited power on their own. A 'subject' may become increasingly important to consider once they group together, combining their power positions.

Finally, there are stakeholders who have little means and interests for the IS landscape in this domain, which are called the *crowd*. Actors in this category are unlikely to change the outcome of the system under study.

This analysis yields the following implications. It seems paramount that gaining support from at least the ministry of HW&S, the information system suppliers and the interest groups for insurance companies is crucial to make attempts to transform the information infrastructure succeed. Although not all these parties have a direct interface with the information systems in the primary care, they may directly or indirectly affect the organization of IS in this domain.

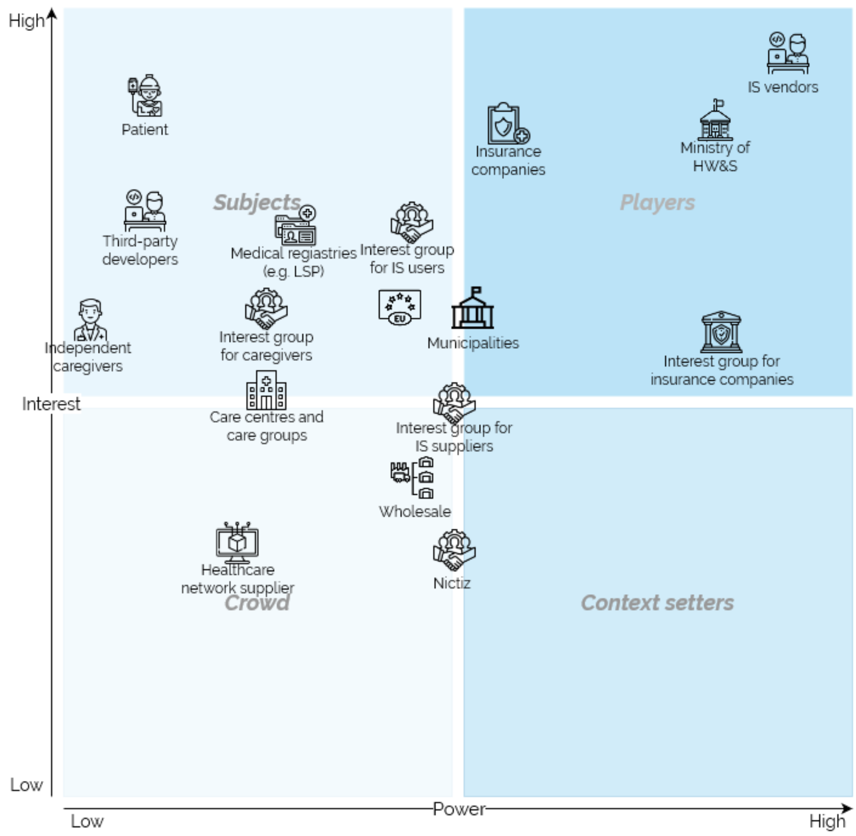


Figure 4.2: The stakeholders arranged on their power- and interest-position

4.3. Information systems in first-line healthcare

The current landscape of information systems in the primary care domain in The Netherlands is characterized by great *heterogeneity*, i.e. high variety in IS and actors (Aanestad et al., 2017). These systems in turn, are connected to other systems through varying network connections. This subsection discusses how information systems are connected, where data is stored and how it is transferred. Figure 4.3 shows a conceptual overview of IS in first-line healthcare. This figure is explained in this section.

Healthcare providers rely on information technology to support them in day to day activities. For general practitioners such technology may be applications that allow them to log patients' treatments or to schedule new appointments. For pharmacists, such systems may give them the opportunity for ordering medicine and keeping track of what medicines they give out themselves.

The information technology layer is represented in Figure 4.3. The blue boxes represent digital applications that can be used by practitioners. As can be seen, the applications per health provider are grouped. A HIS is a collective name for all information systems for general practitioners (Dutch: Huisarts informatiesysteem). Similarly, a AIS is a collective name for all information systems for pharmacists (Dutch: Apothekers informatiesysteem). All other groups of care providers also have their respective information systems, this is denoted by the term XIS.

There are several suppliers that develop, maintain and sell software applications to health care practitioners. Company A can for instance develop and supply 'application 1' to a general practitioner, while it also develops and supplies 'application 2' to pharmacists. These applications give the user an interface and they provide all kinds of functionality needed for practitioners to support them in their work. The applications allow practitioners to access registries that keep track of what information is stored at which server, this can for instance be related to patients' medical history or it may keep records concerning the supply of medicine. Additionally, there are so-called GZN (Dutch: Goede Zorgnetwerken) which are parties that can provide a secure network, separated from regular internet network, for transferring health-related data. These GZNs are represented by the bold dotted line in Figure 4.3. Furthermore, there are standardization-organizations that check whether parties have rights to access certain registries. They ensure that data is transferred according to correct rules and regulations, they set standards for information transactions that software suppliers must adhere, this structure should stimulate interoperability of data that is collected at different locations in the network.

On data storage

Stored data concerns all kinds of information relating to patients' treatments: medicines that have been supplied, allergies, history of past illnesses, etc. Currently, data is either stored at servers at the location of the information system supplier or at the caregiver.

- Storage in separated servers at the information system supplier: Mostly, data is stored at servers at the site of the information system suppliers. For instance, supplier A facilitates the software for a practitioner, when the practitioner interacts with the software, all its data is stored at the server of the supplier. A software supplier may supply different applications, e.g. a HIS and an AIS. In this structure, the software supplier has different servers for the data that is stored for their HIS- and for their AIS-application.

- Combined storage at the software supplier's server: This structure is similar to the one mentioned above, only now, the software supplier has one server that stores both the information from their HIS- and AIS-application.

- Sorage at a local server at the practitioner's site: Thirdly, some practitioners still store data locally at their own practice. This latter method is is at risk that when the server breaks down, its data will likely be lost.

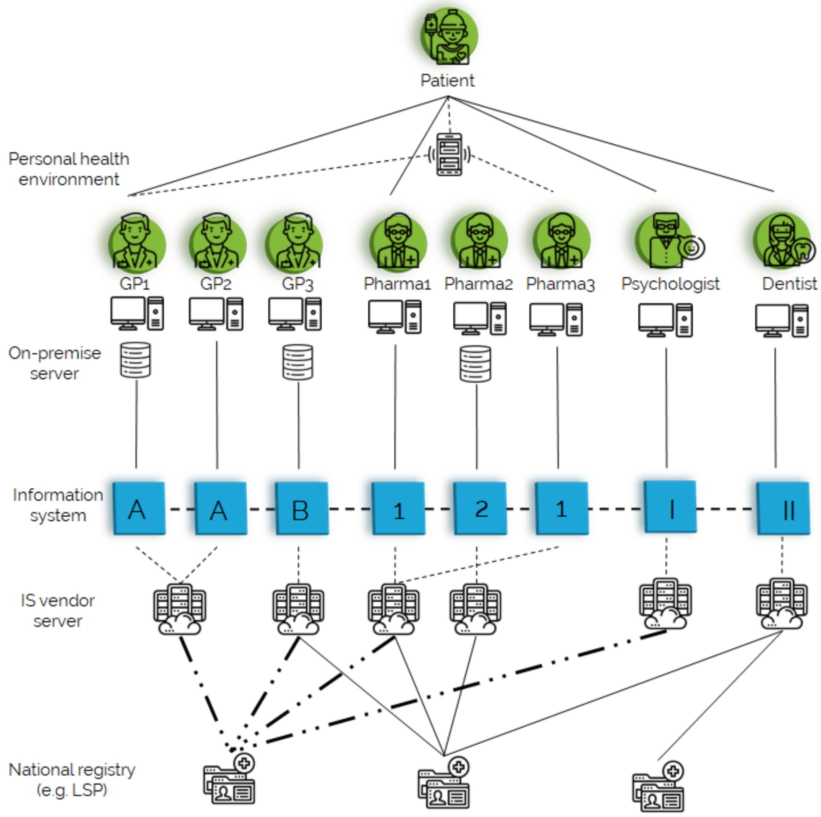


Figure 4.3: Conceptual visual representation of the Information Infrastructure

The indexes (at the bottom in figure 4.3) do not store actual data. They keep track of *where* in the system, data concerning a patient is stored. An example of such a registry is the Landelijk Schakelpunt (LSP).

On data transferring

When a general practitioner 2 (GP in figure 4.3) wants to request information from general practitioner 1, there are several possibilities for how data may be shared through the network. The most common way is that the general practitioner will send a request through its own information system (the blue block in the figure). The information system will consult the corresponding national registry. A standardization authority will check whether the request is valid. Subsequently, the registry will tell him where the required information can be found, in the case of fig 4.3 the information is located at the location of GP1. After this, the information system of GP2 can request GP1 to share the patient's treatment history. The GP1 will send the relevant information according to a standardized format.

Some registries make use of a secured network connection (NL: Goede Zorgnetwerk). This is a protected network that does not transfer data through the regular internet. Not all information is transferred through these secured networks. Parties that want to join the system with the affiliated registry, need to be connected to the secured network.

Strangely, it happens that caregivers may not be able to exchange information because their software applications do not operate with the same standards. Often still, caregivers rely on outdated and costly exchange mechanisms such as Zorgmail or even faxing to transfer medical information between caregivers.

4.3.1. On information transferring standards

Given the large number of involved parties and the scattering of data storage over a network of actors, it is obvious that the health domain relies on standards for information transactions. These standards ensure that information can easily be stored, requested and exchanged between caregivers and the patient

(Nictiz.nl, 2020). There is a wealth of different standards for information exchange, some of the most widely adopted standards in industry, are:

- **EDIFACT**: EDIFACT is a general standard for message transactions in healthcare that is adopted also outside of The Netherlands. EDIFACT describes the components that a message must possess, e.g.: it must contain a message, that is ordered in segments, with a logical structuring of the segments, those segments contain dat;
- **G-standaard**: G-standard is an international standard, developed in the 1980s that deals with the prescription, ordering and reimbursement of medicinal products (Z-index.nl, 2020);
- **HL7V2**: This standard is mostly adopted in the secondary and tertiary care domain for exchanging medical information between caregivers. Messages are constructed of a set of predefined segments, the location of the segment within a message is also predefined;
- **HL7FHIR**: The FHIR-standard is the most widely adopted standard that allows data interoperability and exchange in all lines of healthcare (MedMij.nl, 2017).

Most standards in primary healthcare have been defined by regulating organizations, such as the Health Level Seven International. These standards are thus *de jure standards*. Parties are not bound to comply with these standards, though if they do not, this will harm the interoperability of their own systems with those of other software suppliers. Field-experts mentioned that the development of new standards takes a long time due to the system suppliers that guard their own interest. If those parties cannot meet a new standard, they will be reluctant to support its development.

These standards concern standards for *data sharing and storage*. These standards should not be confused with standards for APIs, which are discussed in chapters 6 and 7.

4.3.2. Relevant initiatives concerning IS in primary healthcare

Over recent years, there have been several attempts to align stakeholders in the domain of information systems in primary healthcare in The Netherlands.

- **Medmij and OPEN:** An initiative by the Dutch government in collaboration with Nictiz to develop a standard for data transactions between care givers and care users. This set of agreements intends to enable the development of Personal Health Environments (Dutch: Persoonlijk Gezondheidsomgeving; **PGO**). These environments allow care users (patients) to access their personal health data and decide what data they want to share with caregivers (Medmij.nl, 2020).
- **Nuts:** Nuts is a Dutch foundation that thinks information systems in primary healthcare should be organized differently. They argue that the ecosystem should be based on a single solution for everyone. This simple solution should suffice in essential functionality such as addressing and patient treatment logging (Nuts.nl, 2020). This initiative is still in a preliminary face, it is is more of a premise than a well-defined plan.

4.4. Reflections and implications

This section explains what lessons can be derived from the current organization of information systems. All trends described in this section are based on the findings from expert interviews and desk research, part of which is shown in Table 4.1. These statements were stated during the discussions with the field experts. In subsequent discussions with field experts, these statements were validated.

This section first reflects on the current organization concerning the alignment of actors (subsection 4.4.1), the organization of control (subsection 4.4.2) and openness in the current system (subsection 4.4.3). Section 4.4.5 compares the current organization of stakeholders and ISs supporting the primary care domain to that of a platform-based organization. Finally, subsection 4.4.6 sheds a light on whether the context in the Dutch primary care domain is feasible for the development of a digital platform.

Table 4.1: Summary of talks with field experts

Role	**Focus of attention**
Manager Business Development at software supplier	• The lack of innovation in information systems in the primary care domain can for a large part be attributed to (1) the wide diversity of involved actors, each acting towards their own best interest, and (2) to insufficient financial incentives to act in an innovative way. • In a future situation, it should be clear whether the solution entails a *centralized* or *decentralized* control and that there is no single actor that can control the market. • Important requirements for a future situation is that there is flexibility in the information infrastructure to react to changing demands, there is a financial structure in place that is targeted at realizing effective and efficient healthcare support and there should be measurements to ensure continuity. • There are interest groups for care providers that have a large power position in transforming the information infrastructure. • The software suppliers and their information systems are incapable of adapting to changing demands.
Product Owner at Healthcare Information Systems supplier	• There are little incentives for caregivers to require innovations from the information systems they use. Also, there are barriers to transferring to other software suppliers because the systems have different functionalities and user interfaces and they often involve long-term contracts.
Product Owner at AIS supplier	• The government does not impose standards on information exchange between different suppliers of information systems. Currently, these standards are defined by the market parties and whatever parties comply to those standards. • Current systems have a hard time connecting different users on the care provider side.
Head of Products at software supplier	• One has to account for the fact that not every random caregiver has access to attributes of patient records that they do not need for performing their role as a care provider to the patient. • Incentives for more effective and efficient patient care is lacking among care givers or they are hindered by insurance companies. • There is the difficult concept of 'responsibility', what if there is a mistake that can be (partly) attributed to the failure of an information system? That is difficult to explain to involved parties.
IT Architect at software supplier	• There is little incentive for innovating. Also, the market entry barriers are high due to high investment costs and low market entry possibilities as contracts usually involve long term arrangements. • Insurance companies have a large power-position over what innovations or medicine can be reimbursed. They indirectly have a large impact on the role of information systems in primary healthcare • There is no single server that may store all patient data. Therefore, there is not a national database with patient data but rather there are registries that log where patient data is stored.
Director at software supplier	• The current information systems fail to adopt novel technological developments that can benefit the primary healthcare domain. • It is difficult to allocate responsibility over patient's digital health related data; should the caregiver, the patient or the IS supplier be responsible?
Director at Healthcare IT network provider	• Software suppliers have a large power-position because if a large supplier fails to go along in attempts to innovate the domain, the market is unlikely to adopt the innovation. • There are little incentives for software suppliers and care providers to innovate. • Laws and regulations and public opinion may hinder attempts to innovate.
Two IT healthcare consultants	• There is a question in the field of information systems in this domain as to how alignment between actors and systems should be achieved. It may be best if the government would impose standards, currently, there is no party that determines the standards. Standards are organized by the market, therefor there is a myriad of different communication standards. • Patients have to give consent to every care provider they interact with. There is no central place where a patient can organize who has access to his/her information.

4.4.1. On alignment of stakeholders

An information infrastructure needs to ensure that multiple parties in the network can work together and that their respective interests are respected in the overarching interest of the entire network of parties (Star and Ruhleder, 1996). Alignment of information systems in the primary care domain is mainly organized by defining standard for how to store and transfer data from one server to another server in the network.

Reflection 1: On interoperability of IS from different vendors

Alignment of the technological infrastructure is essential for effective transfer of data. If caregiver A wants to receive information concerning a patient from caregiver B, they need to be able to trade information even when they do not have the same IS suppliers. Interoperability, i.e. the ability for transactions across different platforms (Eisenmann et al., 2009), is achieved in two ways:

Firstly, alignment of systems is achieved through *standardization* (how systems can interact by predefined standards (Tiwana et al., 2010)). In the current system, there is a wealth of different standards (Nictiz, 2019a), for instance for communication of health data. The most used standards in this domain in The Netherlands are EDIFACT and HL7V2 (Nictiz, 2019a). These standards are used when a healthcare provider requests information that is stored at another server than its own. Currently, these standard are not enforced. The choice whether to adopt these standards, is up to the software suppliers. Choosing to adopt a standard enhances their interoperability with other providers, which may ultimately add value to the customer. It has happened that standardization parties (such as Nictiz) requested software vendors with a large market share to adopt a standard, hoping that smaller vendors would follow. Recently, the Dutch government seems to understand the importance of clear standards for data exchange (Van den Berg, 2019) and expresses their intention to be closer involved ensuring better exchange of data in the healthcare domain.

Secondly, when a healthcare provider decides to switch to another IS supplier, the IS suppliers have tools (gateways) in place that manage to transform the input from the source location (in the form of a database with records) to the database-structure that is used by the new software supplier. There is no common description for data semantics, how medical data is stored in the servers of the IS suppliers.

Reflection 2: On strategic behaviour of IS vendors

The multitude of actors and interests hinders attempts to innovate in the IT health domain. Over the years, various parties have secured a role in the network of information systems in the primary care domain. For instance, a party provides the application to the care provider, another party supplies the network infrastructure, a third party may provide the national index where health records are stored. These parties are interdependent, meaning often that changes in the network affect different parties. Changes in organizational structures for instance to react to user needs are thus complex as they may require involvement of different parties. When one of these parties fails to cooperate towards those changes, because it is not in their interest, they may paralyze the efforts to transform the network. This is one of the main causes mentioned why previous attempts to reorganize this domain are have failed.

Reflection 3: On historical evolvement of IS infrastructure

Originally, information systems were designed to suit the needs for their specific care type. For instance, a general practitioner uses a HIS, a pharmacist an AIS, etc. However, the need for effective collaboration between different types of practitioners requires possibilities to exchange data easily across the different silos. Interconnecting these different systems has led to a complex system with many intermediate parties and interrelationships. Changes to the IS infrastructure are hardly ever controlled by any single actor.

4.4.2. On the organization of control

The notion of control is defined as the ability to encourage desirable behaviour among other participants in the network (Tiwana et al., 2010).

Reflection 4: On decision rights

In the as-is situation, a patient has to give consent to each caregiver individually to share his or her patient-data with other caregivers. This means, for example, that a person must give consent to every new general practitioner or pharmacist or psychologist to get access to the files that are stored at another caregiver. Control thus lies with the patient.

The situation becomes different when an introduce is introduced that allows patients to see their medical records themselves. When a third (intermediate) party delivers the software and interface for this application, they have to get consent from all relevant caregivers to show the patient his/ her personal information.

Reflection 5: On data storage

Data is stored at multiple locations in the network. Information concerning a patients treatment history may be stored partially at a physiotherapist, general practitioner, pharmacist etc., while all these parties will also have some general information concerning the patient. In this current form, there is no single point that holds the most recent and accurate data, rather data is scattered across different locations.

Secondly, the where the data is physically stored may vary across different care providers. Most providers store data at the server of the software supplier. Others may have a local server to store information.

Reflection 6: On data ownership

Patients must give consent whether a caregiver may share his/her health related information with other parties. This process of giving consent is required at every caregiver that a patient interacts with. Whenever consent has not been provided, even in case of emergencies, other caregivers cannot get access to the health records of the patient. Moreover, patient data is stored at the side of the IS vendors or at on-premise servers at the caregiver.

Reflection 7: On data maintenance

In the as-is situation, caregivers are responsible for updating patients' records. A patient is not able to update any health related information him/herself. Software suppliers are responsible for maintaining the information systems and ensuring that they adhere to the current standards (whenever they decide to adhere).

Transparency of personal health data is enhanced by the introduction of Medmij. This initiative was initiated by the Dutch Government and will become operational over the course of 2020.

4.4.3. On the system's openness

Openness was previously defined as the degree to which external parties are allowed to use, develop services on- or commercialize the platform (Benlian et al., 2015; Boudreau, 2010). This subsection reflects on how this concepts is observed in the existing situation.

Reflection 8: On openness in relation to innovation

The software basis for the current information systems in the healthcare domain are closed, i.e. proprietary. More open systems may stimulate platform and service development (Boudreau, 2010), as has also been found in studies in the health domain (Furstenau and Auschra, 2016).

This lack of openness can be attributed to three things. Firstly, IS suppliers fail to share their data or knowledge concerning the organization. For instance, when IS suppliers are requested to join in a communication standard, they may decline to cooperate as compliance to the set standard may harm their own market share. To retain their customers to their software, they may choose to close their software.

Another reason for software suppliers is that their software and the operating systems that operate them are outdated. Software vendors may refrain from adopting new technological solutions because that may render their own software unnecessary. Also, their software may just not be able to facilitate new needs or technological solutions. Thirdly, software suppliers only sparsely share APIs or develop standardized APIs for other suppliers to use parts of their software-basis (Bus et al., 2019).

Reflection 9: On openness in relation to data sensitivity

Due to the sensitive nature of healthcare related data, parties in the network are reluctant to open up. Degrees of openness in information systems in this domain should thus be carefully managed, no to jeopardize the security of the data.

4.4.4. Additional reflections

This section discusses observations that arose in this stage of the research that cannot easily be attributed to one of the preceding topics.

Reflection 10: On a focus on short term challenges

Whenever actors encounter a problem, challenges or unanswered need, they develop a solution specifically suited to that problem. Software suppliers may for instance find workarounds to deal with pressing issues. While there is a focus on solving pressing issues, there is little focus on a long-term solution to be flexible in making changes to the information infrastructure en to be able to deal with changing needs at the side of the customer.

Reflection 11: On market entry possibilities

Healthcare providers and information system suppliers typically engage in long-term contracts (around 5 years). This means that only once every 5 years there is the opportunity for healthcare providers to switch to a different software supplier. Moreover, there is a financial barrier for new entrants. The costs to gain a position in the existing market are high, while the margins are low together with the low flexibility for caregivers to shift to another software supplier.

Reflection 12: On inefficiency due to redundancy in IS

Although there is a wealth of software suppliers, their systems offer similar functions. This gives rise to a loss of efficiency and a loss of innovative capacity.

Reflection 13: Financial risks hinder innovation

It is financially unattractive to be innovative. Healthcare providers in in first-line care are often paid per patient-visit or per patient registered at the practice. Consequently, there is little urgency to work more efficiently, as preventive care will likely not have a positive contribution to their income. Also, these caregivers typically have little knowledge on information systems and they do not feel the responsibility for improving the information systems.

4.4.5. Does the current infrastructure resemble a platform-oriented system?

There is no binary distinction between what IS can be considered a digital platform and what not. Still, a comparison can be made between the existing situation, in relation to common features of digital platforms. For instance, Tiwana (2014) and Baldwin et al. (2009) find that digital platforms are based on the principle of modularity of a core platform and loosely coupled modules. In table 4.2[1], comparisons are made between the existing situation and a platform-based situation.

Several distinctions can be observed between the existing situation and a platform-based situation. First, the main roles in a platform-oriented system are not represented in the as-is situation. One of the main properties of a platform-oriented system is that such as system revolves around a focal platform that is surrounded by a periphery of additional users and complementors (as explained in section 2.1). Secondly, the IS suppliers develop proprietary information systems that only limitedly provide access for

[1] Distinction was inspired by the works of De Reuver and Van der Wielen (2017) and Li et al. (2019)

outside developers to develop services based upon the supplier's system. A third motivation is that there is no horizontal integration of information system suppliers. Systems that are integrated (for instance an information system and a registry) are integrated vertically, in a supply-chain manner. Fourthly, there are no architecture and governance structure in place to provide external developers with a framework to develop complements. As a result, it is unclear what incentives and constraints there are that give complementors needed flexibility and alignment to develop complements. Fifth and finally, in the current system the market entry barriers are high whereas in a platform-oriented environment these barriers are usually lowered to stimulate the development of complementary services.

Table 4.2: Comparing the current system's architecture and platform architecture principles

Principle	Current infrastructure organization	Platform oriented organization
Value creation	• Different software suppliers separately developing similar IT-based products and services. Adoption of software from external providers is limited	• Ecosystem requires collaboration between platform owner and complementors to develop products and services complementary to each other
Structure	• Information systems are mostly closed for outside developments. IS suppliers only sparsely share APIs for outside developers	• A platform organizes for some level of openness through interfaces, architecture and governance principles
Collaboration with outside actors	• Systems of different stakeholders in the domain are vertically integrated in one value-chain	• Systems of different stakeholders (from different industries) offer complementary products and can be both horizontally and vertically integrated
Alignment of actors and systems	• Alignment between parties is either lacking or is realized through (non-enforced) standards	• Alignment is realized through governance mechanisms and through established interfaces
Market entry	• Market entry barriers are low as every new entrant must build a novel solution including all the required functionalities	• Market entry possibilities are lowered because complementors are given predefined interfaces and tools (e.g. APIs and SDKs) to build upon existing solutions
Incentives for innovation	• No incentives for complement development	• There are incentives (e.g. a large potential market of users, rewards) in place for complementors to add value to the platform
Complexity	• High in complexity due to the high number of interdependencies among actors	• Simple architecture due to modularity principle
Multi-sidedness	• Two-sided product connecting patient and specific care provider	• At least three-sided connecting complementor, patient and one or more caregivers

4.4.6. Are there opportunities for platform development?

Does the current situation lend itself for successful establishment of a digital platform? Tiwana (2014) identified several conditions under which there may be a feasible opportunity for a platform-based solution to emerge in an IS domain. He argues when at least two of the four opportunities exist, there is potential for the development of a platform. The opportunities are mentioned below together with a description whether these are present for Dutch first-line care:

- *Two distinct sides:* The core customer group of a digital service within the primary care domain would be the care providers and the patients. Both these groups can be considered users. In addition, a platform-oriented ecosystem allows close interaction between care providers centred around a patient and a service, something that the current information infrastructure is incapable of;
- *Unexploited long tails:* This characteristic concerns the existence of sufficient niches affiliate to the core platform, that provide fertile opportunities for complementors to develop services that may be too narrowly focused for the focal platform owner to pursue. The primary care domain involves niches related to medical complaints, e.g., diabetes, depression, obesity;
- *One side on board:* Considering the surge of digital healthcare applications and increasing adoption of these applications, it can be argued that there is an interest both from developers and users in the

development of applications that serve to improve patients' well-being;

- *Cross-side network effects:* Recapturing cross-side network-effects, these effect concern when the increase of users on one side of the platform adds value to a group of actors on another side of the platform. For instance, the more patients use an application, the may useful this application might become to caregivers and the more attractive it becomes for complementors to develop applications for the corresponding platform. As this development is not easy to forecast, we are reluctant to adopting the assumption that this opportunity exists.

This reasoning indicates that fertile conditions exist for a digital platform to emerge in this domain. Given that these statements are supported only by findings from a website resources and expressions by field experts, it is recommended to examine these conditions closely prior to engaging in developing a platform-oriented system.

5

Suggestion - Literature review on platform architecture and openness

The subject of digital platforms and platform openness have been studied extensively. Needless to say, these previous studies may provide useful starting points and theories that may inform the design of a digital platform for Dutch first-line healthcare. To investigate what relevant theories previous studies offer, a literature review on the concepts of platform architecture and platform openness was conducted.

This chapter firstly describes the outcomes of a literature review on platform architectures, in section 5.1. Secondly, it reports the findings from a literature review on platform openness, in section 5.2. The approaches taken to these reviews are reported in appendix section B.2.

5.1. Literature on platform architecture

How do researchers describe platform architectures? What perspectives on architecture are described in academic literature, and how can these perspectives be applied to the question presented in this thesis? These questions are covered in this section. First, general findings in relation to scientific literature on platform architectures are described in subsection 5.1.1. Secondly, different perspectives on the architecture of digital platforms are reported in subsection 5.1.2. Third, configurations for platform architectures are discussed in subsection 5.1.3.

5.1.1. General comments on platform architecture literature

The search itself, conducted for scientific publications on digital platforms revealed some interesting findings. For one, searching for articles on digital platform architectures in the scholarly database of Scopus shows that interest in digital platform architectures has escalated over recent years. Moreover, the body of literature is not unambiguous, in the sense that researchers describe platform architectures at different levels of abstraction. For example, some researchers describe platform architectures as the organization logic of the platform at different layers (e.g. (Yoo et al., 2010) or (Silva et al., 2019)). Even within these studies, researchers describe different different numbers and sorts of layers. Others study platform architectures at the level of the ecosystem, that is how do platform owners orchestarate external parties around the platform by the design of the platform's architecture (e.g. (Blaschke et al., 2019; Kazan et al., 2018)). Considering this ambiguity in the description of platform architectures in literature, it is deemed necessary to be clear on exactly how platform architecture is considered for this thesis and how that matches with findings from other researchers. This research has focused on the latter category, how can platform owners use the platform architecture to determine how external contributors interact with the platform.

5.1.2. Perspectives on architecture

Digital platforms are considered complex systems, due to the large number of interdependencies and connections between parts (Tiwana, 2014). This makes it difficult to predict in advance how the platform will interact within its application environment. The platform architecture describes how the different components of the platform are connected. As such, the platform architecture is an important concept to use to reduce the platforms complexity.

Complexity introduces issues for developing a platform. A complex platform, one with large heterogeneity in linkages among the different components, is difficult to maintain and it stifles the evolvement of the platform over the long term. One can imagine when it is unclear how modules should be coupled to the platform, this is an obstacle for innovators to develop complementary offerings. Furthermore, a platform architecture can provide a way to ensure that certain parts of the system evolve over time, while others remain stable (Baldwin et al., 2009). This allows both stability to enhance resilience and simultaneously needed flexibility to adjust to changing needs in the outside environment (Kazan et al., 2018).

In an extensive work on digital platforms, Tiwana (2014) argues that a platform architecture should serve two purposes: partitioning and integration. *Partitioning* refers to the "decomposition of the ecosystem such that each subsystem in it is relatively autonomous from others" (Tiwana, 2014, p. 80). It often denotes how the contribution of different parties are coupled and decoupled in a platform-based ecosystem (Cabigiosu et al., 2013). Furthermore, partitioning should ensure that the different components can function almost independently to one another (Constantinides et al., 2018) so that when one component breaks, this does not break the entire system.

Integration involves the "coordination of development activities among app developers and the platform owner" (Tiwana, 2014, p. 82). Tight integration means that components are coupled through complex structures. This may lead to rigidity (Baldwin et al., 2009), while others argue that it is better for the platform's competitive position (Kazan et al., 2018). Integration is typically achieved by means of the *interfaces*, i.e. the rules and code that make sure that the platform and the components are interoperable (Baldwin et al., 2009; Boudreau, 2010).

Different platforms have different ways of organizing their architecture, and the way of organizing is often dependent on strategic goals of the platform owner (Kazan et al., 2018). For this thesis, the intention is to find out what different architectures are reported and what their implications are for the selection of the architecture for the first-line care domain. Before going into detail for the configurations found in literature, different perspectives on architectures are discussed.

Modularity

Researchers seem to agree that the architecture of a platform-based ecosystem is based on the principle of *modularity*. Modularity is based on the proposition that platforms are composed of a core, interfaces and modules (Baldwin et al., 2009; Eaton, 2016; Karhu et al., 2018). Modules can be added to the core platform, while interdependence between the modules and the platform is intentionally reduced (Tiwana, 2014). Recall that a module, in this case, is "an add-on software subsystem that connects to the platform to add functionality to it (e.g., iPhone apps and Firefox extensions)" (Tiwana, 2014, p. 675).

Layered architecture of platform and (physical) products

Yoo et al. (2010) introduced what they call the *layered modular architecture*. This model takes into account the interrelationship of physical components (a device and a network) and digital layers (the service and the contents).

The perspective adopted for this thesis

Given this variety in descriptions of platform architectures in previous studies, what view does this thesis take? From chapter 4 it became clear that current IS in first-line healthcare in The Netherlands experience limited openness towards external developers. This limits innovation, while innovation is expected to benefit first-line healthcare. Moreover, a platform differs from tightly integrated information systems in the sense that their modularity allows loose (de-)coupling of functionality. The current situation is characterized by tightly integrated IS. Third, chapter 4 showed that complexity in IS in first-line healthcare results from strategic behaviour of actors in the domain. To understand how a digital platform architecture can be designed with respect to its environment, it was decided to study how a platform architecture can be configured in relation to its external environment. For this, the perspective of platforms as modular architectures was adopted.

To study design choices relating to the platform architecture, from this perspective of modularity, the architecture is considered as the collection of design choices for the *core*, the *interfaces* and the *modules*. This selection of components of the architecture is similar to that of (Spagnoletti et al., 2015). This approach entails that literature has been searched that reports different configurations for the core and the interfaces of a platform, and how this affects the platform's interaction within its application domain. In this thesis, the configuration of the modules has not been studied. The design of the architecture for the modules is considered to be a decision for the complementors, and is therefor not included in this thesis.

5.1.3. Configurations for architectures

Within this perspective of a digital platform architecture conceptualized as a design choices for the core, the interfaces and the modules, platforms can be configured in different ways. Tiwana (2014) explains that modularity can be vary from either tightly monolithic approach to a highly modular one. A platform owner will often try to find a balance between those two extremes. The most important advantage to a monolithic approach is that it often outperforms a modular platform in the short run, while a highly modular structure is better for development of the platform on the long-term Tiwana (2014).

This section explains what different configurations of a platforms core and modules have been found in scientific literature on digital platforms. An overview of the articles and how they were selected is reported in appendix section B.2. Furthermore, a more extensive description of the options listed below, and how they can be interpreted in context of first-line healthcare is provided in the next chapter (chapter 6).

Configurations for the platform's core

The platform core is defined as the "the extensible codebase of a software-based system that provides core functionality shared by the modules that interoperate with it and the interfaces through which they interoperate" (Tiwana et al., 2010, p. 675). The literature review revealed four options to arrange the openness of the core platform:

- **Proprietary platform core** (West, 2003) - The platform has a closed core, this is only visible, accessible and adjustable by the platform owner.
- **Resource openness** (Blaschke et al., 2019; Kazan et al., 2018; West, 2003) - The core is made accessible to outside developers (Karhu et al., 2018). This option is also referred to as open source (West, 2003).
- **Meta-platform** (Ghazawneh and Henfridsson, 2013; Mosterd, 2019; Pon et al., 2015) - A meta-platform can best be understood as an integration platform (Hein et al., 2018). A trusted-third party, or possibly a consortium of platform owners, organizes the meta-platform. This meta-platform in turn, holds core functionality and identifies interfaces that are shared with industry-platforms.

- **Gateways** (Eisenmann et al., 2009; Ondrus et al., 2015) - Interoperability between platforms is achieved by means of gateways. Gateways can be regarded as adapters or technical standards that allow communication between two discrete platforms.

Configurations for the openness of the interfaces
Interfaces specify how the modules interact with the focal platform. Building on Baldwin et al. (2009) and Boudreau (2010), Tiwana (2014, p. 110) describes interfaces as "... the basic set of rules to ensure the technical interoperability of apps with the platform." This definition is also used in this thesis. Interface openness denotes the degree to which platform providers share their interfaces with parties outside their own organisation. Literature revealed three ways for configuring the openness of the interfaces:

- **Proprietary interfaces** (Gawer, 2014; Mukhopadhyay and Bouwman, 2019) - Interfaces are solely visible and usable to the focal organisation.
- **Selectively open interfaces** (Gawer, 2014) - Interfaces are exclusively shared with selected parties.
- **Open interfaces** (Mukhopadhyay and Bouwman, 2019; Tee and Woodard, 2013) - Interfaces are openly shared with all parties that are interested in collaborating with the platform.

Configurations for the stability and standard of interfaces
Interface standardization denotes the "... degree to which an app communicates, interoperates, and exchanges data with the platform using predefined, well-specified interfaces, protocols, and rules that are not allowed to change." (Tiwana, 2014, p. 110). For configuring the stability and standards for the interfaces, three options were distilled from literature.

- **Non-stable interfaces** (Brunswicker and Schecter, 2019; Cabigiosu et al., 2013) - Interfaces are flexible and specific to one module.
- **Stable interfaces** (Baldwin and Clark, 2000; Brunswicker and Schecter, 2019; Cabigiosu et al., 2013; Yoo et al., 2010) - Interfaces are stable, or frozen (Tiwana, 2014). Both the modules and the platform are allowed to be changed, but the interface remains stable.
- **Industry-standards** (Baldwin and Clark, 1997; Cabigiosu et al., 2013; Cennamo and Santaló, 2019) - In this scenario, the interfaces is defined based on a standard that is shared by the entire market. The same interface may thus be available to platforms from different platform providers.

5.2. Literature on platform openness

Recall that the goal of this thesis is to understand design trade-offs relating to platform openness to inform the configuration of a digital platform in first-line healthcare. In addition to understanding how platform architectures can be designed, it is needed to understand the phenomenon of platform openness. An understanding of platform openness is considered a useful step to understand what degree of openness may be suitable for first-line healthcare. Knowledge from earlier researches why platform owners would choose openness or rather a closed platform architecture, can inform how architecture and openness can be configured for first-line healthcare.

This section reports the findings of a literature review on digital platform openness. An explanation of the approach to the literature review is included in appendix section B.2. The remainder of this section is organized as follows. First, general remarks concerning the literature study on openness are mentioned in subsection 5.2.1. The second part of this chapter (subsection 5.2.2) describes information that previous research has revealed on the openness of digital platforms.

5.2.1. General comments on platform architecture literature

Platform openness has been studied extensively by digital platform researchers. Like platform architectures, also platform openness has been studied from various perspectives. Moreover, platform openness choices can be made at different parts of the ecosystem, for instance how platforms in how they (do not) comply with or open standards or how they organize for technology lock-in (Teixeira, 2015). Moreover, platforms owners may open up their platform to different roles, e.g. to supply-side or demand-side users or even to parties from different industries (Ondrus et al., 2015). For this literature review, scientific articles were consulted that discuss motivation and concerns that a platform owner must take into account for deciding on the level of openness of a platform.

The goal of this section is to describe the main findings on the implications of platform openness. The purpose of this section is to understand what the possible implications of openness may be to first-line healthcare. In a later stage (sub research 3 and 4) this information is used to understand what degree of openness is expected to be useful for first-line healthcare.

5.2.2. Factors influencing the level of openness

Inspired by how openness was studied in scientific articles, this section firstly describes why platform owners may choose a proprietary (i.e. closed) strategy. Subsequently, it is discussed what motivations platform owners have to pursue platform openness. Motivations for platform openness can also come from the platform's environment, these motivations are also discussed. Finally, risks of openness, as found in literature, are reported.

Reasons for pursuing a proprietary platform strategy

Recall, in a proprietary strategy the platform owner can be considered a vertically integrated, private network in which one organization controls the platform, its interfaces and the complementary offerings (Blaschke et al., 2019). The platform relies on in-house R&D for the development of complements (Eisenmann et al., 2009). Academic literature highlights several options for why platform owners pursue proprietary strategies. These strategies are shown in Table 5.1.

One reason for choosing a proprietary approach is the opportunity to appropriate financial returns. Organizations that succeed in establishing and maintaining a successful closed platform, have no need to share returns, thus benefit from returns of the success of the platform and often higher margins (West, 2003).

Secondly, successful platforms can result in a lock-in of its users (Roesch et al., 2019; West, 2003), i.e. it is less attractive for users to transfer to a different platform (Tiwana, 2014). Once a platform becomes larger, it becomes increasingly attractive to users. The more users invest in a platform, the bigger the barrier becomes to transfer to a different platform. The provider of this platform gets an increasingly powerful position that may result in a sustained competitive advantage (De Reuver et al., 2011).

A third advantage of a proprietary approach is that it becomes more difficult to imitate the platform. Copying of a platform by a different platform owner, to build a new platform is a threat called forking (Karhu et al., 2018). Forking is detrimental to the value of the focal platform. Open platforms are more prone to copying and forking because their core resources and associated intellectual property rights are openly shared. Proprietary platforms do not share their platform core with outside parties, making them less susceptible to such malicious activities.

Fourthly, proprietary platforms have the advantage that the platform owner has tight control over the platform, interfaces and modules. Developing and maintaining the platform does not require coordination with outside parties. This makes these platforms less vulnerable to sluggishness as a result of coordination or political manoeuvring resulting from involvement of different parties and interests (Eisenmann et al., 2009; West, 2003).

It should be mentioned that successfully managing a proprietary strategy is often only possible for one or two parties that have a dominant market position (West, 2003).

Table 5.1: Motivations for choosing a proprietary platform strategy

Motivation for a proprietary strategy	Reference
High appropriation of financial returns	(Roesch et al., 2019; West, 2003)
User lock-in	(Roesch et al., 2019; West, 2003)
Difficult to imitate	(West, 2003)
Tight control, low need for coordination	(Eisenmann et al., 2009; West, 2003)

Internal factors for platform openness

This thesis defines *internal factors for platform openness* as the motivations that a platform owner may drive towards adopting an open platform strategy. Openness one the one hand means that a platform shares its resources with other parties. On the other hand, it also means that a platform may become interoperable with other platforms in the industry. Several advantages may come from choosing an open strategy. Table 2 presents some of the most prominent advantages of platform openness that were found in scientific publications, which we will address here.

Most of the advantages in Table 5.2 are interdependent of each other. By opening the platform to external parties, a platform owner lets external parties add complements to the platform. This enhances the overall functionality and attractiveness of the platform to both end-users as well as to complementor providers.

First of all, Gebregiorgis and Altmann (2015) find that an open platform is attractive to third party developers. This leads to an increased use of the platform by complementor developers (van Angeren et al., 2016) and variety in developers (Tiwana, 2014), giving rise to an increase in the number and variety of services and applications developed for the platform (Boudreau, 2010). The large offer of complementary services makes the platform more attractive to end-user (West, 2003). Similarly, a platform with a high number of end-users is attractive to third party developers because it leads to a greater potential market (Ondrus et al., 2015). This phenomenon of a self-enhancing loop of attractiveness to users is commonly referred to as network effects (Parker et al., 2017). The importance of network effects has been previously described in chapter 2. The presence of network effects leads to a higher adoption rate. This for instance can be of importance when a platform launches as Ondrus et al. (2015) showed that openness can ensure that a platform reaches a critical mass of users.

Other motivations to open up a platform is that openness can result the combination of a platform owner that leverages third party complementors leading to higher quality complements resulting from co-creation between the platform owner and the complement developer (Ceccagnoli et al., 2012). What is more, De Reuver et al. (2011) show that openness can lead to higher flexibility to adapt to changing demands and thus to greater long-term evolvability (Tiwana, 2014). Eisenmann et al. (2009) stress that openness can lead to better quality of the overall platform, due to the feedback of the community of users. Finally, Boudreau (2012) finds that platforms can use the developments of other, compatible, platforms to strengthen their own platform.

Table 5.2: Internal motivations for choosing an open platform strategy

Internal motivation for an open strategy	Reference
Attractive to third party developers (influencing also the factors below)	(Gebregiorgis and Altmann, 2015)
Increased number of complementors;	(Choi et al., 2019; van Angeren et al., 2016)
Increased diversity of complementors;	(Tiwana, 2014)
Co-creation by third-parties	(Boudreau, 2010; Ceccagnoli et al., 2012)
Increase in external innovation	(Boudreau, 2010)
Attractive to end-users	(West, 2003)
Network effects	(Parker et al., 2017)
Likelihood to reach a critical mass of actors	(Ondrus et al., 2015)
Enhanced flexibility to changing demands	(De Reuver et al., 2011)
Long-term evolvability	(Tiwana, 2014)
Sharing of costs for platform development and maintenance	(Eisenmann et al., 2009)
Higher quality platform resulting from feedback by developer community	(Eisenmann et al., 2009)
Share the development of new technologies that emerged on other, compatible platforms	(Boudreau, 2010)

External factors for platform openness

Sometimes, it is not the platform owner that is willing to open up a platform but external factors that force a platform to evolve to a more open platform. One reason that a platform decides to open up is due to a lack of market share. Opening up a platform will enhance the platform's appeal, giving the platform owner the opportunity to increase its revenues from the sales of complementary offerings (West, 2003). A second reason, also mentioned by West (2003), is that the demand from users and complementors to open up is too high for a platform owner to retain a proprietary strategy. Thirdly, it may happen that a rival's platform's standard becomes the market-dominant standard. In this case, it becomes infeasible for the focal platform owner to maintain a proprietary standard, and the platform owner will have more success following the competitor's standard, inherently making it open to other parties. Fourthly, when a platform becomes too dominant (often characterised by user lock-in and high entry-barriers for competitors), policy-makers may force a platform to open up. A policy-maker may break this dominant position by enforcing interoperability (Zhu and Iansiti, 2007) or by sharing its data (The Economist, 2019b). This gives policy-makers the opportunity to create market dynamics that allow for competition between platform owners and between complementors.

These external factors are presented in Table 5.3 below.

Table 5.3: External factors for open platform approach

External factor for an open strategy	Reference
Lack of market share	(West, 2003)
Demand to open up by users and complementors is too high	(West, 2003)
A competitor's standard becomes the dominant standard	(West, 2003)
A regulator enforces openness to break market dominance	(The Economist, 2019b; Zhu and Iansiti, 2007)

Negative effects of having platform openness

Besides the positive effects of platform openness (see Table 5.2), openness also introduces negative consequences to the platform owner. Those consequences are shown in Table 5.4, and are elaborated on here. One of the downsides of platform openness is that fierce competition between complementors can result in a negative attitude among complementor developers, thereby hindering innovation of novel services on the platform (Nikayin et al., 2013). This introduces to disincentives for complementors to develop offerings for the platform (Boudreau, 2012; Choi et al., 2019). A second disadvantage is that in an open platform, a platform owner is no longer the sole party to appropriate rents from sales of services on the platform (Eisenmann et al., 2009; Parker et al., 2017). Instead, financial gains are shared across ecosystem participants. Thirdly, open platforms require coordination between different participating and interacting actors (Wareham et al., 2014). A fourth negative side-effect of openness is that the presence of low-quality complements can harm the overall perceived quality of the platform, as found by Wessel et al. (2017). Finally, open platforms are at risk of forking (Karhu et al., 2018).

Table 5.4: Negative effects from an open platform approach

External factor for an open strategy	**Reference**
Increases fear of competition among complementors	(Nikayin et al., 2013)
Reduces revenues and profits for platform owner	(Eisenmann et al., 2009; Parker et al., 2017)
Introduces coordination costs	(Wareham et al., 2014)
Disincentives for complementors to innovate	(Boudreau, 2012; Choi et al., 2019)
Low quality complements can harm the platform	(Wessel et al., 2017)
Risk of forking	(Karhu et al., 2018)

6

Development - Concept design

In this chapter, the findings from the preceding steps are combined with the purpose of developing a conceptual artefact. This artefact is an overview design options that platform owners can choose from to select a desired level of openness. This artefact should enable field-experts to articulate trade-offs for whether the design options for architectural openness are desired for the Dutch primary care domain.

This chapter is organized as follows. First, section 6.1 discusses what platform openness entails for the domain under study. Secondly, the conceptual artefact is presented, interpreted and its purpose is explained in section 6.2. Thirdly, the design options for their respective dimension are explained in section 6.3.

6.1. What does digital platform openness entail for Dutch primary healthcare?

How can we interpret platform openness for the primary care domain in The Netherlands? That is a what this section sets out to describe, in part answering to sub research question 3. For this, subsection 6.1.1 explains the assumptions and choices made that underlie the application of an open platform in the primary care domain, as presented in subsection 6.1.2

6.1.1. Assumptions and scoping choices

To be able to discuss trade-offs for openness of a digital platform in Dutch primary healthcare, an example application had to be sketched. In Table C.1 in chapter 1 it became clear that designing a digital platform requires making a substantial amount of decisions upfront. Not all these decisions could be made and substantiated within the time frame of this study and without careful consideration. Therefore, several assumptions were made on these design decisions. Those assumptions are discussed here.

One party is the platform leader

One of the most important decisions that an organization faces concerning the establishment of a digital platform, is choosing the mode of platform ownership (De Reuver and Keijzer-Broers, 2016; Ondrus et al., 2015; Saadatmand et al., 2018). Studying these modes of ownership is not part of this thesis, therefor an assumption is made towards this factor. For this thesis, it is assumed that a proprietary, for-profit, party is the platform owner/platform leader (not a federation of parties or a government authority). This platform owner has the desire to establish a digital platform and is solely responsible for making the design choice for the platform's openness. This assumption is in contrast with situations where the core is controlled by a governmental organization or by an alliance of different parties. the reason for taking this perspective is that it was considered the most straight-forward approach with the least need to take into account political decision-making processes.

Multiple platforms can exist in parallel

This thesis has as a starting point that multiple platforms may exist in parallel. As this study has taken a green-field approach (installed-base ignorant, see section 1.3) to designing a platform-based ecosystem, no predefined market dynamics are implied, meaning that there is not yet any party that has established a dominant market-position. All platforms can have equal market share.

What is in the core

This decision has also been mentioned repeatedly as one of the important decisions needed to be made prior to platform launch. The platform core should in itself provide certain core functionality (Tiwana, 2014). For this thesis, it was assumed that the core supplied at least the following capabilities: patient treatment logging, authentication, authorization.

6.1.2. Describing an open platform in healthcare and example application

Based on the perspective that a platform architecture comprises a core, interfaces and modules, a perspective on a digital platform in primary healthcare has been formulated. This perception has been visually represented in 6.1(b) below.

Core

The core is supplied and managed by the platform owner. This may for instance be considered as one of the current suppliers of information systems (e.g. a HIS) in this domain.

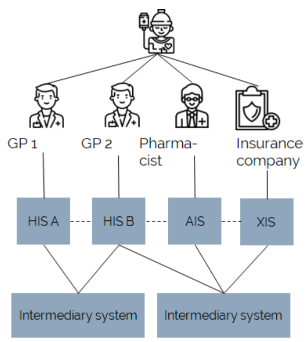
Interfaces

Interfaces are the tools and code-bases that allow coupling of modules to the platform. Those interfaces are designed, developed and managed by the platform owner. The platform owner can thus determine how these interfaces are defined.

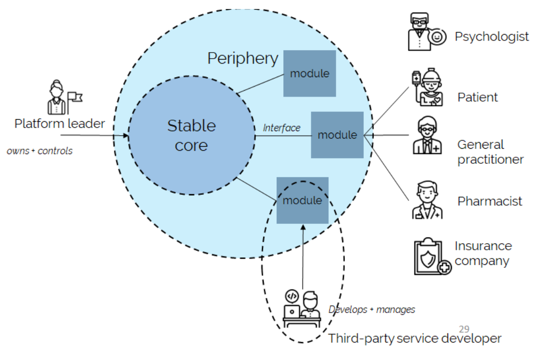
Modules

Modules are parts of functions that can be attached to the platform to add functionality. An example of such a module could be the added functionality of providing a calendar function, that allows caregivers and patients to manage appointments.

An example application for this platform-based ecosystem perspective is included in the box below the figures.



(a) Simplistic representation of the current situation



(b) Simplistic representation of a platform-based ecosystem

Figure 6.1: Simplified graphic representations of perceptions of the as-is situation and of the platform-based ecosystem situation

Hypothetical application of a digital platform paradigm in the primary healthcare domain

Current system: In short, caregivers in first-line healtcare are supported by an IS that allows them to perform all kinds of actions from logging patient treatments, to ordering medicine to checking patients' treatment history at other caregivers. For each type of care provider, there is a different sort of information system (e.g. HIS or AIS). These information systems are connected through intermediary systems and technologies. This current system is described more clearly in chapter 4. A simplistic representation is provided in 6.1(a). These current systems are thus *tightly vertically integrated* systems, in which the entire value-chain of the system is developed and maintained by a single proprietary party.

Platform-based ecosystem situation: For this thesis, it is argued that a lively and dynamic ecosystem of third-party service developers is beneficial to the primary healthcare domain. Leveraging the knowledge of third-party developers is expected to lead to increase in innovation efforts for the primary healthcare domain, developing services that benefit both the side of the care givers as well as the patients.
In an example situation for a platform-oriented information systems in the primary healthcare domain, the platforms' core contains core functionality that is shared among all participating parties (e.g. logging patient treatments, authorization, identification). Additionally, complementors can offer modules that can be coupled to the platforms' core. These modules may mediate between user groups, adding values to different actors in the ecosystem. In this example, an independent software developer may add an application to the platform by using interfaces and boundary resources, e.g. APIs and SDKs (or boundary resources) that are provided by the platform owner.

Example 1 In the example presented in figure 6.1(b), a developer may have the idea for an IoT-medicine box that can track what medicine a patient takes in. This exact intake can be monitored. While this is useful for the patient, it may also allow the patient's pharmacist and general practitioner to keep track of the medicine take in and health status of the patient. This way, the caregivers can give accurate support to the patient.

Example 2 A patient makes use of his mobile phone camera to keep track of complaints concerning a mole on his/her skin. The picture can be send to a general practitioner. Simultaneously, this picture may be analysed, comparing it to pictures of moles of other patients. Information regarding this analysed picture can assist the general practitioner in making a decision that he/she can discuss with the patient.

6.2. Concept artefact: Design choice chart

In chapter 5, it was concluded that this thesis adopted the perspective on platform architecture as the combination of a *core*, *interfaces* and *modules*. For this thesis, it was assumed that the platform owner can determine the architecture of the core and the interfaces. Because the configuration of the modules cannot be influenced by the platform owner, this factor is not considered for this study. The two components that are thus considered as the dimensions that can be configured, are the core and the interfaces. For each of these components, different modes for organizing them have been derived from literature.

6.2.1. Purpose of this design choice chart

The purpose of making this design choice chart is threefold. Firstly, the goal is to establish a means for platform owners to inform them on what design choices they face for determining what architectures they may deploy to achieve a desired degree of platform openness (contributing to knowledge contribution 2 in subsection 1.2.2).

A second goal of developing this design choice chart relates to unifying the concepts of platform openness and platform architecture (relating to contribution 3 in subsection 1.2.3). The intention of this chart is to define how configurations of the platform architecture can lead to the achievement of strategic goals.

Third and most importantly, this chart is used as a means to elicit trade-offs in designing a digital platform in the first-line healthcare domain in The Netherlands (following up on knowledge contribution 1, subsection 1.2.1). To this end, this study will examine whether it is possible to use this chart to develop an understanding of what trade-offs are expressed by field-experts on platform openness in this domain. For this, validation discussions were conducted, which are reported in chapter 7.

6.2.2. Chart presentation

Figure 6.2 shows the design options that platform owners can choose from. This *Design choice chart* is explained and interpreted in the next subsection (6.2.3).

Architecture dimensions	Design choices			
	Option 1	Option 2	Option 3	Option 4
Core	Proprietary (West, 2003)	Resource openness (Kazan et al., 2018) (Blaschke et al., 2019) (West, 2003)	Meta-platform (Mosterd, 2019) (Hein et al., 2019) (Bygstad & Hanseth, 2018)	Gateways (Eisenmann et al., 2009) (Ondrus et al., 2015)
Interface openness	Proprietary interfaces (Gawer, 2014) (Mukhopadhyay et al., 2019)	Selectively open (Gawer, 2014)	Open interfaces (Tee & Woodward, 2013) (Mukhopadhyay et al., 2019)	
Interface stability	Non-stable interfaces (Brunswicker & Schechter, 2019) (Cabigiosa et al., 2013)	Stable interfaces (Brunschwicker & Schechter, 2019) (Baldwin & Clark, 2000) Yoo et al., 2010). (Cabigiosa et al., 2013)	Industry-standard interfaces (Cennamo et al., 2019) (Cabigiosa et al., 2013) (Baldwin & Clark, 1997)	

Figure 6.2: Concept for design chart for openness of the platform architecture

6.2.3. Chart interpretation

The chart in Figure 6.2 should be used as follows. A platform owner is requested to make a decision on each of the dimensions. For instance, a platform owner might choose a proprietary approach to the core-dimension, a selectively open approach to the interface openness-dimension, with stable interfaces from the interface standards-dimension. This means that the platform owner (or the interview respondent) has four options for the first dimension, and three options for the latter two dimensions.

6.3. Design choice dimension explanation

This section explains what the different design options entail and what the consequences are for choosing these options. The section is structured along the same dimensions as represented in Figure 6.2.

6.3.1. The core-dimension

The platform's core, which essentially is the platform, is managed by the platform owner. A platform owner can opt for different strategies for opening or closing the core. These strategies have been visualised in Figure 6.3.

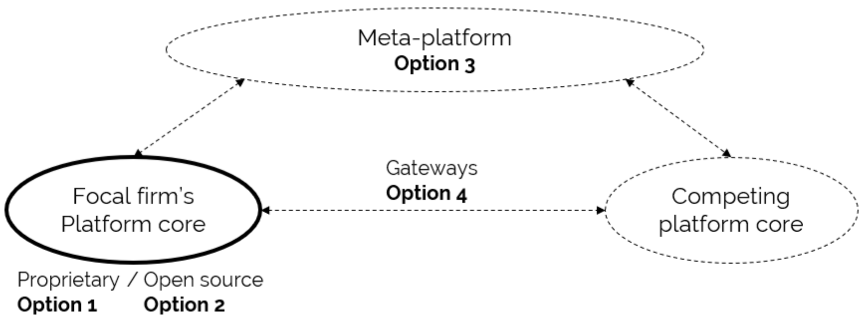


Figure 6.3: Visual representation of the design options for the platform core

Table 6.1 converges the findings from the literature reviews on platform architecture and platform openness. It represents what consequences are associated with the design options, as reported in literature. In the *validation* (chapter 7), these design options will be presented to field-experts in first-line healthcare to study what trade-offs they express on the design chart.

Table 6.1: Consequences of selection of the design options for the core-dimension

Design option	Consequence	Reference
Option 1: Proprietary core		
	• high appropriation of returns	(West, 2003)
	• difficult to imitate	(Roesch et al., 2019; West, 2003)
	• high entry-barriers	(West, 2003)
	• easy to coordinate	(Eisenmann et al., 2009; West, 2003)
	• possibility of user lock-in	
	• fierce competition	
	• less suited for innovation	(Eisenmann et al., 2009)
Option 2: Resource openness		
	• reduces development costs	(Eisenmann et al., 2009)
	• community feedback	(Chesbrough, 2003; Eisenmann et al., 2009; West and Gallagher, 2006)
	• high quality core	(Chesbrough, 2003; Eisenmann et al., 2009; West and Gallagher, 2006)
	• less feasible for economic returns	(West, 2003)
Option 3: Meta-platform		
	• Industry platform integration	(Hein et al., 2018)
	• competitive dynamics	
	• coordination required	(Eisenmann et al., 2009)
	• least common denominator dynamics	(Eisenmann et al., 2009)
Option 4: Gateways		
	• compatibility of functionality in the cores of affiliated platforms	(Hanseth and Lyytinen, 2016; Ondrus et al., 2015)
	• enhances platform attractiveness for complementors	
	• reduces competitiveness of industry platforms	

Core - Option 1: Proprietary

A proprietary strategy is to have a closed platform core, i.e. only the sole platform owner has the right to see, access and change the platform's core.

Organizations that are successful at maintaining a proprietary platform strategy, have the benefit that they can appropriate all financial returns (West, 2003). What is more, a proprietary platform owner has the advantage that they may be difficult to imitate and they can set high entry barriers (West, 2003). Also, they due to their tight integration, they are fairly easy to coordinate. As indicated by Eisenmann et al. (2009) proprietary platforms may exert better performance because of their tight integration, this especially holds true in emerging markets or markets are in transition.

Disadvantages of a proprietary strategy is that the market is less viable of innovation. They are less attractive for complement developers (Eisenmann et al., 2009) because they do not integrate well with other platforms. This strategy often only holds possible for one- or two market-leaders. resulting in fierce competition and possibly winner-takes-all dynamics.

Core - Option 2: Resource openness

Resource openness entails to make the platforms' core fully accessible to all external developers (Boudreau, 2010; Karhu et al., 2018). This option is also referred to as open source platforms (West, 2003), of which Linux is an example. Resource openness can for instance be forfeiting the core's intellectual property by opening up the platform core's codebase (Karhu et al., 2018). In this option, users and complementors can affect the future development of the platform (West, 2003).

Researchers ascribe both positive and negative perspectives on this option. This way of organizing the architecture of the core has the advantage that it reduces costs for development and maintenance of the platform for the owner (Eisenmann et al., 2009). Furthermore, opening up to joint platform core development may result in a higher quality platform, as the best version of the core will surmount. In addition, the quality may improve because co-development will yield feedback from a community of co-developers (Chesbrough, 2003; Eisenmann et al., 2006; West, 2003; West and Gallagher, 2006). On the other hand, a disadvantage is that it is more difficult for the platform owner to reap economic benefits (West, 2003). In addition, it is less suitable for complement development.

Researchers do not seem to agree on whether resource openness has a positive or negative effect on the attitude of complementors to develop additional products for an open source platform. Choi et al. (2019) mention that resource openness reduces the incentives for complementors to engage in developing on the platform because it increases the costs of coordination. Anvaari and Jansen (2010) and Koch and Kerschbaum (2014) state the opposite, that an open source strategy positively correlates with complementors willingness to contribute to a platform. As a result of this discrepancy, this argument does not provide useful information for this design chart.

Core - Option 3: Meta-platform

A meta-platform can be best understood as an integration platform (Hein et al., 2018). A trusted-third party, or possibly a consortium of platform owners, organize the meta-platform. This meta-platform in turn, holds core functionality and identifies interfaces that are shared with industry-platforms. A similar approach is also sketched by (Bygstad and Hanseth, 2018) to integrate services by different providers. Besides these works, there is fairly little research on meta-platforms that connect platforms in industry.

The following factors have been associated with this design option. An advantage of this option is that it can facilitate in a set of required core functions, while still providing autonomy for the platforms to develop their platform according to an own strategy. There are also disadvantages to this option is that it requires co-ordination between the meta-platform controller and the industry-platforms. The platform may still need to evolve as a result of changes in the platform's environment, however, adopting changes is typically more difficult when it requires multiple parties with varying interests to agree (Garud et al., 2002; Simcoe, 2007). In addition, this design option can also lead to "least common denominator" dynamics

(Eisenmann et al., 2009, p. 9) due to “tyranny of the majority voting”, i.e. when a big part of the affiliated platform members do not posses the required capabilities to work with the state-of-the art technology or when platform owners have a vested interest. A third possible disadvantage is that platforms may still opt for proprietary gain, thus evolving with a closed strategy (while respecting the shared agreements on the level of the meta-platform).

Core – Option 4: Gateways

The fourth and final option we consider is to open up through adopting gateways. Interoperability between two platform can be managed by gateways or technical standards (Hanseth and Lyytinen, 2016; Ondrus et al., 2015). Gateways can be thought of as adapters, pieces of software that can connect two different services that might have different versions or capabilities (Hanseth and Lyytinen, 2016).

An advantage of the usage of gateways is that technical standards makes functions in the core compatible over different platforms (Hanseth and Lyytinen, 2016; Ondrus et al., 2015). A big advantage of this option is that it lowers barriers to entry and it can nullify monopolies by making them interoperable (The Economist, 2019b). A negative effect is that this may lead to a greater number of parties that develop a platform, introducing fierce competition among platform leaders.

West (2003) finds that when organizations fail in successfully managing a proprietary strategy, they are forced to open up their platform. Opening up a platform introduces more coordination while it reduces chances of locking-in users.

6.3.2. The interface-openness dimension

As another way of opening a platform, platform leaders can also choose to open up by opening up the platform through the interfaces (Boudreau, 2010; Hein et al., 2018; Karhu et al., 2018).

Interfaces determine how the different components interact with the core (Baldwin and Clark, 2000). The interface can, according to Gawer (2014, p. 1243) be seen as “a divider, but also a connector and a conduit of selected information facilitating interconnection”. This research adopts the perspective of Gawer (2014, p. 1243) concerning interface openness, as “the interface contains information that is accessible to external agents and usable by them to allow to build complementary innovation that is compatible with this interface”. Interfaces determine what components of the platform the complementors have access to. Thus, interface openness is an important measure for platform control (Mukhopadhyay and Bouwman, 2019; Tiwana et al., 2010).

The design options for interface openness are visually presented in Figure 6.4. In addition, table 6.2 shows what consequences have been associated with the design options.

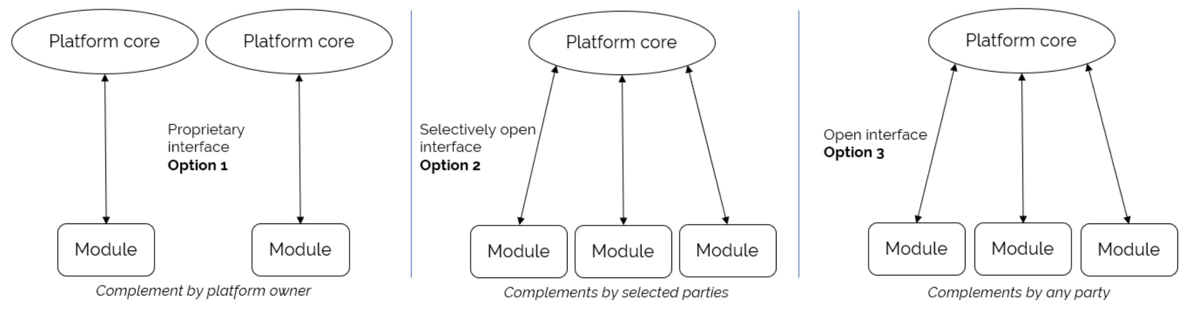


Figure 6.4: Visual representation of the design options for the interface openness-dimension

Table 6.2: Consequences of the design options for the interface openness-dimension

Design option	Consequence	Reference
Option 1: Proprietary interfaces		
	• efficiency	(Gawer and Cusumano, 2013)
	• flexibility	(Gawer and Cusumano, 2013)
	• high control	(Gawer and Cusumano, 2013)
	• high appropriability	(Roesch et al., 2019)
	• high R&D costs	
	• all knowledge for innovation must be available in-house	(Tiwana, 2014)
Option 2: Selectively open interfaces		
	• reduce R&D costs	
	• tap into external capabilities	
	• high control	(Cennamo et al., 2018)
	• high quality complements	(Cennamo et al., 2018)
	• less generativity	
	• success dependent on selection of partners	
Option 3: Open interfaces		
	• attractive to complementors	(Gawer and Cusumano, 2013; Tiwana, 2014)
	• enhances innovation	(Gawer and Cusumano, 2013; Tiwana, 2014)
	• high variety in complements	
	• potentially limitless source of capabilities	
	• reduced control	
	• fierce competition	(Boudreau, 2010)
	• lower quality complements	(De Reuver and Bouwman, 2012; Wareham et al., 2014)

Interface openness - Option 1: Proprietary interfaces

In this option, interfaces are defined for loose coupling of modules to the core, however, these interfaces are not open to external organizations. Rather, these interfaces remain closed to be solely used by the lead firm (Gawer, 2014). Closed interfaces relate to closed platforms. They are often not interoperable with other services or with competitor's platforms (Roesch et al., 2019). Gawer and Cusumano (2013) also refer to this type of platform as an internal platform.

The following factors have been associated with this design option. Advantages of this strategy to the platform owner is that the focal firm gains efficiency and flexibility by using a modular architecture, allowing the firm to reuse common components. This way, they can more quickly adapt to changing user-needs compared when they would have a tightly-integrated organization (Gawer and Cusumano, 2013). In addition, these platforms can have high appropriability (i.e. the possibility for harvesting rents) and it can lead to lock-in, in which the users have little opportunity to switch to a competing supplier (Roesch et al., 2019). Another advantage is that the platform owner has control over the development of the platform. Disadvantages of this strategy are that it incurs high costs for R&D as all innovation is done in-house. This option thus fails to leverage the innovation-capacity of external parties.

Interface openness - Option 2: Selectively open interfaces

In case selectively open interfaces, interfaces are shared exclusively with selected partners who are allowed to develop complementary assets. This type of platforms relates to what Gawer and Cusumano (2013) call supply chain platforms (also in: Gawer (2014)).

For a platform owner, this mode of interface openness has the advantage that it allows the platform to outsource its R&D, leveraging external capabilities and reducing costs. In comparison to fully open interfaces, this design option has the advantage that it can control the quality of complements, improving the overall value of the platform (Cennamo et al., 2018). On the downside, the generativity of this platform will be lower compared to an open interface. Also, its success strongly depends on the selection of partners.

Interface openness - Option 3: Open interfaces

A strategy for open interfaces can be considered as the establishment of open APIs (Application Programming Interfaces). These interfaces allow third party developers to extend the focal platform's functionality by adding new modules to it. This leads to greater interoperability and the possibility for complementor developments to multihome (i.e. to exploit their service on different platforms). The phenomenon of multihoming is indicated with the dotted line in figure Figure 6.5. In the case of open interfaces, the interfaces are openly shared with other parties (and complementors) in industry (Gawer, 2014).

One of the most prominent advantage of using open interfaces is that it provides a platform owner with the possibility to cultivate the expertise and resources of a development community, leveraging knowledge of users that the platform owner itself does not have him/herself (Gawer and Cusumano, 2013; Tiwana, 2014).

A negative effect of open interfaces may be that it introduces a high number of third party developers, leading to high competition among those developers (Boudreau, 2010). Another downside that can be introduced by openness of interfaces is that it may give room for applications of lesser quality to make use of the platform, for which researchers have shown that it damage the perceived overall quality of the platform (De Reuver and Bouwman, 2012; Wareham et al., 2014).

6.3.3. The interface stability dimension

Whether interfaces remain stable over time and to different complements is an important leverage-point for platform owners in controlling their relationship with external contributors (Tiwana, 2014). The design of the interfaces can determine whether an IS is more a monolothic IS or a modular platform. Based on the review of literature in chapter 5, the stability of interfaces was conceptually represented as a choice between stable, non-stable or industry-wide standards for interfaces. The distinction depends on whether a platform has a separate interface for different apps, one interface to share with all its apps or that the platform complies with an interface that is standard for the entire industry. This distinction is described in more detail below.

Figure 6.5 graphically shows the different options for the design of the standards for the interfaces. The corresponding table 6.3 explains the consequences associated with the options, as found in the review.

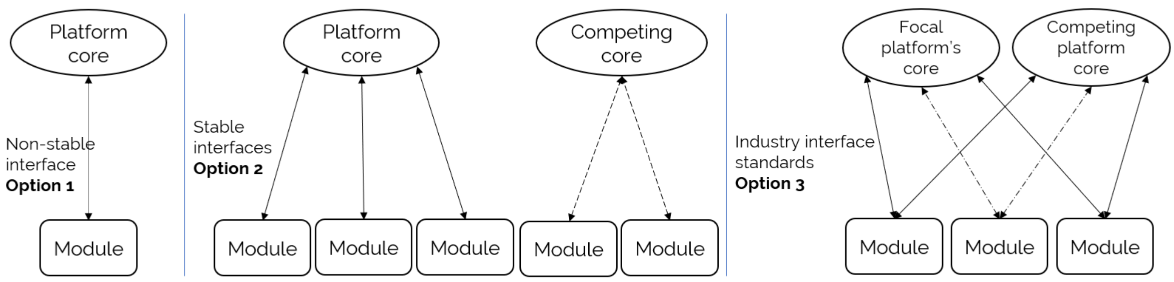


Figure 6.5: Visual representation of the design options for the interface standards-dimension

Interface standards – Option 1: Non-stable interfaces

In this option, interfaces are non-standard, they suit the needs of a specific party and a specific product (Cabigiosu et al., 2013). These platforms and cores thus require more coordination between the platform and its complements (Brunswicker and Schecter, 2019). It gives more control to the platform owner.

Table 6.3: Consequences of the design options for the interface standards-dimension

Design option	Consequence	Reference
Option 1: Non-stable interfaces		
	• more control for platform owner	(Brunswicker and Schecter, 2019)
	• increases need for coordination between platform and modules	(Brunswicker and Schecter, 2019)
Option 2: Stable interfaces		
	• increased flexibility	(Cabigiosu et al., 2013)
	• More attractive to complementors	(Baldwin and Clark, 2000; Brunswicker and Schecter, 2019; Yoo et al., 2010)
	• less need for co-ordination	(Cabigiosu et al., 2013)
Option 3: Industry standard interfaces		
	• multihoming of complements	(Cennamo et al., 2018)
	• transparency in industry	
	• attractive to complementors	(Baldwin and Clark, 1997; Cennamo et al., 2018)
	• reduces differentiation between platforms	(Cennamo et al., 2018)
	• difficult to gain competitive advantage	

Interface standards – Option 2: Stable interfaces

Stable interfaces can be interfaces that are specified by a single firm and that are not changed after a project has started. Stable interfaces thus have the advantage that modules may change, while the interface does not (Tiwana, 2014).

This option provides room for flexibility and reduces uncertainty of the core because interaces are fixed after launch (Cabigiosu et al., 2013). Stability leads to less need for co-ordination and for higher predictability in interdependency between the platform core and the module (Cabigiosu et al., 2013). Furthermore, stability in interfaces leads to higher re-usability of the platform by complementors (Baldwin and Clark, 2000; Brunswicker and Schecter, 2019; Yoo et al., 2010). Stable interfaces are not necessarily standard interfaces.

Interface standards – Option 3: Industry standards

Industry standards concerns whether platform owners choose to comply with industry standards. An industry-standard is defined here as ”a detailed specification that is agreed on by multiple players in the industry” (Tiwana, 2014, p. 113). That is, standards are shared across different parties in the industry. This may lead to a plug-and-play situation in which complements can easily attach to different platforms (Cennamo et al., 2018). These standards can be determined either *de jure* or *de facto*. For this thesis, no distinction is made whether it concerns de factor or de jure standards as it is not deemed relevant at this stage of the study on a digital platform in first-line healthcare.

Due to the standard-property, modules can be “mixed-and-matched” (Baldwin and Clark, 1997). This means that while the interfaces stay fixed, the modules can change (Cabigiosu et al., 2013). Standardization thus enhances the modularity of the architecture, providing room for innovation.

However, this strategy reduces the differentiation between platforms based on their complements (Cennamo et al., 2018). What is more, industry standards decrease the chance for a platform to gain a competitive advantage.

7

Evaluation - Of concept design

This chapter deals with the fourth step in the design cycle: evaluation. The design choices described in chapter 6 are discussed with field-experts in IS in first-line healthcare. The purpose of this evaluation-step is to identify what trade-offs industry-experts express concerning design choices for architectural openness for a digital platform in Dutch first-line healthcare. This step involves conducting semi-structured interviews. The results from these interviews will be used for iterating the concept design from chapter 6 and for answering sub research question 4.

First, section 7.1 reports descriptives about the interviews. The results of the semi-structured interviews are provided in section 7.2. Finally, section 7.4 gives answers to sub research question 4. In addition, the approach to the coding process is reported in appendix section B.3. The slides that were used during the semi-structured interviews to present the design choice chart and design options are included in appendix H.

7.1. Interview descriptives

All semi-structured interviews were conducted in the second half of December 2019 and the first half of January 2020. Eight respondents participated in the semi-structured interviews. The discussions had the form of one-on-one discussions between the researcher and the interviewee. On one occasion, it was a one-on-two discussion because both respondents could only meet at the same time. This was the case for PI1 and PI2. The interviews had an average duration of 73 minutes (minimum 60 min.; max 94 min.). Furthermore, the respondents showed high engagement during the interview, indicating that they could relate to the subjects discussed. The protocol to the interviews is included in appendix section B.3.

7.2. Results

This section presents the results from the analysis of the semi-structured interviews. For this analysis, the interview transcripts were coded. Subsequently, relationships between the codes were identified to construct theory on the trade-offs that field-experts expressed concerning the architectural openness of a digital platform in first-line healthcare. No predefined codes were used to inform the coding process or to describe how the codes that emerged would relate to each other. The results of the semi-structured interviews are discussed in relation to the dimensions of the design choice chart.

In the results-section, some tables and respondent-codes are referred to. The respondent-codes correspond to respondents that expressed a corresponding statement. Table 7.1 shows an overview of the respondents. A more extensive overview of the respondents is provided in chapter 3. The tables reporting the outcomes of the transcript-analysis show two numbers between accolades. These refer to the *groundedness* (the number of times mentioned) and *density* (the number of relations to other codes). How the coding was done, is described in appendix E.

Table 7.1: The interviewees and their corresponding codes

Code	Organization type	Role
PI1	IS vendor; Interest group for IS developers in healthcare	Manager business development; board member
PI2	Interest group for IS developers in healthcare	Director
TI1	IS vendor in first-line healthcare	Head of IS products
TI2	IS vendor in first-line healthcare	IT-architect
TI3	IS vendor in first-line healthcare	Product (application) owner
MI1	Supplier of webpages for caregivers and personal digital health environments	Director
MI2	Information system supplier in the Dutch first-line care domain	Director
HI1	Combined practice for general practitioner and pharmacy	Pharmacy doctor

7.2.1. Trade-offs relating to the openness of the core

The results are discussed as following: first general remarks concerning the core openness are discussed together with a reflection on the current state-of-affairs, as distilled from the interviews. Subsequently, findings on the analysis are reported in relation to the design option. Afterwards, the preferences expressed by the respondents are discussed. Finally, the findings per design dimension are concluded.

General remarks and reflections on the current situation

In the interviews, the respondents repeatedly compared the design options to the existing situation. First of all, it was mentioned that the current situation resembles option 4 (Gateways). To translate information or functionality from one system supplier to another, gateways are used to translate data from one system to another. This is perceived as inefficient and cumbersome (TI2, TI3).

Second, *least common denominator dynamics* and *political dynamics* are said to play an important role. Some of the IS suppliers with a large market share, refuse to innovate or to go along in proposed changes to information standards (TI1, TI3, HI1). They are only willing to adopt a standard, if that standard resembles their own way of working, their way of working becomes the 'de-facto standard'.

Other known issues with the current situation of IS in first-line healthcare are (third) a *lack of perceived urgency to innovate*: Parts of the infrastructure are out-dated, even with on-premise servers. Caregivers fail to see the urgency to innovate the information systems that support their needs (HI1). Fourth, a *focus on short-term solutions* leads to a *scattering of initiatives* (TI1). Although there is a desire to adopt industry-wide solutions for information system standards, these prove to be unsuccessful due to a focus on short-term solutions. Every time a new need emerges in the market (e.g. a need by caregivers for new functionality), one party builds a solution to serve that need. This leads to a scattering of initiatives and solutions in this domain. Fifth, respondents report *a lack of mechanisms to enforce change* as a reason for slow innovation in IS in first-line care. There is no authority with power to enforce that IS suppliers adhere to changes in industry wide solutions (TI3). Sixth and finally, users are *stuck with long-term contracts* and they perceive a *high switching barrier* because they feel familiar to the way of working of their IS supplier (TI3). All these findings correspond to the conclusions from chapter 4.

During the interviews, it also occurred that respondents expressed trade-offs that related to the core dimension in general, rather than specific to one of the design options. These trade-offs are listed below.

- **One core vs. competition** - At the one hand, respondents would prefer a situation with one core, while on the other they say to want competition and not to have a monopoly. These viewpoints seem to be inconsistent with one another. It is worth examining both options.

Two reasons were exclaimed why a situation with multiple platform providers is beneficial. The first is that this was said to introduce competition, and competition will stimulate innovation (TI3). Second, PI1 is in favor of an ecosystem with multiple interdependent platform leaders. This will reduce the chances of lock-in, while enhancing flexibility of the overall ecosystem.

On the other hand, three motivations were mentioned why the ecosystem would be better of with a single platform. For one, a solution with only one platform would be beneficial to the user experience (TI2). Secondly, this would mean that everyone would have the same experience and a single shared way of working (TI2, TI1). Third, there is little to none distinctive value-proposition to be achieved in core functionality, like patient treatment logging, authentication, etc. (TI2, MI2). Or:

> *"In the core functionality is no distinctive value-proposition, those are must-do's."* – TI2

- **Factors in general interest of first-line healthcare -** Some factors were mentioned to be in the general interest of first-line healthcare, independent of the design options. These were considered requirements ('should/ should not be able to do...') or even constraints ('must/must not do...') to a platform-based ecosystem for first-line healthcare. First, it should not raise entry-barriers to new suppliers. Additionally, the platforms should be reliable, and reliably deal with data-management. This also requires transparency of the roles in the ecosystem, for instance for who provides what functionality and which stakeholders are reliable for the system (MI1).
- **Is there a role to be played by the Dutch Government as the platform leader?** - Some interviewees argue that there may be a role for the Dutch government to act as the platform leader (MI1, PI2, TI2). The main motivation for having the government as a platform leader are, that (1) they are a sole objective party to deliver a platform (PI2), (2) there is no distinctive value proposition in the core functionality anyway (TI2), and (3) the government could determine the conditions on which innovation can take place (MI1). Counterarguments for the role of the government is that the government may lack the required technical knowledge and/or the incentives to continuously innovate and improve the quality of the platform core (HI1).

A network graph showing the trade-offs associated with the current situation and trade-offs in the general interest of healthcare have been included in appendix E.

Trade-offs associated with core option 1 - Proprietary core

Five trade-offs are associated with a decision for a proprietary core. The strongest association are (1) opportunities for user *lock-in* and (PI1, TI2) (2) that platforms that have a large user-base may find a proprietary core useful to strengthen their position relative to competitors (MI1). To a lesser degree, respondents found this option (3) *easy-to-coordinate* (TI2), (4) that it is *stable* (M1) and (5) it is more likely to result in a situation with a *monopolist* dominating the market (PI1, PI2 and TI2).

These findings largely coincide with what has previous been reported in scientific literature (chapter 5). In addition to what was reported in scientific literature, respondents reported that a proprietary was associated with high stability and with the higher chances of a monopolist scenario.

In terms of desirability of these trade-offs, the field-experts mentioned that they value stability of a proprietary platform core and that it is easy to coordinate. On the downside, lock-in and a monopolist are undesirable phenomena associated with this design option.

Trade-offs associated with core option 2 - Resource openness

Table 7.2 shows that a lot of trade-offs have been associated with an open source strategy for the platform core. The strongest association reported was the enhancing of *innovation* (TI1, TI2, TI3 and MI1). This enhanced innovation can be attributed to out-of-the box implementation of additional functionality,

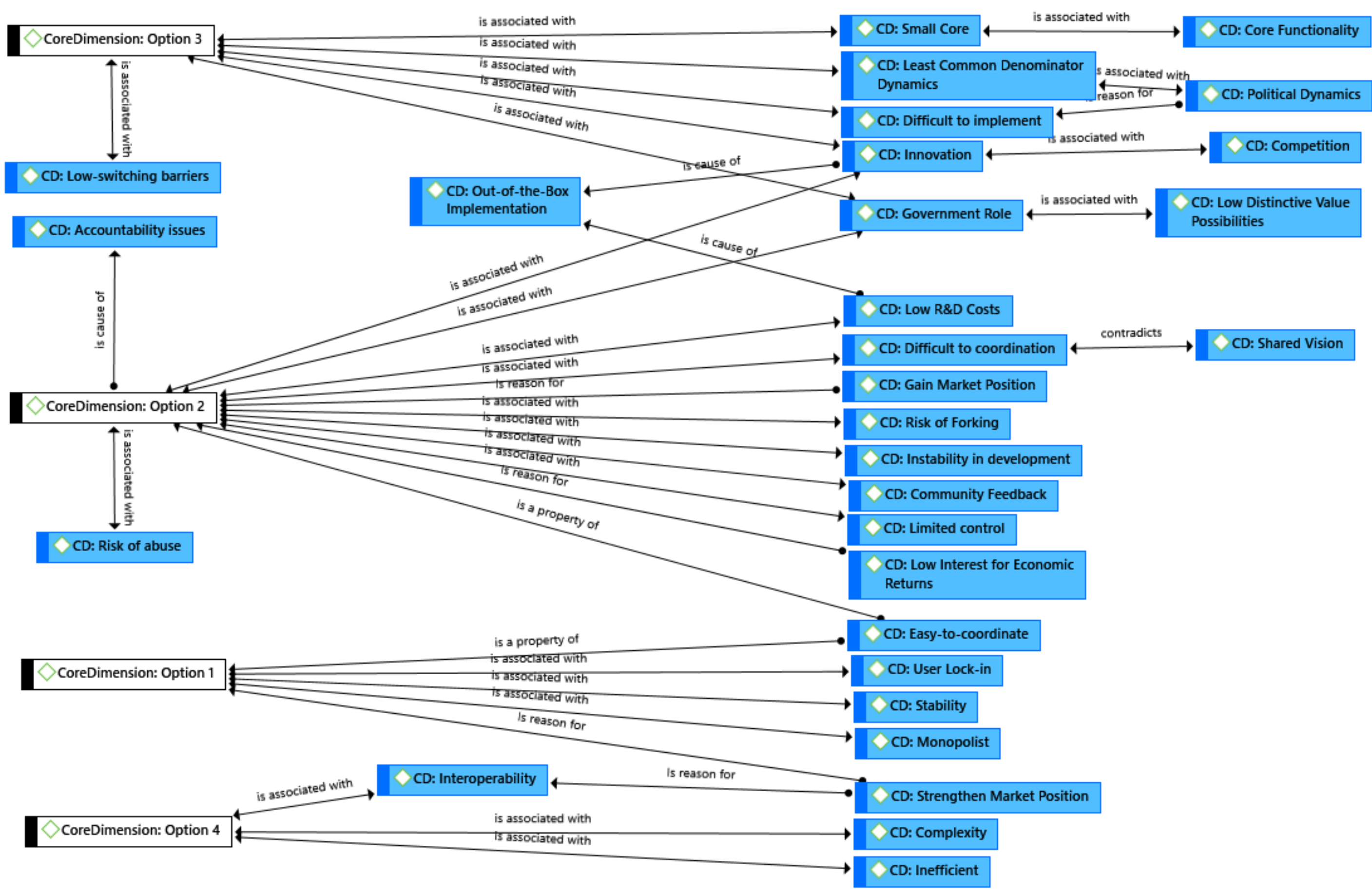


Figure 7.1: Network graph on trade-offs associated with the design options for the core

developed by external developers. Another strong association between resource openness was with *accountability issues*: when an open source platform fails and it is unclear who can be held accountable for this failure (TI1). This is highly undesirable in healthcare, where the consequences of such failures may have direct consequences to patients' health.

> *"A difficult question concerning open source platforms in healthcare is who has ownership and accountability. That is a big responsibility with significant consequences to patients' health."* –TI1

Other trade-offs were mentioned far less frequently. *Low R&D* (TI1) and *community feedback* were mentioned as a benefit to this option, due to involvement of external developers (TI3). Moreover, this option was said to give less *economic returns* (TI2). Disadvantages to resource openness are *risk of forking* (MI1), *risk of abuse* due to malicious behaviour of external parties (TI3). In addition, the open source option was associated with *instability* (MI1).

On the notion of coordination, field-experts expressed contradicting statements. While some mentioned a risk of lower control (TI1, TI3), others expressed that an open source platform is just as well easy to coordinate (TI2). Those worrying about coordination, acknowledged that a *shared vision* for the entire ecosystem could help to solve coordination-related issues.

It was mentioned that a reason that a platform owner may choose to adopt an open source strategy is when it is a small market player, that wants to use an open source approach to quickly *gain a market share* by attracting complementary service developers (MI1).

Table 7.2: Results on consequences associated with core openness with with {Groundedness : Density}

	Option 1	Option 2	Option 3	Option 4
Consistent with literature	Strengthen market position {2:2} Easy-to-coordinate {1:2} User lock-in {2:1}	Out-of-the-box implementation {1:2} Low R&D costs {1:2} Innovation {7:11} Risk of forking {1:1} Community feedback {1:1} Low interest for economic returns {1:1}	Least common denominator dynamics {5:3}	Interoperability {2:2}
Additional trade-offs	Monopolist {1:1} Stability {1:2}	Difficult to coordinate {2:3} Risk of abuse {1:1} Accountability issues {3:1} Gain market position {1:1} Limited control {2:2} Easy-to-coordinate {1:2} Uncertainty in development {1:1}	Difficult to implement {5:2} Political dynamics {4:3} Innovation {7:11} Ease-of-use {6:2} Government role {2:4} Core functionality {8:1} Low switching barriers {2:1}	Strengthen market position {2:2} Inefficiency{2:2}
Not featured by respondents	High appropriation of returns Difficult to imitate	High quality core	Competitive dynamics	

One interesting perspective was mentioned in an interview with TI2. TI2 was in favor of a situation where the government would provide the core platform. This platform might as well adopt an open source strategy. With a proprietary strategy, there would be little incentives to improve the core, while an open source platform will have more incentives to continuously improve the platform core. Or: *"There would be little incentives NOT to open the core."* –TI2

Trade-offs associated with core option 3 - Meta-platform

This option was mostly conceived by the respondents as one single organization for the most essential *core functionality*. As mentioned previously, some functionality (e.g. authorization, identification, patient treatment logging) needs to be organized for everyone. The current way of organizing this (when multiple parties build similar functionality but in slightly different ways) is considered inefficient. Respondents said it would be good if there is *one core platform* that defines the core functionality (TI1, TI2, MI1 and MI2). What is more, this core should be sufficiently small to *only include necessary functionality*, this way there can still be competition on the quality of additional functionality.

Interestingly, a low number of trade-offs was associated with this option but these trade-offs overall have high groundedness and density. This suggests that the field-experts expressed similar reflections on the design option for a meta-platform. In addition to the trade-offs mentioned above, the most mentioned trade-offs are: (1) that a meta-platform is associated with higher *innovation*(MI1, TI2). This is because the software developers will be less concerned with providing core functionality, but they can focus on developing services. Secondly, (2) it is associated with greater *ease-of-use* because the IS suppliers and complements are forced to work with similar core functions and code (TI2, TI3, HI1).

On the downside, this alternative is associated with (3) *difficulty to implement*. This difficulty to implement is caused by *political dynamics* and *least common denominator dynamics* (TI1, TI2, TI3, MI1, MI2). On the least common denominator dynamics, PI1 and TI3 argued that this should absolutely not hinder attempts to innovate or to develop a meta-platform. They said that they would prefer a situation in which the least capable parties would be excluded, rather than protecting involvement of all parties. What is striking, is that the meta-platform was repeatedly mentioned as a desirable design but, respondents also added that they think it is difficult to achieve this situation. A prerequisite for such a situation to arise, is to have clear coordination of parties and mechanisms to enforce adherence to the rules of the meta-platform (TI1, TI3 and MI2). Respondents think that these prerequisites will be difficult to achieve (TI1, MI2).

Trade-offs associated with core option 4 - Gateways

The respondents showed little interest in option 4 and also reported little trade-offs on this design alternative. This was considered a *complex* and *inefficient* way of organizing the ecosystem (TI1, TI2 and TI3). Also, this option was associated most with the current way of organizing information systems in the first-line care domain (see the quotes at the end of this subsection on the core dimension). A motivation for choosing this fourth option, is when a player has a medium share of the market and chooses to be *interoperable* with competing platforms to *strengthen its market position* (MI1).

Preferred design choices concerning the platform core

Concerning the preferences that respondents expressed during the interviews, the following results emerged. Most respondents were in favor of a meta-platform (TI1, TI3, MI1, MI2 and PI1). This was mainly because the respondents want to have the respondents want essential functionality to be the same for the every involved actor. To a lesser degree, respondents also saw option 2 (resource openness) as a viable design to a digital platform in first-line healthcare. This option was considered desirable by TI2 and MI1, mainly for it creates incentives to innovate. TI2 again said that he would prefer resource openness, provided that one party would provide the platform core. Making this core open source would give more incentives to innovate and improve the core compared to when the core is closed. Furthermore, option 1 (proprietary core) was only considered a desired situation by TI2, provided that there is only one platform in the market, preferably owned by the government. The main advantages are the centralization of control and stability of the platform. Finally, option 4 (gateways) was never mentioned as a preferred situation. This is only considered useful to enhance interoperability between systems. Overall it is perceived to contribute to a more heterogeneous landscape and a focus on short-term solutions over long-term quality.

> *”Option 4 is what we are currently doing and it is super non-productive.”* –TI2

> *”We currently experience least common denominator dynamics. We want to establish industry-wide solution (meta-platform or industry-standard interfaces) but due to political dynamics and a lack of coordination, these attempts fail. When new care needs emerge, developers build proprietary solutions. These proprietary solutions work, but due to these solutions, the urgency for an industry-wide solution disappears.”* –TI1

7.2.2. Trade-offs relating to the openness of the interfaces

Figure 7.2 and table 7.3 show the analysis of the codes of the semi-structured interviews for the interface openness-dimension. What immediately becomes clear from these models, is that design options 2 (selectively open interfaces) and 3 (open interfaces) have a lot of trade-offs in common, while this is not the case for design option 1 (proprietary interfaces). The results for this dimension are elaborated on in this section.

General remarks and reflections on the current situation

Concerning the present situation of IS in first-line healthcare, it was mentioned by HI1 that the current situation most resembles options 1 and 2. There is some openness of interfaces, systems can use functionality provided by outside developers, albeit that this does not happen regularly.

The interviews also revealed two insights concerning interface openness in general:

- **Openness is desired to stimulate innovation but it should guarantee control over quality, security and identity management** - Opening up the interfaces with the platform is believed to enhance the pace of innovation of functionality that improves first-line healthcare. However, the respondents mentioned requirements, concerns resulting from openness towards the control of *security, identity and quality*.

  Quality control was by far the most mentioned concern in the interviews. Quality control denotes ensuring that complements are of sufficient quality, that they reliably offer the functionality that they pretend to provide. Security control denotes the control over the integrity of data-management (storage, process, transfer) by complementors (MI2, TI2), but also that the security of the functionality is free of errors (MI2). Finally, identity control denotes that there is insurance that the user (patient or caregiver) is in fact who he/she pretends to be.

  > *"Innovation can never come at the cost of quality or security."* – MI2

- **Openness of interfaces is desired to stimulate innovation but it should protect ease-of-use of the platform with the variety in complementary functionality** - Another concern expressed by respondents was that openness of interfaces may lead to scattering of health information, gathered and stored at various locations, this may be detrimental to the overall user experience (TI3). As an example, assume that a woman provides a preference in module A not to be resuscitated, but this information is not consistent with information provided in another module B. This discrepancy may have a big impact when contradicting information is stored at different locations. Such challenges in the user experience must be accounted for, which is expected to become more difficult in a situation with open interfaces.

During the discussions, this dimension was associated with governance. The field-experts stated that the choice between the options depended on the way control over the ecosystem could be organized. While the relevance of governance was acknowledged by the researcher, the interviews did not go into detail on governance but stuck to the predefined architectural choices. As already stressed by Tiwana (2014) architecture and governance need to be matched in order for a successful platform to emerge. This was supported by the trade-offs that emerged in this part of the interview. This shows an interesting direction for further research.

Table 7.3: Results on consequences associated with interface openness

	Option 1	**Option 2**	**Option 3**
Consistent with literature	Easy to coordinate {1:1} Tight integration {1:1} Cost efficient {1:1} Monopolist {1:1}	Innovation {8:4} Lower R&D {1:2} Number of complementors {1:1} Efficiency {1:3}	Innovation {8:4} Lower R&D {1:2} Lack of control {3:1} Threat to platform quality {2:3}
Additional trade-offs	Tailoring {3:3} Lock-in {2:1} Sensitive functionality {2:2} Number of platforms in market {1:1}	Quality control {23:8} Security control {5:4} Tailoring {3:3} Efficiency {1:3} Data management control {2:1}	Quality control {23:8} Security control {5:4} Risk of abuse {5:2} Unfamiliar partners {3:1} Number of complementors {1:1}
Not featured by respondents	High appropriability Flexibility		Fierce competition Attractive to complementors

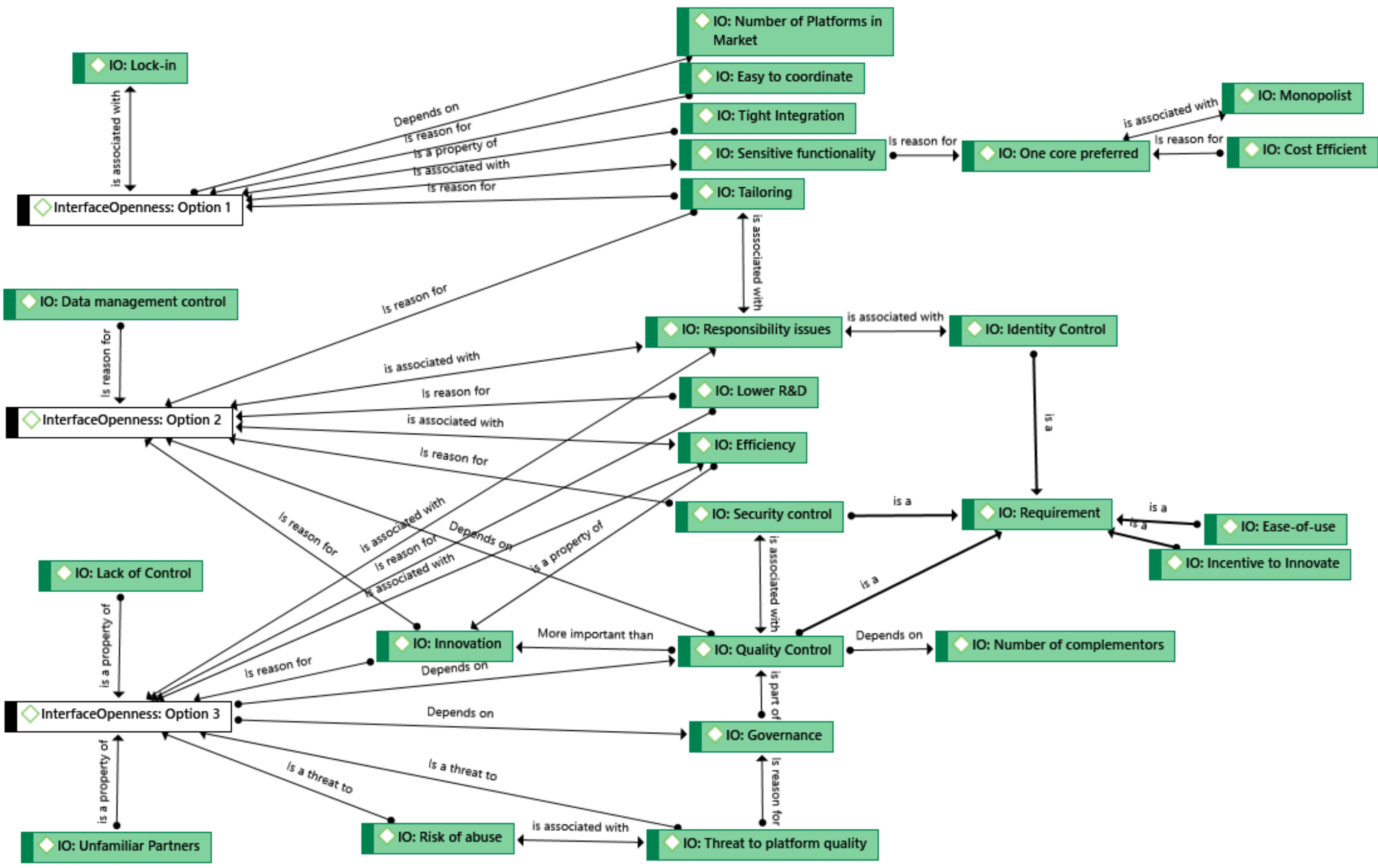


Figure 7.2: Network graph on trade-offs associated with the design options for the interface openness dimension

Trade-offs associated with interface openness option 1 - Proprietary interfaces

Factors that are associated by interviewers with proprietary interfaces, are: (1) it allows *tailoring* to the needs of users (TI1), (2) it allows for *tight integration* and control over the loosely coupled modules (TI2). *Lock-in* is a third (3) consequence associated with this option.

On the downside, proprietary interfaces are said to come at the costs of innovation. When innovation is the goal, this initial advantage becomes a threat. This reveals an inherent trade-off between tight control and freedom of external developers that drives innovation. This finding resembles observations that were done by Constantinides et al. (2018); Tiwana et al. (2010).

Proprietary interfaces are considered useful when the functionality that is related concerns *sensitive functionality* (e.g. the medication monitoring, Dutch: medicatiebewaking; TI1). As also mentioned with the core-dimension, certain functionality is so generic and important, that interviewees say that it can best be *organized once by one party*, for instance by the *government* (see illustrating statement below). Another reason mentioned why one platform core may be preferred is that it is *cost-efficient*, as opposed to a situation when multiple parties develop similar functionality (PI2). Another reason for choosing a proprietary strategy to interfaces is when the platform owner has a properly functioning application and wants to *tailor interfaces to needs of external partners* (TI1). A third circumstance when proprietary interfaces are considered feasible is when there are *a lot of platform providers in the market*, as complementors than still have the possibility to choose their platform (PI1). This is not the case if there is one platform to which users are bound to use.

> *"Medication monitoring is currently a core function. It is something that allows IS-vendors to distinguish themselves, and, it comes with great responsibility. Therefore, you will not easily*

open up this part; unless, it is organized properly by a single party." –TI1

Trade-offs associated with interface openness option 2 - Selectively open interfaces

Selectively open interfaces were considered the intermediate option, balancing between a closed system and an open ecosystem. It was acknowledged that to stimulate innovation, some openness of interfaces (option 2 or 3) is recommended. The consequences associated with both options are reported in table 7.3.

Six advantageous consequences associated with this option are enhanced (1) *innovation* (PI1 and TI2) and (2) *lower R&D costs* (TI1). Moreover, this option still allows the opportunity to (3) *tailor* interfaces to the needs of a specific user (TI2). Most importantly, this option gives the platform owner the means to (4) *control* the *quality* (5) *security* and (6) data-management control of modules that are hosted on the platform (Mi1, TI1 TI2 and TI3). Data management control was said to be part of quality control. Finally, options 2 and 3 are both considered more efficient than proprietary interfaces, as they require less effort by the platform owner to develop new interfaces for every additional function.

Trade-offs associated with interface openness option 3 - Open interfaces

Open interfaces are the most open of the options and have a lot of trade-offs in common with option 2 (selectively open interfaces): *lower R&D*, *innovation* (PI1, MI1, MI2 and TI2) and *efficiency* (PI1). Compared to option 2, more negative consequences are associated with option 3. It is even considered more important to account for proper *governance* and *quality control*, to mitigate negative properties associated with open interfaces. Some of these risks are, *lack of control* (TI1), *unfamiliarity with platform contributors* (TI1, MI1, PI1), *risk of abuse* by dubious complementors (PI1, TI2) and finally that low quality or harmful complements may *harm the overall platform quality* (TI1 and TI2).

The main motivation mentioned for choosing fully open interfaces is to stimulate innovation. Most respondents said they would prefer option 2 because it allows for more control over the quality and security of the platform and its complements.

"The opener you are, the bigger your chance of success when it comes to innovations." – MI1

Preferred design choices for the openness of interfaces

The interviewees were clear in their judgements for what option to prefer. Quality and security control is inherently so important to the healthcare domain, that option 2 is preferred over option 3. Option 1 is deemed sub-optimal, due to its lower innovation-capacities. None of the respondents mentioned that they would choose option 1 (proprietary interfaces).

The choice between options 2 (selectively open) and 3 (open) depends on what control mechanisms are used. As such, this relates to governance. Although governance is not a included in this study, this finding stresses the need for integrating architectural design with the appropriate use of governance in platform design and control.

"Option 2 is preferred because it is easier to guarantee the quality of the platform and the modules" –MI1

"You want a platform provider that delivers a high quality core, with the possibility for outsiders to develop complementary offerings. But innovation cannot be unlimited, there must be quality control." –PI2

7.2.3. Trade-offs relating to the stability of the interfaces

This section discusses the third dimension of the design choice chart, the interface stability dimension.

General remarks and reflections on the current situation

The current situation was said to mostly resemble option 1 (non-stable interfaces) (TI1, HI1) and to a lesser extent option 2 (HI1). This situation is cumbersome, every software that developed by an external contributor needs a separate interface. Over the years, this has led to an unmanageable wealth of interfaces.

The interviews indicated some consequences that are in the general interest of the stability of the interfaces. For PI2 it is crucial that a platform-based ecosystem way of organizing this domain allows users to *switch between service- and platform suppliers*. In addition, TI1 and MI2 mentioned that the choice between one of the three options, depends on the functionality that is associated with it (see also the quote below). They think that industry-standard interfaces should be available for the most generic and essential functionality. These are functions that have low opportunities for distinctive solutions and it would be best if they are similar to all users and providers.

> *"For some functionality you really want option 3, that counts for functionality that simply has to be provided but for which there are little opportunities to distinguish oneself as a platform owner. For this you just want one commonly shared solution"* – TI1

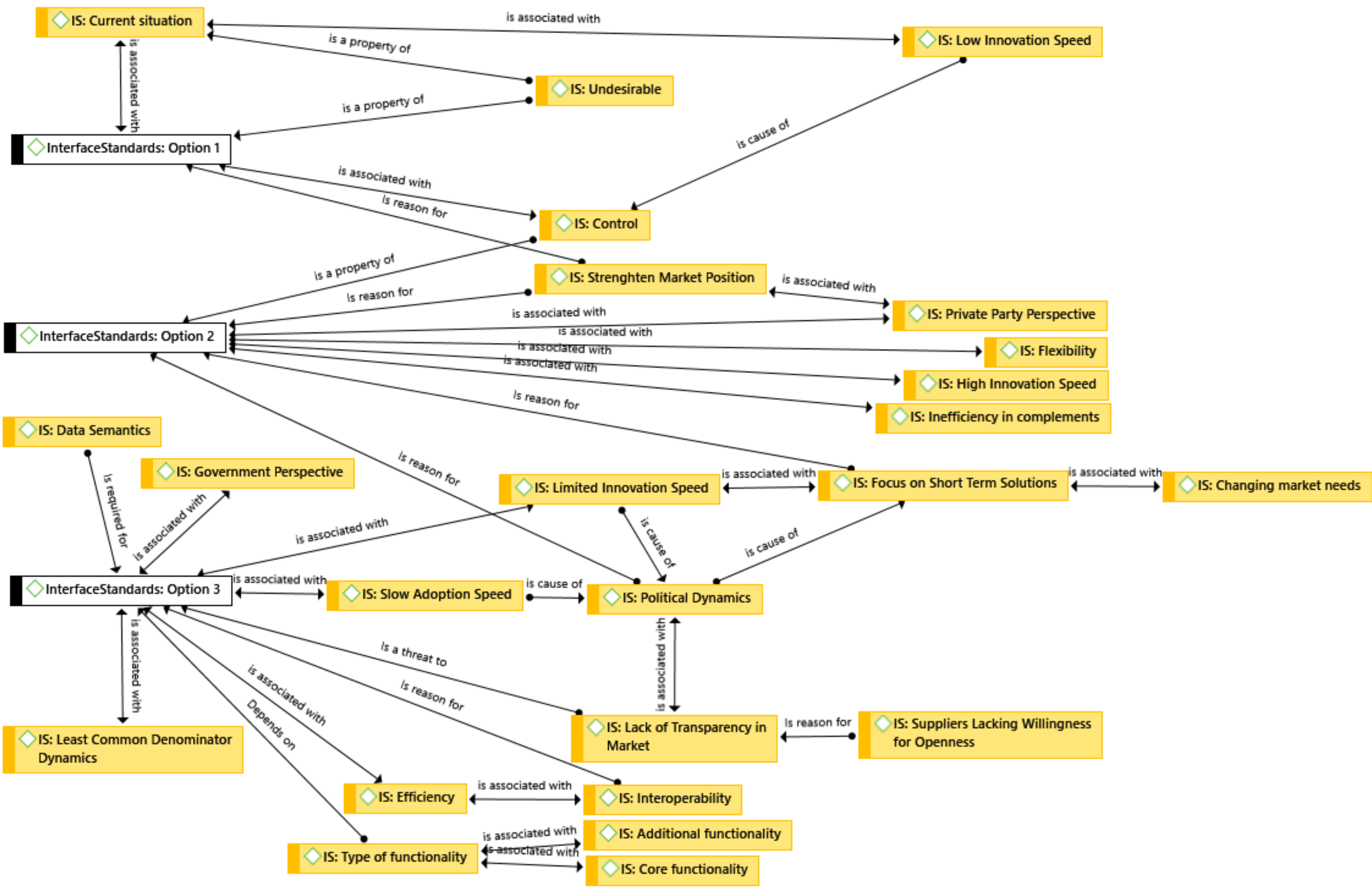


Figure 7.3: Network graph on trade-offs associated with the design options for the interface stability dimension

Trade-offs associated with interface stability option 1 - Non-stable interfaces

Little remarks were made on the design option for non-stable interfaces. They were indirectly associated with a *low innovation speed*. A reason why actors choose this strategy, is when a platform owner wants to attract complement developers only to his/her own platform - to strengthen their *market position* (TI1

Table 7.4: Results on consequences associated with interface stability

	Option 1	Option 2	Option 3
Consistent with literature	Low innovation speed {1:2} High control {2:2} Private party perspective {3:2}	Innovation {2:1} Control {3:3} Flexibility {1:1}	
Additional trade-offs	Strengthen market position {2:3}	Strengthen market position {2:3} Political dynamics {5:5} Inefficiency in complements {1:1} Private party perspective {3:2}	Limited innovation speed {3:3} Slow adoption speed {2:2} Data semantics {2:1} Type of functionality {2:1} Political dynamics {5:5} Lack of transparency in market {3:3} Government perspective {1:1} Interoperability {2:2} Least common denominator dynamics {1:1}
Not featured by respondents	Increased need for coordination		Low quality complements Fierce competition

and MI1). TI3 associated non-stable interfaces with high control over complements, but added that this is ineffective because you only have control over a limited amount of affiliated complements.

Trade-offs associated with interface stability option 2 - Stable interfaces

As visible in Figure 7.3, stable interfaces (stable only to the focal platform) relate to many codes in the network. Upsides associated with the second option are for one, that it associated with *high innovation speed* (TI2 and MI1). Secondly, it enhances *flexibility*, a platform owner can freely update interfaces and does not have to wait for industry standards to evolve (TI2). TI1 adds that a benefit of option 2 is that the platform owner has *control* over the complements in the ecosystem.

Some negative connotations to stable interfaces, are its association with *political dynamics*, because setting industry-wide interfaces takes too long to develop, most suppliers currently stick to their own interfaces (TI1). For this reason, this option is also associated with *a focus on short-term solutions* (TI1).

Similar reasons are appointed for choosing option 2 as for option 1, that is: establishing or strengthening one's market position (TI2 and MI1).

Trade-offs associated with interface stability option 3 - Industry standard interfaces

Third and finally, discussing the interface-standard dimension was a question where the respondents could fairly easy relate to. This discussion has been going on among information system vendors in the first-line care domain for some time, while only few successful developments have emerged. In short, industry-standards seem desired but they are only rarely adopted.

Another general property associated with industry-standards, is *data semantics* (MI1 and TI2). Data semantics (the same measures and syntax are used for data storage at different servers, from different suppliers) is frequently mentioned as an important step towards interoperability and efficiency of information systems in the care domain. One can imagine that it is important that medication in one server has the same meaning in another server (1 pill of medicine A is also one pill of the same medicine A in another server).

Advantages to industry-standards are *efficiency* because the different platforms can more easily communicate and integrate (TI2 and MI1); this was also associated with *interoperability* between different platforms (TI2). It was stressed by HI1 that from the viewpoint of the caregiver and the patient, one just wants a situation that is similar to all users on all platforms. This would plead for adoption of option 3.

One factor that hinders the development and adoption industry-standards is the *lack of transparency* (TI1 and MI2). Contradictory to what one might think, industry-wide standards are also associated with a *limited-innovation speed* and *low adoption speed of innovations* (MI2). These properties are explained by the sluggishness of standard development. As it takes long to develop a new standard, due to *political dynamics*, attempts to innovate cannot wait until the industry-standards are defined.

> *"The real innovation is hindered by the pace at which standards are being developed."* –TI2

> *"In my experience, there is currently a lacking willingness to open systems, that explains why no industry-standards have successfully emerged."* –MI2

Preferred design choices concerning the interface stability

While according to literature industry-standards are promising from a complement-developer point of view, this option is considered less suitable for first-line healthcare than option 2. Option 2 is associated with higher rate of innovation and is less susceptible to sluggishness due to political dynamics. Option 1 is considered even less useful than option 3 because it is not associated with a high rate of innovation.

7.3. Reflections on the concept design artefact

This section concisely reflects on the usage of the concept design artefact, that is: the design choices and the design choice chart that was used to guide the semi-structured interviews. An extensive reflection on the usage of the concept design artefact is included in appendix.

The concept artefact was considered a useful means to identify trade-offs for platform openness in the Dutch primary care domain. Firstly, the respondents expressed similar concerns on relating topics, supporting the initial observation by the researcher that the respondents had a similar understanding of the concepts introduced by the researcher. There was some difference in the level of technical knowledge (and affiliation with the material) between the different interviewees but this was not too significant to be considered a limitation to the usage of the table. A second argument why the table was considered helpful, was that the interviews resulted in extensive and rich discussions on openness in the healthcare domain, as expressed for instance by TI2 in the quote below. Thirdly, there was both overlap in the responses the interviewees expressed as well as insights that were only provided by a single respondent. The latter observation also suggests that the interviewees had the same level of abstraction in mind during the discussions.

Several suggestions to clarify the chart were made by the respondents, these are reported in Table F.1. Most notably, it was recognized that there was some discrepancy between the options 1 and 2, and the options 3 and 4 of the *core-dimension*. While options 1 and 2 concern a platform-level decision, options 3 and 4 relate to an ecosystem-decision and are involved with the question of interoperability of different platforms. This comment was acknowledged and taken into account for iterating the concept design. Based on the interviews, several modifications have been made as a first iteration to the concept artefact.

7.4. Answer to sub research question 4

The fourth sub research question was: *What trade-offs relating to openness exist in the Dutch first-line healthcare domain that inform a decision for a platform architecture?*.

From the semi-structured interviews, two types of answers to this question arose. First, several *trade-offs* were mentioned to be favourable or unfavourable for a digital platform in primary healthcare. Secondly, the interviews revealed *design tensions*, i.e. trade-offs that require striking a balance between paradoxical needs (Tiwana, 2014).

Table 7.5: Suggestions for modifying the concept design chart

Concept	Suggestion	Interview	Modified y/n
Core-dimension	There is a difference between options 1 and 2 compared to 3 and 4; options 1 and 2 describe only one platform, while 3 and 4 have more to do with interoperability between different platforms	PI1, PI2 and MI21	This distinction was acknowledged by the researcher and mentioned in subsequent interviews
Interface-openness dimension	Some of the sketched consequences have confusing consequences, e.g.: option 1 (low generativity), option 2 (high generativity), option 3 (high generativity). It would be more useful to show the degrees to which they differ (so option 2 would become 'medium generativity')	PI1	Acknowledged by the researcher and adjusted for later interviews
Interfaces in general	It was mentioned that for the primary healthcare domain, interfaces can be interpreted from a 'functionality-perspective' and from a 'data-transferring perspective'. Both perspectives are important to address. Data-transferring is an important topic in the care domain, one with which current IS-developers struggles to find agreement on a solution	MI1	No, this is included in the discussion in appendix F
Consequences in general	It was remarked that most consequences relate to economical trade-offs, while for the care domain other consequences may be important	TI2	This suggestion was acknowledged but not included, this concerns the goal of this research, identifying trade-offs important for the primary care domain

7.4.1. Trade-offs on design choices for architectural openness

The openness of a platform architecture in first-line healthcare was conceptualized as design choices relating to different degrees of platform openness on three dimensions: the platform core, the openness of the interfaces and whether the interfaces remain stable over time and complementors or whether they comply with industry-standards.

Figure 7.4 shows the design choice chart with the preferences expressed by the interview respondents highlighted in blue. In the chart, the core is divided over two dimensions instead of one. Concerning the core of the platform, the respondents mostly preferred a meta-platform to facilitate the most essential functionality. This way, redundancy in development efforts would be limited, simultaneously leading to greater interoperability and efficiency. An open source approach was suggested to the meta-platform to stimulate incentives to keep innovating the meta-platform. At the same time, respondents wanted to retain proprietary platform cores 'underneath' the meta-platform. This was said to stimulate competition and, consequently, innovation. For the interface openness dimension, there was a strong preference for selectively open interfaces. This preference can be attributed to the need for quality control. Respondents prefer openness of interfaces but at the same time state that there must be sufficient control over the complements that couple to the platform. On the final layer, the interface stability, there was a clear preference for stable interfaces. While industry-standard interfaces are theoretically thought to be useful to stimulate innovation, in practice the field-experts feared that political dynamics would hinder the establishment of industry standards, which in fact limits innovation.
Table 7.6 shows the most prominent and strongly supported trade-offs on the openness of the architecture of a platform in first-line healthcare.
Openness for the core is supported by most respondents. More specifically, field-experts prefer to have the most critical functionality to be included in a meta-platform. This is said to enhance innovation and to enhance ease of use. In addition, resource openness is suggested to provide incentives to continuously keep improving the meta-platform - in absence of competition on the level of the meta-platform.

Architecture dimensions	Design choices		
	Option 1	Option 2	Option 3
Core openness	Proprietary	Resource openness	
Core interoperability	Meta-platform	Gateways	
Interface openness	Proprietary interfaces	Selectively open	Open interfaces
Interface stability	Non-stable interfaces	Stable interfaces	Industry-standard interfaces

Figure 7.4: The design choice chart with the preferred options highlighted in blue

Some risks are associated with openness. A requirement is that there should be clear allocation accountability to the functionality in the ecosystem. In addition, a requirement for a meta-platform is that there must be means to enforce parties to comply to the standards of the meta-platform. Moreover, a meta-platform is thought to be difficult to implement.

For the interfaces, field-experts are strongly in favor of openness but to a limited extent. Openness is desired because it comes with more innovation. But openness on the interface requires cautiousness.

First of all, openness is said to be only desired for non-critical functionality. Certain functionality (e.g. the medication monitoring) are thought to be too sensitive to outsource to external developers. Furthermore, the platform owner should be able to retain control over the apps in the ecosystem to limit possible negative effects of low quality or malicious apps. Finally, two important constraints were mentioned: (1) there must be quality control to guarantee the quality of health related applications. Second (2) there must be means to ensure security of the applications and the data they manage.

On the stability of the interfaces, remarkable conclusions were drawn. Industry wide-standards were thought to come with the greatest rate of innovation but this presumption was contradicted by the interviewees. As a result of political dynamics, parties protecting their own interest and a lack of transparency, innovation is actually limited by the speed of the adoption of industry-standards. For this reason, the field-experts preferred interfaces only stable to the focal platform over industry-wide interfaces.

In summary, openness is desired for a platform architecture but only to a certain extent. Openness is beneficial because it stimulates innovation. But openness can only be good for first-line healthcare when it takes measures to ensure quality, security, ease-of-use and it is limited to non-critical functionality. In addition, due to the political character of the industry, it is not likely that a shared solution, in the form of a meta-platform or industry-wide standards will become the solution for the entire domain in The Netherlands. The implications of these findings will be discussed in chapter 9.

7.4.2. Tensions in the design trade-offs

In the trade-offs are also contradicting needs. These are worth stressing as these provide challenging questions for how platform owners should try to balance contradicting needs for finding a desired degree of platform openness in first-line healthcare. The tensions were derived from the analysis in this chapter:

Table 7.6: Most important trade-offs on the openness of the platform architecture

Design dimension	Trade-off	Explanation
Core openness	Innovation	Respondents are clearly in favor of more innovation in IS in first-line healthcare. They associate innovation with resource openness and a meta-platform. This suggest that openness of the core is valued over closed systems;
	Least common denominator dynamics	There are no mechanisms to enforce parties to comply or be discarded from the system;
	Political dynamics	A meta-platform will be difficult to implement due to the involvement of various parties protecting their own interest;
	Core functionality	The most important functionality should be arranged through a meta-platform;
	Ease-of-use	A common way of working is important to IS in first-line healthcare. A platform solution cannot come at the cost of a scattering of IS and applications;
	Accountability	With openness of the core in healthcare, there must be clear allocation of ownership and accountability of the functionality in the ecosystem;
	Difficult to implement	A meta-platform is desired but considered difficult to implement;
Interface openness	Quality control	There must me measures to ensure quality of the platform and of the complements;
	Innovation	There is a need for incentives to stimulate innovation;
	Security control	There must be means to ensure security of data in the platform and the complements in its ecosystem;
	Sensitive functionality	Field-experts are reluctant in opening parts of the IS that deal with sensitive functionality in terms of healthcare;
	Control	Platform owners should be able to keep control over the ecosystem, to shut off applications that show malicious behaviour;
	Quality of complements and platform	Experts fear that low quality or malicious apps or may harm the quality of the platform.
Interface stability	Political dynamics	Parties act in their own best interest, resulting in a focus on short term solutions and scattering of initiatives. This makes it difficult to reach agreement on an industry-wide solution;
	Lack of transparency	Parties are not transparent but remain closed to protect their market position;
	Limited innovation speed	Innovation speed is limited due to difficulty in coordination involved parties towards industry-standards.

Table 7.7: Overview of the design tensions found in chapter 7

#	Tension
Tension 1	*There should be incentives and a structure that allows innovation by different parties, while retaining sufficient control over core functionality;*
Tension 2	*There must be a structure that allows innovation, while also clearly ascribing accountability, i.e. ownership and responsibility;*
Tension 3	*There must be common ways of working (meta-platform or industry-standards), while limiting political dynamics and least common denominator dynamics;*
Tension 4	*Allowing openness for external developers to develop innovative services and products, while being able to ensure control over quality, data-management and security;*
Tension 5	*Giving outside developers access to develop complementary services, while limiting the risk of abuse and the risk of loss of quality;*
Tension 6	*Allowing openness to stimulate innovation while keeping tight control over functionality associated with high sensitivity to healthcare;*
Tension 7	*Industry-wide standards would be most efficient for innovation but they are paradoxically unsuitable for innovation due to political dynamics;*
Tension 8	*Software vendors prefer a proprietary standards over industry-standards in order to strengthen their market position, while it at the same time limits the pace of innovation;*
Tension 9	*Industry-standard interfaces are preferred, mostly for generic functionality while software suppliers prefer proprietary (stable) interfaces for competing on a platform level on other functionality;*
Tension 10	*Industry-standards are considered promising but software vendors are not keen to strive for transparency of their own interfaces.*

8
Conclusion

This thesis set out to understand how the architecture for a digital platform in Dutch first-line healthcare can be designed, in order to facilitate a desired degree of platform openness. The motivation for this thesis is that information systems in first-line healthcare in The Netherlands are currently organized inefficiently and there is little innovation in IS in this domain. More innovation and better integration of IS from different caregivers is expected to benefit first-line healthcare. This may give way for innovations that can increase the efficiency of care and it may enable greater patient participation. More efficient care is desired, since the healthcare domain is under increasing pressure due to increasing need for care while healthcare resources do not increase. The premise for this thesis, was that a digital platform-based ecosystem way of organizing IS in the Dutch first-line care domain stimulate innovation, the adopting and implementing innovations. In addition, it would enhance interconnectivity of actors in first-line healthcare. The focus of this study was on what design trade-offs affect the desired level of openness of the platform architecture.

A design study (based on the design cycle approach by Vaishnavi and Kuechler (2004)) was conducted to develop an understanding of how a platform architecture may be developed to design an open platform in the first-line care domain. Based on the design cycle, sub research questions were developed. This section deals with answering those sub research questions.

This chapter is structured as follows: first, the sections 8.1, 8.2, 8.3 and 8.4 answer the sub questions. Subsequently, section 8.5 provides an answer to the main research question of this master thesis research.

8.1. Answer to sub research question 1

The first sub question, was:

> *What does the existing landscape of information systems in the Dutch first-line healthcare look like?*

Chapter 4 dealt with answering the first sub question. For this, an exploratory study was conducted inspired by a constructivist grounded theory approach. Based on desk research and discussions with field-experts, a description was developed of how this domain is organized and what are some of the most pressing issues that hinder successful adoption of innovations in this domain. In response to the sub research question, the following conclusions can be drawn:

- The primary care domain is characterized by large heterogeneity in IS, IS suppliers, interconnections, and users. Data is scattered over IS various suppliers. There is inefficiency in the development of IS because many different software vendors develop software with similar functionality;

- There are little incentives for innovation, there is low transparency and high lock-in of users at the side of IS suppliers. Due to a lack of financial incentives, caregivers are reluctant to invest in IS. Software suppliers are not keen in providing transparency in order to secure their market position. User lock-in is achieved in two ways. First, software vendors make use of long-term contracts (examples of 7 yrs contracts). Secondly and as a result, caregivers are used to their IS, even though these might have sub optimal functionality.
- There are initiatives to open up IS in primary healthcare. The government is striving to achieve greater openness through Medmij. Nuts is also in favour of open information systems but they are still in early stages without a proof-of-concept or a clear vision of a desired technical architecture.
- Power to change the organization of information systems in primary healthcare resides mostly with the Ministry of HW&S, IS suppliers and insurance companies.
- The current landscape is characterized by tightly integrated software solutions, i.e. a low level of modularity. This leads us to concluding that it does not resemble a platform-architecture.
- There seem to be feasible opportunities for the development of a digital platform-based ecosystem in this domain.

8.2. Answer to sub research question 2

The second sub research question related to the subsequent step in the design cycle, i.e. *suggestion*. The purpose was to find theoretical concepts that can inform the design of an artefact. A literature search was conducted to identify what factors inform choices for platform openness and to understand what architectural configurations may affect the design of a digital platform in the first-line care domain. The following sub research question was formulated for this part of the research:

> *What configurations of digital platform architectures allowing varying degrees of platform openness have been reported in scientific literature?*

From the literature research it became clear there is no consensus on an unambiguous definition of platform architecture configurations. Different researchers describe different levels of abstraction when it comes to platform architectures. It is clear however, that architectures can be configured in different ways, leading to differences in short- and long-term outcomes of the platform and its ecosystem. What is more, researchers do seem to agree on the role of *modularity* in digital platform architecture.

For this thesis, the configuration of digital platform architectures has been described in terms of design configurations on three architectural *dimensions*: the *core*, the *openness of interfaces* and the *stability/standardness of interfaces*. On these dimensions, platform owners can choose different configurations, prior to the launch of the platform. A total of ten design options were identified from scientific literature, divided over the three dimensions. These design dimensions and design choices are represented and discussed in section 8.3 and Figure 8.2.

The second part of this sub research question was dedicated to understanding platform openness. Digital platform openness is a widely studied property in digital platform research. The choice for whether to open up depends on a lot of factors, some the platform owner is capable of influencing while others fall outside the reach of the platform owner. Some of the properties mostly ascribed to high levels of openness are greater attractiveness to complementors, greater generativity, gaining a market share and according network effects. On the other hand, greater openness may introduce coordination costs, loss of quality and a loss of control.

The factors influencing the level of openness were categorized on (1) motivations for choosing a proprietary platform, (2) motivations for selecting an open digital platform strategy, (3) external factors that may move a platform towards an open strategy and finally (4) negative consequences associated with openness of digital platforms. The output of the literature review was included in the concept design (developed for sub research question 3) and was used as input for the semi-structured interviews (for sub research question 4).

8.3. Answer to sub research question 3

The following sub research question guided the third part of the design study, *development*:

> *What concept design can be used to identify trade-offs for choosing openness of the platform's architecture?*

After considering two design options, the chart in figure 8.2 was developed. In addition, the design options were conceptually represented, similar to figure 8.1. The findings form the literature review on platform openness were converged with the findings on the architecture dimensions. This resulted in a combination of design options, with associated consequences relating to openness (as reported in scientific literature) for each design option. The detailed figures are reported in the corresponding chapter 6. The architecture choices for the modules were not considered for this thesis, hence their transparency in figure 8.1.

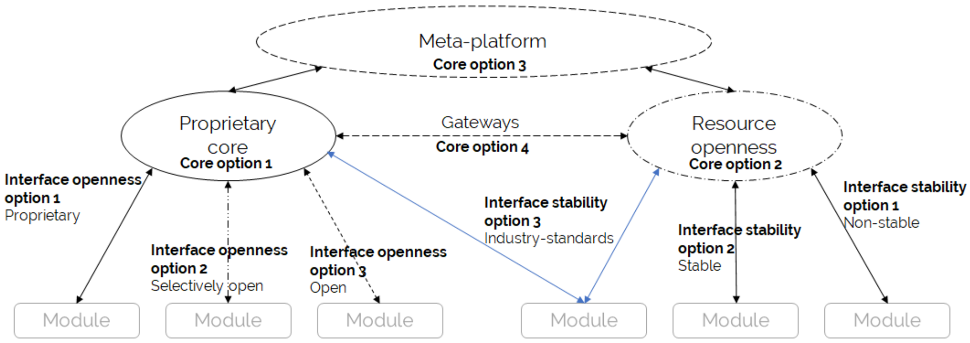


Figure 8.1: Conceptual representation of the design options from figure 8.1

For the openness of the core, two dimensions were identified, with a total of four design options. Respondents were asked to make a decision on each of the dimensions. The first dimension relates to the openness of the core. A proprietary core is a closed strategy to the core platform, only visible, accessible and adjustable by the platform owner. Resource openness is an open source strategy. The core is accessible to outside developers.

The second dimension relates to how platform cores are interoperable with different platforms. Again two options were considered. First, a meta-platform is an integration platform that can contain core functionality, which in turn can be opened to platforms on a lower level. Second, gateways are adapters that make platforms interoperable with one another.

The third dimension that was studied involved the openness of the interfaces. The first option for this dimension were proprietary interfaces. The interfaces are in this case only usable by the platform owner. Second, selectively open interfaces. Interfaces are opened up for a selected partners. Third, open interfaces are openly shared and accessible to all who want to contribute complements to the platform.

The final dimension considered the stability of the interfaces. This denotes whether the interfaces are predefined and/or account for the entire industry. Non-stable interfaces are not predefined and may be flexible to specific modules. Stable interfaces are predefined and remain stable over time. Industry-standard interfaces assumes that all platforms in industry comply to a similar standard for the definition of the interfaces. This thesis did not take a standpoint whether the standards are defined de jure or de facto.

8.4. Answer to sub research question 4

The final sub research question before answering the main research question, was:

> *What trade-offs relating to openness exist in the Dutch first-line healthcare domain that inform a decision for a platform architecture?*

To answer this question, semi-structured interviews were conducted with field-experts in the domain of IS in first-line healthcare in The Netherlands. During the interviews, the design choice chart and the corresponding design choices were discussed. The interviews were analyzed and coded, using the software of Atlas.ti, version 8. The results of the analysis, revealed trade-offs relating to openness of a platform architecture in first-line healthcare.

From the semi-structured interviews, two types of answers to this question arose. First, several *trade-offs* were mentioned to be favourable or unfavourable for a digital platform in primary healthcare. Secondly, the interviews revealed *design tensions*, i.e. trade-offs that require striking a balance between paradoxical needs (Tiwana, 2014).

8.4.1. Trade-offs on design choices for architectural openness

Table 8.1 shows the most prominent and strongly supported trade-offs on the openness of the architecture of a platform in first-line healthcare.

Openness for the core is supported by most respondents. More specifically, field-experts prefer to have the most critical functionality to be included in a meta-platform. This is said to enhance innovation and to enhance ease of use. In addition, resource openness is suggested to provide incentives to continuously keep improving the meta-platform - in absence of competition on the level of the meta-platform.

Some risks are associated with openness. A requirement is that there should be clear allocation accountability to the functionality in the ecosystem. In addition, a requirement for a meta-platform is that there must be means to enforce parties to comply to the standards of the meta-platform. Moreover, a meta-platform is thought to be difficult to implement.

For the interfaces, field-experts are strongly in favor of openness but to a limited extent. Openness is desired because it comes with more innovation. But openness on the interface requires cautiousness.

First of all, openness is said to be only desired for non-critical functionality. Certain functionality (e.g. the medication monitoring) are thought to be too sensitive to outsource to external developers. Furthermore, the platform owner should be able to retain control over the apps in the ecosystem to limit possible negative effects of low quality or malicious apps. Finally, two important constraints were mentioned: (1) there must be quality control to guarantee the quality of health related applications. Second (2) there must be means to ensure security of the applications and the data they manage.

On the stability of the interfaces, remarkable conclusions were drawn. Industry wide-standards were thought to come with the greatest rate of innovation but this presumption was contradicted by the interviewees. As a result of political dynamics, parties protecting their own interest and a lack of transparency, innovation is actually limited by the speed of the adoption of industry-standards. For this reason, the field-experts preferred interfaces only stable to the focal platform over industry-wide interfaces.

In summary, openness is desired for a platform architecture but only to a certain extent. Openness is beneficial because it stimulates innovation. But openness can only be good for first-line healthcare when it takes measures to ensure quality, security, ease-of-use and it is limited to non-critical functionality. In addition, due to the political character of the industry, it is not likely that a shared solution, in the form of a meta-platform or industry-wide standards will become the solution for the entire domain in The Netherlands. The implications of these findings will be discussed in chapter 9.

Design dimension	Trade-off	Explanation
Core openness	Innovation	Respondents are clearly in favor of more innovation in IS in first-line healthcare. They associate innovation with resource openness and a meta-platform. This suggest that openness of the core is valued over closed systems;
	Least common denominator dynamics	There are no mechanisms to enforce parties to comply or be discarded from the system;
	Political dynamics	A meta-platform will be difficult to implement due to the involvement of various parties protecting their own interest;
	Core functionality	The most important functionality should be arranged through a meta-platform;
	Ease-of-use	A common way of working is important to IS in first-line healthcare. A platform solution cannot come at the cost of a scattering of IS and applications;
	Accountability	With openness of the core in healthcare, there must be clear allocation of ownership and accountability of the functionality in the ecosystem;
	Difficult to implement	A meta-platform is desired but considered difficult to implement;
Interface openness	Quality control	There must me measures to ensure quality of the platform and of the complements;
	Innovation	There is a need for incentives to stimulate innovation;
	Security control	There must be means to ensure security of data in the platform and the complements in its ecosystem;
	Sensitive functionality	Field-experts are reluctant in opening parts of the IS that deal with sensitive functionality in terms of healthcare;
	Control	Platform owners should be able to keep control over the ecosystem, to shut off applications that show malicious behaviour;
	Quality of complements and platform	Experts fear that low quality or malicious apps or may harm the quality of the platform.
Interface stability	Political dynamics	Parties act in their own best interest, resulting in a focus on short term solutions and scattering of initiatives. This makes it difficult to reach agreement on an industry-wide solution;
	Lack of transparency	Parties are not transparent but remain closed to protect their market position;
	Limited innovation speed	Innovation speed is limited due to difficulty in coordination involved parties towards industry-standards.

Table 8.1: Most important trade-offs on the openness of the platform architecture

8.4.2. Tensions in the design trade-offs

In the trade-offs are also contradicting needs. These are worth stressing as these in particular provide challenging questions for how platform owners should try to balance contradicting needs for finding a desired degree of platform openness in first-line healthcare. The tensions were derived from the analysis in this chapter:

#	Tension
Tension 1	*There should be incentives and a structure that allows innovation by different parties, while retaining sufficient control over core functionality;*
Tension 2	*There must be a structure that allows innovation, while also clearly ascribing accountability, i.e. ownership and responsibility;*
Tension 3	*There must be common ways of working (meta-platform or industry-standards), while limiting political dynamics and least common denominator dynamics;*
Tension 4	*Allowing openness for external developers to develop innovative services and products, while being able to ensure control over quality, data-management and security;*
Tension 5	*Giving outside developers access to develop complementary services, while limiting the risk of abuse and the risk of loss of quality;*
Tension 6	*Allowing openness to stimulate innovation while keeping tight control over functionality associated with high sensitivity to healthcare;*
Tension 7	*Industry-wide standards would be most efficient for innovation but they are paradoxically unsuitable for innovation due to political dynamics;*
Tension 8	*Software vendors prefer a proprietary standards over industry-standards in order to strengthen their market position, while it at the same time limits the pace of innovation;*
Tension 9	*Industry-standard interfaces are preferred, mostly for generic functionality while software suppliers prefer proprietary (stable) interfaces for competing on a platform level on other functionality;*
Tension 10	*Industry-standards are considered promising but software vendors are not keen to strive for transparency of their own interfaces.*

Table 8.2: Overview of the design tensions found in chapter 7

8.5. Answer to main research question

The main question this thesis set out to answer, was:

> *How can digital platform architectures be configured to facilitate openness of a digital platform in the first-line healthcare domain in The Netherlands?*

Based on the interviews, a preferred design for the architecture was appointed, based on trade-offs relating to platform openness. The preferred design options are highlighted in blue in figure 8.2. Concerning the core of the platform, the respondents predominantly preferred a meta-platform to facilitate the most essential functionality (e.g. authentication, patient treatment logging). This way, redundancy in development efforts can be limited while simultaneously enhancing interoperability and efficiency. An open source approach was suggested to the meta-platform to stimulate incentives to keep innovating the meta-platform. At the same time, respondents wanted to retain proprietary platform cores 'underneath' the meta-platform. This was said to stimulate competition and, consequently, innovation. For the interface openness dimension, there was a strong preference for selectively open interfaces. This preference is attributed to the need for control on the quality of complements. Respondents prefer openness of interfaces but at the same time state that there must be sufficient control over the complements that couple to the platform. On the final layer, the interface stability, there is a preference for stable interfaces. While industry-standard interfaces were thought to be useful to stimulate innovation, in practice the field-experts feared that political dynamics would hinder the establishment of industry standards, consequently limiting innovation.

Architecture dimensions	Design choices		
	Option 1	Option 2	Option 3
Core openness	Proprietary	Resource openness	
Core interoperability	Meta-platform	Gateways	
Interface openness	Proprietary interfaces	Selectively open	Open interfaces
Interface stability	Non-stable interfaces	Stable interfaces	Industry-standard interfaces

Figure 8.2: The design choice chart with the preferred options highlighted in blue

9

Reflection & Recommendations

This final chapter reflects on the research process and outcomes. The goal of reflecting on this research is to identify contributions made to the knowledge-base and to practice, to clarify limitations that may have been relevant to this thesis and to establish directions for future research.

This chapter has been ordered on four topics. First, section 9.1 reflects on the usage of design science research for this thesis and what lessons can be derived from this application. Secondly, section 9.2 explains what limitations must be kept in mind concerning this study. Third, section 9.3 discusses what noteworthy contributions were derived from this study. Finally, this chapter and report are concluded in section 9.4 by examining recommendations for practice and for future research.

9.1. Reflection on the usage of a design science approach

A design science approach was used to guide this research in answering the focal research question. DSR involves the usage of theories in the development of novel artefacts. Reflecting on this study thus involves a reflection on the insights this thesis research yields for the knowledge-base, as well as to assess how it performs to solve real-world problems (Hevner and Chatterjee, 2010). In line with Walls et al. (1992), this reflection of the design study touches upon the process of the design and the artefact that resulted from it.

9.1.1. Reflections on the design approach

Design science is an approach that is concerned with the design and development of an artefact (Hevner et al., 2004), based on a thorough understanding of the problem and by making use of existing theories that inform the design. The focus of this study was not primarily to design and develop an artefact. Rather, this thesis used the design of an artefact to identify design trade-offs in digital platform design.

Although the DSR approach was successful for identifying the intended trade-offs, its application is not undisputed. Firstly, DSR typically has the design of an artefact as the main purpose, while for this thesis this was not the case. The ultimate purpose is the socio-technical design of a digital platform in first-line healthcare but this was not feasible within the constraints of this thesis. Secondly, iteration is an important property of design science, and also the cycle by Vaishnavi and Kuechler (2004), but iteration was only limited possible within the time constraints of this study. Only one iteration was made on the design choice table. In hindsight, an exploratory study on trade-offs relating to openness of IS in first-line healthcare might have been suitable. This would also require an exploration of literature on digital platform architectures and semi-structured interviews to identify trade-offs specific to Dutch first-line healthcare.

On the other hand, the Design Cycle by Vaishnavi and Kuechler (2004) was still useful for the intended outcome of this study. First, it provided a structured approach to get a grip on a complex design challenge. The Dutch first-line healthcare domain and its information proved to be a complicated system for an outsider to understand. The design cycle combines developing awareness of the problem situation with an objective perspective from previous theories. This combination was most useful for the context of this thesis. Secondly, DSR was useful because it formed a bridge between scientific research and industry. Using insights from scientific research sheds an objective and new light on the challenges that the industry deals with. This benefit was acknowledged by interviewees, who found that this approach was a good and objective starting point for a discussion on the organization of IS in first-line healthcare.

9.1.2. Reflections on the design outcomes

This section reflects on two outcomes, i.e. the design choice chart and the trade-offs that emerged for digital platform design in first-line care.

The design choice chart

- **Strengths** The design chart was useful for identifying trade-offs on design options for the openness of the platform architecture. The chart was usable by respondents with in-depth knowledge on IS, platforms and architectures and by respondents with less affinity with these concepts.
- **Weaknesses** On the downside, the design choice chart is a simplistic abstraction of the design choices. The table does not pretend to be exhaustive in showing all possible design options for the architecture. Furthermore, although the table discusses platform architecture, the *interface openness* was associated with platform governance. The choice between the options 2 and 3 was said to be dependent on the way control was organized.
- **Feasibility** The design choice chart gave way to engaging conversations on the architecture of information systems in first-line healthcare. It was sufficiently clear and concise for respondents to express their desires, concerns and trade-offs in terms of design choices.
- **Untested assumptions** The table took the perspective that multiple platforms can exist in parallel and that these platforms were organized independent from each other by single platform owners. It does not account for platforms to be owned and controlled by multiple parties.

In summary, the artefact was useful for its purpose of identifying trade-offs. However, since the design options on the architecture were not exhaustive, more research on possible architectures is recommended.

The trade-offs for platform openness in first-line healthcare in The Netherlands

The results from this thesis research raise implications to the organization of IS in first-line healthcare:

- **On the existing situation of IS in first-line healthcare** - The current organization of IS in first-line care in The Netherlands is cumbersome. There is considerable redundancy in development efforts of IS suppliers, and there are low incentives to innovate in IS. Attempts to innovate often fail due to political dynamics of IS suppliers securing their market position.

  An analysis of the stakeholders in the domain of IS in first-line healthcare shows that changes in the organization of IS can most likely be achieved by (1) IS vendors, (2) the ministry of Health, Welfare & Sports, (3) insurance companies, or (4) the interest group for insurance companies. These stakeholders were said to have the highest power over the organization of IS in this domain.
- **Why openness would be desirable** - Whether openness of IS is desirable, depends on the perspective of the platform owner. Different perspectives are associated with different choices.

  Openness is associated with greater interoperability between IS, high ease-of-use to end-users and complement developers and greater opportunities for innovation as opposed to proprietary IS. Considering the purpose of increasing efficiency of healthcare support, openness would thus be beneficial. The relationship between openness and innovation has been studied extensively (for instance

(Boudreau, 2010)). Interestingly, openness is associated with higher ease-of-use. This was argued because openness would more likely result in a shared approach by different platform providers, as opposed to the current closed IS supplied by different IS suppliers. Whether this argument is in fact true, cannot be concluded on the basis of this study. This finding is consistent with (Fürstenau et al., 2018) who report that a digital platform enhances interoperability of different ISs. Ease-of-use is important to first-line healthcare as the usage of IS must support caregivers and patients in their treatments, a complex IS infrastructure is thus undesirable.

The conclusion that integration and interoperability is a challenging issue in the design of a digital platform in healthcare is consistent with research conducted by Fürstenau et al. (2018). They discuss issues that a platform ecosystem in healthcare needs to address, based on a case in the U.S.. They find a tension between a need for interoperability and integration of services versus a focus on innovation.

Opponents of openness will argue that openness will lead to lesser opportunities for securing a market share of end-users. IS suppliers that already have a large market share are thus expected to be more reluctant to opening up their IS than parties that have a lower market share of users.

- **Limitations to openness in first-line healthcare** - Some threats to platform openness have been mentioned. First, openness cannot come at the cost of quality of IS services. Second, data-management and security of data must be guaranteed. Third, in an open ecosystem there must be clear allocation of accountability, in case of failure of components in the ecosystem.

  Another downside to openness is the lack of control. IS suppliers state that they want control over complements. In case a complement fails or shows malicious behaviour, the IS suppliers stated that they need to be able to control complements in their ecosystem. In another study on platforms in healthcare, Fürstenau et al. (2018) find that *governance* of the platform and its ecosystem requires control both by the caregivers and the technology suppliers. They suggest that the care providers are leading in organizing governance, and that technology suppliers can join the consortium (that organizes governance) as partners.

  Another way to organize control over complements comes from governance mechanisms and boundary resources. Both topics have not been addressed by this thesis. For instance, Karhu et al. (2018) mention a set of boundary resources that can be deployed to govern the behaviour of complementors. Eaton (2016) also discuss how platform owners can manage the behavior of complementors on a platform. They add that platform owners should be cautious in how they govern complements, for complementors may try to bypass governance mechanisms if they do not feel the governance structure is reasonable.

  Mukhopadhyay et al. (2016) suggest that control mechanisms can be used to mitigate threats of loss of control. Directions for the design of control mechanisms could be to design mechanisms for input control, output control or behavioural control of complementors on the platform.

- **On opening up the IS** - It was concluded in subsection 4.4.5 that currently IS in first-line healthcare are mostly siloed and vertically integrated. This corresponds with research of Bygstad and Hanseth (2018); Bygstad et al. (2015) who study opening up digital platforms in the context of healthcare. Their 2018 study suggests that opening up IS can be done by establishing boundary resources. How to design boundary resources is suggested as a useful step in developing an open digital platform.

9.1.3. Reflection on the usage of theories

Scientific theories form an important part of design science, they inform the design space. Several comments can be placed on the usage of theories. First, there is no unambiguous way to relate and combine findings from different studies on digital platforms. This is due to differences in the scope, level of abstraction, and application domain that the researchers focus on. This observation is in line with De Reuver et al. (2018b). For this reason, they suggest researchers to provide clarity on their use of definitions and the scope of their research.

In the literature review in chapter 5, this conceptual ambiguity was challenging for conceptualizinging platform openness and how to define architecture configurations. This master thesis study has attempted to take an objective approach to including findings from previous studies, by refraining from attributing quality interpretations (advantages or disadvantages) to consequences on choices for the architectures.

Another observation was that scientific literature on the consequences of platform openness mostly revealed economic effects of openness. This observation was also done by some of the interviewees (TI2, TI3). It was interesting to find out that different trade-offs were considered important for first-line healthcare, with a focus on control of quality and security, ascribing responsibility and to limit negative effects of strategic behaviour and complexity in decision making.

9.2. Limitations to this research

There are also limitations recognized to this research. One limitation is that this thesis takes an installed-base ignorant approach to designing a platform-based ecosystem in Dutch first-line healthcare. Additional research is needed to find out *how* to transform the current organization of information systems towards a platform way of organizing information systems in the domain. Secondly, this thesis describes a high level of abstraction, while it does not take into account implementation of a digital platform with respect to the information infrastructure. It was mentioned repeatedly that there is significant technical debt in the domain under study, some caregivers still store data on-premise on servers running outdated operating systems that are susceptible to data breaches (e.g. Windows 7). It would be interesting to bridge the gap between the findings form this study and practical implementation.

A second limitation is that perhaps not all relevant viewpoints were identified concerning trade-offs of openness on platform architectures. Illustrative to this limitation is that respondents foremost discussed their opinion on what was 'in the best interest of healthcare'. While this perspective is laudable, it is plausibly incomplete because it does not reflect strategic behaviour of parties searching for economic gains. Given that the domain under study currently faces a lack of transparency and willingness to cooperate, it is likely that also actors exist that have a more proprietary perspective than the interviewees of this study. Moreover, although a broad variety of respondents was selected, not all respondent-groups were represented equally.

A third limitation concerns the analysis of the semi-structured interviews. It is good practice in coding and analysis of semi-structured interviews for multiple researchers to discuss on the coding process or to code the interview transcripts independently and combine the findings afterwards. This is believed to contribute to the objectiveness of the analysis and not to miss out on relevant information (e.g. (Hevner and Malgonde, 2019; Järvi et al., 2018)). For this research, the analysis was only conducted by one researcher.

Fourth, there is a challenge in distinguishing a digital platform perspective on standards for interfaces and the standards for information exchange that currently exist in the first-line care domain. The definition and adherence to standards for information exchange and for data semantics form a daily challenge in first-line healthcare. These however should not be confused with standards for interfaces to couple modules to platforms in digital platform-based ecosystems. It would be interesting and useful to combine the perspectives on standards for information transactions and the functional coupling of information systems.

9.3. Contributions of this research

This thesis has implications both to research (subsection 9.3.1) and to practice (subsection 9.3.2).

9.3.1. Contributions to the scientific knowledge base

This section reports reflection on the knowledge contributions and the position of the research in DSR.

Reflection on the intended contributions

Chapter 1 proposed three interesting contributions to the scientific knowledge base that this thesis could make. Below, these are discussed:

- **Ex-ante design of digital platforms -** By studying how a platform can be designed ex-ante, this study responds to calls from De Reuver et al. (2018b) and Schreieck et al. (2016). This is done by clarifying what design choices platform owners face prior to the establishment of a platform. By revealing design choices on the architecture, experts were able to express trade-offs on how they would think a digital platform may benefit IS in the application domain.

  In addition, it was found that there is conceptual ambiguity for how researchers study configurations for platform architectures. For instance, (Blaschke et al., 2019) also discusses configurations for digital platform architectures but chooses a selection of architectural dimensions different to this research. A product of this thesis is a concise overview of design options for the architecture of a platform. While this thesis does not solve the aforementioned conceptual ambiguity, it proves to be suitable for identifying design tensions within the context of healthcare. This table may be tested more frequently, expanding also to other application domains to find out whether new choices and dimensions may be added or adjusted to the table.

- **Digital platform design in the healthcare domain -** By revealing trade-offs in the design of a digital platform in healthcare, this thesis extends on the works of Fürstenau et al. (2018) and Grisot et al. (2018). Both studies are concerned with how digital platforms should be designed, with an interest in application to healthcare.

  Fürstenau et al. (2018) was interested in what design trade-offs platform owners experience for the design of a digital platform in healthcare. They ask to extend studies on platform design in healthcare for different countries.

  The study reveals tensions between a desire for openness and cautiousness towards maintaining control, accountability and also with respect to stakeholder dynamics (least common denominator dynamics and political dynamics) in the design of a digital platform.

- **Digital platform architectures and openness -** Third, this thesis extends scientific work on the relationship between platform architecture and platform openness. Both Blaschke et al. (2019) and Kazan et al. (2018) requested future researchers to expand understanding on the relationship between configuring a platform architecture and meeting strategic goals.

  This thesis has extended the works of Blaschke et al. (2019) and Kazan et al. (2018) by showing how potential platform owners can clarify design trade-offs by considering different design choices for a platform architecture. Whereas Kazan et al. (2018) reasons on the strategic goals in relation to the platform architecture in hindsight, this thesis takes an ex-ante approach. Moreover, the usage of design dimensions was inspired by the design taxonomies from Blaschke et al. (2019). While both (Blaschke et al., 2019) and Kazan et al. (2018) use design configurations for the platform architecture to classify platforms in hindsight, this thesis extends the application of design choices for dimensions of the architecture by using these design choices prior to the development of a digital platform. Inspired by these classifications, this thesis showed that it is possible to use such design choices to reveal tensions relating to strategic goals of platform owners.

Positioning the contribution in design science research

In terms of the work of Gregor and Hevner (2013), this thesis can arguably be classified as *exaptation*. Gregor and Hevner (2013) describe how contributions of DSR can be positioned. They propose a classification in quadrants, based on the *maturity of the solution* and the *maturity of the application domain*.

Exaptation is about applying a known solution to a new problem (Gregor and Hevner, 2013). Digital platforms have been the topic of a vast amount of scientific research. To the researchers understanding, there has been little research on applying a digital platform paradigm to the Dutch first-line healthcare domain. This domain is specific in terms of involved actors and systems. It is therefor unlikely that the findings in this thesis can easily be extrapolated to other countries or application domains.

9.3.2. Contributions to practice

Based on the results from this thesis, it is concluded that openness of digital platforms to outside developers is beneficial to stimulate innovation. Openness of a platform in first-line healthcare should not be unconstrained. Among IS suppliers there is a preference for stable interfaces that are selectively opened to external developers. By complying to industry-standards, it is expected that the rate of innovation will be slowed down as opposed to when a platform owner maintains its own stable interfaces. In addition, platform owners must first determine how they will organize control over the ecosystem, before engaging in an open platform-based ecosystem. Control measures should take into account data-management control, quality control and security control.

Openness is in particular considered useful for parties that do not possess the largest installed user base. In contrast, field-experts believe that IS suppliers that currently have a large market share of users, benefit from the low rate of innovation. They have higher chances of appropriability and locking in users when their systems remain closed.

Another contribution is that a meta-platform is expected to be desirable for the most critical and core functionality of digital platforms in IS (e.g. authentication, medication control). A meta-platform will enhance interoperability and innovation. A threat to this option is that it is difficult to achieve due to political dynamics and least common denominator dynamics. Authorities that are likely to benefit from a meta-platform, e.g. the ministry of H,W&S will need to implement measures so that the meta-platform will not be hindered by political dynamics of involved IS suppliers.

9.4. Recommendations

Recommendations are discussed on their relevance to science and to practice.

9.4.1. Recommendations to scientific research agenda

The following recommendations to future research have emerged throughout this study:

- Based on this thesis, the first recommendation to future researchers is what mechanisms can be designed to maintain control over the quality and security of open platforms in healthcare. Concerns on the control of quality, security and accountability were the most mentioned risks to opening IS in Dutch first-line healthcare. This call to understand how governance can be designed to deal with governing the quality and variance of complements has also been suggested by (Cennamo et al., 2018).

  Relating, there is a strong call from researchers to understand how boundary resources can be designed to meet strategic goals (Eaton, 2016; Schreieck et al., 2016). Understanding how boundary resources may be designed to deal with the trade-offs from this thesis research, will bring us closer to the development of a digital platform in Dutch first-line healthcare.

- In a later stage, when open digital platforms clearly exist in this domain, it will be interesting to study whether the suggested effects of platform openness prove to be true. For instance, has openness in fact led to more innovation? Or, has openness led to a loss of control and quality of software supporting first-line healthcare? This suggestion for future research resembles a call from (Fürstenau et al., 2018) to gain understanding of the effect of a digital platform to a country's healthcare system.

- This study involved a exploration of challenges in first-line healthcare in The Netherlands and how a platform can facilitate a better way of organizing IS. This study on what tensions exist relating to the openness of platforms can be extended to other countries. Another direction for further research is to do a case comparison on the different levels of openness in healthcare IS in different countries to see what trade-offs have emerged and how control mechanisms have been designed.

9.4.2. Recommendations to practice

The recommendations are discussed for different interest groups:

- **To IS suppliers** - On a general note, the research results suggest that IS suppliers are wise to open up their IS to third party developers to stimulate innovation. Some remarks should be made:

  Investigate opportunities for development of boundary resources. Boundary resources are both suggested to deal with the risk of reduced control (Karhu et al., 2018) and with the process of opening up tightly integrated IS towards a digital platform organization of IS (Bygstad and Hanseth, 2018);

  Investigate control mechanisms that can be deployed to manage the relationship with complementors in the ecosystem. Too tight control may harm the attitude of complementors towards contributing to the platform. Too little control on the other hand may result in low quality complements, harming the overall platform (Wareham et al., 2014);

  Investigate launch strategies. Launch strategies are important in the early stages of a platform (De Reuver et al., 2018a). One must decide for instance how to subsidize or attract a group of users to overcome the chicken-and-egg problem to attract users and create network effects (Tiwana, 2014) and to attain an attain a market potential (Ondrus et al., 2015);

  Do not wait on the establishment of a meta-platform or industry-standards for interfaces. Both are expected to hinder innovation because their development is slow due to political dynamics and least-common-denominator dynamics.

- **To policy makers** - openness of IS is considered beneficial as it is expected to result in more innovation, competition and integration of IS in first-line healthcare:

  Study opportunities for developing a meta-platform. A meta-platform is expected to lead to more innovation and higher efficiency in development due to limiting redundancy in IS development. Furthermore, a meta-platform is expected to lead to greater interoperability, transparency and ease-of-use. The meta-platform should only comprise the most essential core-functionality, this will leave room for competition and innovation in less critical functionality of the ecosystem. Another recommendation is to study what functionality should be included in the core of the platform. This trade-off is relevant to platform owners prior to platform launch (De Reuver and Keijzer-Broers, 2016; Tiwana, 2014), it was also frequently mentioned by interviewees that a meta-platform would only be beneficial if it would contain limited, but critical, functionality.

  Invest in development of industry-standards for interfaces. Industry-standards are expected to be beneficial to third-party developers. Consequently, this is thought to stimulate innovation and competition among complementors, resulting in more efficient IS services in first-line healthcare;

  Investigate the opportunity for resource openness for the core platform. Resource openness is associated with community feedback and a higher quality of the core as opposed when there is only one platform provider. On the other hand, for this option control measures must be implemented to reduce the risk of forking, instability of the core and loss of control over quality or security of the platform;

  Investigate means to enforce compliance to either industry-standards or a meta-platform. Currently, IS suppliers perceive little pressure to comply to standards, resulting in high heterogeneity in terms of systems and interconnections. This limits openness and innovation.

List of Figures

List of Tables

List of Abbreviations

AIS	Apothekers informatiesysteem. English: Pharmacy practitioners' information system
DSR	Design Science Research
HIS	Huisarts informatiesysteem. English: General practitioners' information system
IS	Information system
GP	General practitioner
GT	Grounded theory
XIS	Collective noun for all first-line information systems supporting caregivers

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Scientific article

The article is included on the next page

A digital platform for Dutch first-line healthcare

A study on design trade-offs and openness of the platform architecture

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Abstract

Situation: Information systems (IS) in Dutch first-line healthcare are organized complex and inefficiently. This limits innovation and interoperability of IS in this domain. Innovation is considered useful to make first-line healthcare more efficient. Digital platform literature shows a how a digital platform provides a more flexible approach to IS and greater rate of innovation.
Complication: There is little ex-ante design knowledge on how to develop a digital platform. Also, transforming IS in healthcare is complex and often fails. Moreover, openness of a platform can enhance innovation but also introduces risks such as loss of control.
Question: This research focused on examining what architectural configurations can facilitate a desired level of platform openness for the Dutch primary healthcare domain.
Action: A design science research approach was used to answer this question. Design choices for architectural openness were distilled from literature. A concept artefact on design choices was developed and evaluated with domain experts.
Results: The study shows that openness is desired from the perspective of IS suppliers but that openness can never come at the cost of loss of quality or security. Respondents are reluctant to open up critical functionality embedded in the platform.
Next Steps: Future researchers are suggested to study the design of boundary resources to manage control over complements and the relationship with complementors.

Key words: Digital platform, Platform architecture, Design trade-offs, First-line healthcare, Design science research

1. Introduction

Information systems (IS) play an important role in Dutch first-line healthcare but the current way they are organized is inefficient. There is a high variety of system suppliers and interconnections. This complexity is inefficient as it leads to redundant development work being done and it hinders interoperability between information systems from different suppliers. As a result, there is little innovation in information technology supporting caregivers and patients in first-line healthcare. Innovation in information systems in healthcare is desirable as it can lead to higher patient participation, preventive care and integration of caregivers around a patient – making first-line healthcare more efficient.

This complexity and low rate of innovation in IS is problematic, even more so given the trend of increasing pressure on healthcare. This increase is results from an aging population (CBS Statline, 2019a), escalating costs (CBS Statline, 2019b; CBS.nl, 2018), a declining workforce (CBS, 2019) and a switching burden of disease from short-term illnesses to long-term chronic conditions (McKinsey & Company, 2019; European Commission, 2019). On top of that, technological advancements (such as IoT, big data, blockchain technology and machine learning) offer opportunities to improve healthcare but are not easily incorporated in the current ISs (Idenburg and Dekkers, 2018; The Economist, 2019a). Well-organized information systems, that allow information-exchange across practitioners in first-line care and that stimulate and allow adoption of innovations, may contribute to relieving the pressure on first-line healthcare. Digital platforms show opportunities for more efficient organisation of IS and innovations in first-line healthcare.

Digital platforms are increasingly adopted as a way of orchestrating resources and innovation from different contributors (Parker et al., 2016) and may also be useful for Dutch first-line healthcare. While this trend to digital platforms started in technology-driven industries such as operating systems and search engines (Parker and Van Alstyne, 2018), digital platforms are now impacting and transforming all kinds of industries, from a.o. banking (Deloitte), to education, government services and energy (Mukhopadhyay et al., 2019; Mukhopadhyay and Bouwman, 2019; Tiwana, 2014). Recently, researchers have also begun to address application of digital platforms to the healthcare-industry (e.g. (Fürstenau et al., 2018; Lessard and de Reuver, 2019; Bygstad et al., 2015)). Digital platforms are a way of organizing independent actors and innovations around a stable core system (Cennamo and Santaló, 2019). The platform is the stable object, on which other parties can develop and offer complementary services and products (Baldwin et al., 2009). Digitality denotes that the platform itself is an extensible codebase (Tiwana et al., 2010) that is editable and reprogrammable (Kallinikos et al., 2013). An important principle of platforms is their modularity, i.e. new functionality can be (de-)coupled from the core platform easily (Tiwana, 2014), thereby extending the functionality of the platform (Brunswicker and Schecter, 2019). Such a platform logic is in contrast with tightly integrated systems, in which functionality cannot be easily modified separately from the IS.

Actors wishing to design a digital platforms have to make *design choices*. These choices often require balancing paradoxical needs (Tiwana, 2014; Eaton et al., 2015). Design choices made in the beginning stage of a digital platform may be difficult to adjust later, thus determining to a large extent the platform's short- and long-term development (Blaschke et al., 2019; Saadatmand et al., 2019). Previous research on digital platforms has revealed little knowledge outputs that inform how an actor may design its digital platform ex-ante platform launch (De Reuver and Keijzer-Broers, 2016). Moreover, effective design of a digital platform depends on the platform's strategy in relation to its context (Grisot et al., 2018). While some scholars have recently begun to study digital platforms for healthcare (e.g. (Fürstenau et al., 2018)), these do not show design knowledge on how a digital platform can be designed for first-line healthcare in The Netherlands. This is a challenge, given previous studies have shown that designing and transforming information system infrastructures in healthcare is complex and often fails (Aanestad et al., 2017). In addition, research on platform openness indicates cautiousness is required with respect to openness: while openness is associated with higher innovation (Boudreau, 2010), it also comes with risks (Karhu et al., 2018).

The goal of this study is to develop an understanding of the design trade-offs platform owners express for deciding on the openness of the platform architecture.

The following research question was defined: *What design trade-offs exist that inform the design of an open digital platform architecture in first-line healthcare in The Netherlands?*

In order to answer this research, a design science research approach was used, based on the design cycle of Vaishnavi and Kuechler (2004). Design science is concerned with identifying what and how the knowledge base and methodologies contribute to the design of an artefact, distinguishing it from routine design (Hevner et al., 2004). First, scientific literature was consulted to study how openness for digital platform architectures can be defined. Based on these findings, a concept artefact was designed. This artefact was validated through semi-structured interviews with field-experts. The semi-structured interviews both revealed how the concept design can be adjusted and it clarifies trade-offs that relate to the question of platform openness for Dutch primary healthcare.

This study contributes to design knowledge on digital platforms by revealing trade-offs that are relevant when for first-line healthcare.

This article is structured as follows: First, section 2 discusses how the scope was determined to focus on the role of platform architecture in openness of a digital platform in primary healthcare. This stage results in converging findings from literature on architecture configurations and factors influencing platform openness. Secondly, section 3 describes how a design artefact was developed and how it was tested with semi-structured interviews to derive lessons on how to improve the concept design and to examine what trade-offs inform the design of a digital platform in primary healthcare. Section 4 presents the limitations, contributions and recommendations to practice and the research agenda. The article is concluded in section 5 by answering the research question.

2. Theoretical Framework

This chapter describes how important concepts for this study are defined.

2.1 On platform openness

Openness is an interesting property to study because it closely relates to the ultimate goal of introducing more innovation (Eisenmann et al., 2009; Mukhopadhyay et al., 2019; O'Reilly, 2011), reducing R&D costs (Eisenmann et al., 2009) and increasing flexibility of the information systems supporting the primary care domain (De Reuver et al., 2011). The decision of opening a platform versus a proprietary strategy is thus important for firms that develop and maintain digital platforms (Gawer and Cusumano, 2002; West, 2003).

2.2 On platform architectures

Researchers agree that the architecture of a platform-based ecosystem is based on the principle of modularity. Modularity means that modules can be (un-)coupled to the core platform, while interdependence between the modules and the platform is intentionally reduced (Tiwana, 2014). The architecture thus constitutes of : a *core*, *interfaces* and *modules* (as also visually represented in Figure 1). The platform owner can control the architecture of the core and the interfaces. How the modules are configured, is the determined by the complementors. Because the configuration of the modules cannot be influenced by the platform owner, this factor is not considered for this study. Consequently, only different configurations for the core and the interfaces are considered. These two components are thus considered as the dimensions that can be configured. For each of these components, literature shows different modes for how to organize them.

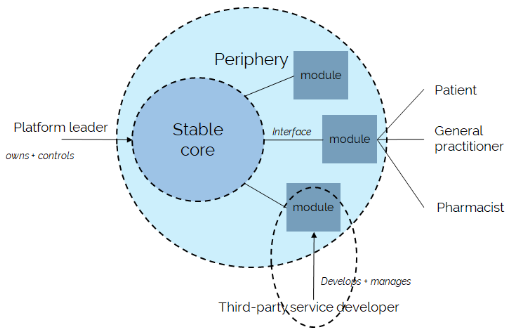

Figure 1: Simplified perception of the platform architecture

2.2.1 Configurations for the core-dimension

Four design options were distilled from scientific literature relating to the core-dimension of a platform architecture.

Core - Option 1: Proprietary This strategy is to have a closed platform core, i.e. only the sole platform owner has the right to see, access and change the platform's core.

Organizations that are successful at maintaining a proprietary platform strategy, are said to have the benefit that they can appropriate all financial returns (West, 2003). What is more, they have the advantage that the platform is difficult to imitate, allowing them to set high entry barriers (West, 2003). As indicated by Eisenmann et al. (2009) proprietary platforms can exert better performance because of their tight integration, this especially holds true in emerging markets or markets in transition.

Disadvantages of a proprietary strategy is that the market is less viable of innovation. They are less attractive for complement developers (Eisenmann et al., 2009) because they do not integrate well with other platforms. This strategy often only holds possible for one- or two market-leaders. resulting in fierce competition and possibly winner-takes-all dynamics.

Core - Option 2: Resource openness Resource openness entails making the platforms' core accessible to all external developers (Boudreau, 2010; Karhu et al., 2018). This option is also referred to as open source platforms (West, 2003), of which Linux is an example. Resource openness can for instance be forfeiting the core's intellectual property by opening up the platform core's codebase (Karhu et al., 2018). In this option, users and complementors can actively shape the platform's future development(West, 2003).

This way of organizing the architecture of the core has the advantage that it reduces costs for development and maintenance of the platform for the owner (Eisenmann et al., 2009) and it may result in a higher quality platform,

4

as the best version of the core will surmount. In addition, the quality may improve because co-development will yield feedback from a community of co-developers (Eisenmann et al., 2006; West, 2003; West and Gallagher, 2006; Chesbrough, 2003). A disadvantage is that it is more difficult for the platform owner to reap economic benefits (West, 2003). In addition, it is less suitable for complement development.

Researchers do not seem to agree whether resource openness has a positive or negative effect on the attitude of complementors to develop additional products for an open source platform. Choi et al. (2019) mention that resource openness reduces incentives for complementors to develop on the platform because it increases the costs of coordination. Anvaari and Jansen (2010) and Koch and Kerschbaum (2014) state the opposite, that an open source strategy positively correlates with complementors willingness to contribute to a platform. As a result of this discrepancy, this argument does not provide useful information for this design table.

Core - Option 3: Meta-platform A meta-platform can be best understood as an integration platform (Hein et al., 2018). A trusted-third party, or possibly a consortium of platform owners, organize the meta-platform. This meta-platform in turn, holds core functionality and identifies interfaces that are shared with industry-platforms. A similar approach is also sketched by (Bygstad and Hanseth, 2018) to integrate services by different providers. Besides these works, there is fairly little research on meta-platforms that connect platforms in industry.

An advantage of this option is that it can facilitate a set of required core functions, while still providing autonomy for the platforms to develop their platform according to an own strategy. Disadvantages to this option are that it requires co-ordination between the meta-platform controller and the industry-platforms. The platform may still need to evolve as a result of changes in the platform's environment, however, adopting changes is typically more difficult when it requires multiple parties with varying interests to agree (Garud et al., 2002; Simcoe, 2007). In addition, this design option can also lead to "least common denominator" dynamics (Eisenmann et al., 2009, p. 9) due to "tyranny of the majority voting", i.e. when a big part of the affiliated platform members do not posses the required capabilities to work with the state-of-the art technology or when platform owners have a vested interest.

Core – Option 4: Gateways The fourth and final option is to open up through adopting gateways. Interoperability between two platform can be managed by gateways or technical standards (Ondrus et al., 2015; Hanseth and Lyytinen, 2016). Gateways can be thought of as adapters, pieces of software that can connect two discrete services that might have different versions or capabilities (Hanseth and Lyytinen, 2016).

An advantage of the usage of gateways is that technical standards makes functions in the core compatible over different platforms (Ondrus et al., 2015; Hanseth and Lyytinen, 2016). An advantage of this option is that it lowers barriers to entry and it can nullify monopolies (The Economist, 2019b). A negative effect is that this may lead to a greater number of parties that develop a platform, introducing fierce competition among platform leaders.

West (2003) finds that when an organization fails in successfully managing a proprietary strategy, they are forced to open up their

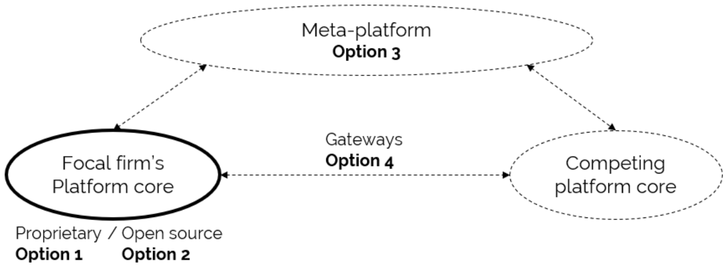

Figure 2: Visual representation of the design options for the platform core

platform. Opening up a platform introduces more coordination while it reduces chances of locking-in users.

2.2.2 Configurations for the interface openness-dimension

Other than opening up the platform at the core, platform leaders can also choose to open up by opening up the platform through the interfaces (Hein et al., 2018; Boudreau, 2010; Karhu et al., 2018).

Interfaces determine how the different components interact with the core (Baldwin and Clark, 2000). The interface can, according to Gawer (2014, p. 1243) be seen as "a divider, but also a connector and a conduit of selected information facilitating interconnection". This research adopts the perspective of Gawer (2014, p. 1243) concerning interface openness, as "the interface contains information that is accessible to external agents and usable by them to allow to build complementary innovation that is compatible with this interface". Interfaces determine what components of the platform the complementors have access to. Thus, interface openness is an important measure for platform control (Tiwana et al., 2010; Mukhopadhyay and Bouwman, 2019).

The design options for interface openness are visually presented in Figure 3.

Interface openness - Option 1: Proprietary interfaces In this option, interfaces are defined for loose coupling of modules to the core, however, these interfaces are invisible to external organizations. Rather, these interfaces remain closed to be solely used by the lead firm (Gawer, 2014). Closed interfaces relate to closed platforms. They are often not interoperable with other services or with competitor's platforms (Roesch et al., 2019). Gawer and Cusumano (2013) also refer to this type of platform as an internal platform.

Advantages of this strategy to the platform owner is that the focal firm gains efficiency and flexibility by using a modular architecture, allowing the firm to reuse common components. This way, they can quickly adapt to changing user-needs compared when they would have a tightly-integrated organization (Gawer and Cusumano, 2013). In addition, these platforms can have high appropriability (i.e. the possibility for harvesting rents) and can achieve user lock-in (Roesch et al., 2019). Another property is that the platform owner has control over the development of the platform. Disadvantages of this strategy are that it incurs high costs for R&D as all innovation is done in-house. This option thus fails to leverage the innovation-capacity of external parties.

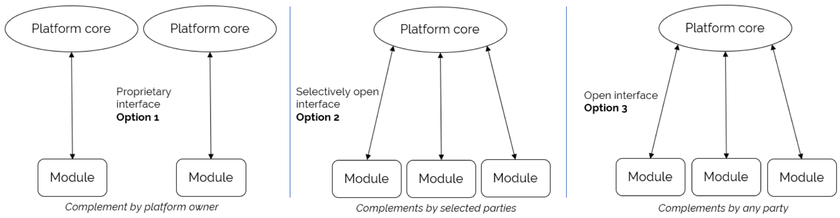

Figure 3: Visual representation of the design options for the interface openness-dimension

Interface openness - Option 2: Selectively open interfaces In selectively open interfaces, interfaces are shared exclusively with selected partners who are allowed to develop complementary assets. This type of platforms relates to what Gawer and Cusumano (2013) call supply chain platforms (also in: Gawer (2014)).

For a platform owner, this mode of interface openness allows the platform to outsource its R&D, leveraging external capabilities and reducing costs. In comparison to fully open interfaces, this design option has the advantage that it can control the quality of complements, improving the overall value of the platform (Cennamo et al., 2018). Generativity of this platform will be lower compared to an open interface. Also, its success strongly depends on the selection of partners.

Interface openness - Option 3: Open interfaces A strategy for open interfaces can be considered as the establishment of open APIs (Application Programming Interfaces). These interfaces allow third party developers to extend the focal platform's functionality by adding new modules to it. This leads to greater interoperability and the possibility for complementor developments to multihome (i.e. to exploit their service on different platforms). The phenomenon of multihoming is indicated with the dotted line in figure Figure 4. In the case of open interfaces, the interfaces are openly shared with other parties (and complementors) in industry (Gawer, 2014).

One of the most prominent advantage of using open interfaces is that it provides a platform owner with the possibility to cultivate the expertise and resources of a development community, leveraging knowledge of users that the platform owner itself does not have him/herself (Tiwana, 2014; Gawer and Cusumano, 2013). A negative effect of open interfaces may be that it introduces a high number of third party developers, leading to high competition among those developers (Boudreau, 2010). Another downside that can be introduced by openness of interfaces is that it may give room for applications of lesser quality to make use of the platform, researchers have shown this damages the perceived overall quality of the platform (Wareham et al., 2014; De Reuver and Bouwman, 2012).

2.2.3 Configurations for the interface standards dimension

Figure 4 graphically shows the different options for the design of the standards for the interfaces.

Interface standards – Option 1: Non-stable interfaces Interfaces are non-stable, they suit the needs of a specific party and a specific product (Cabigiosu et al., 2013). These platforms and cores thus require more intensive coordination between the platform and its complements

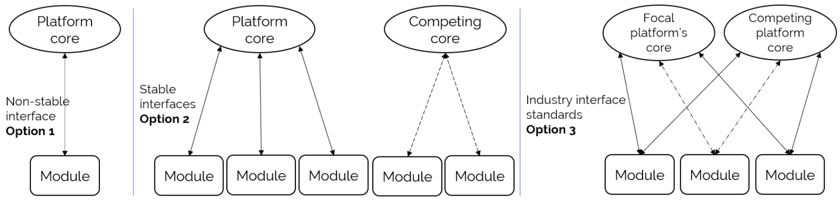

Figure 4: Visual representation of the design options for the interface standards-dimension

(Brunswicker and Schecter, 2019). It gives more control to the platform owner.

Interface standards – Option 2: Stable interfaces Stable interfaces can be interfaces that are specified by a single firm and that are not changed after a project has started. In this situation modules or the platform may change, while the interface does not.

This option provides room for flexibility and reduces uncertainty of the core because they are fixed after launch (Cabigiosu et al., 2013). Stability leads to less need for co-ordination and for higher predictability in the interdependence between the platform core and the module (Cabigiosu et al., 2013). Furthermore, stability in interfaces leads to higher reusability of the platform by complementors (Brunswicker and Schecter, 2019; Baldwin and Clark, 2000; Yoo et al., 2010). Stable interfaces are not necessarily standard interfaces.

Interface standards – Option 3: Industry standards Industry standards are shared across different parties in the industry, may lead to a plug-and-play situation in which complements can easily attach to different platforms (Cennamo et al., 2018). This is an attractive strategy for complementors.

Due to the standard-property, modules can be "mixed-and-matched" (Baldwin and Clark, 1997). This means that while the interfaces stay fixed, modules can change (Cabigiosu et al., 2013). Standardization thus enhances the modularity of the architecture, providing room for innovation. However, this strategy reduces the differentiation between platforms based on their complements (Cennamo et al., 2018). What is more, industry standards decrease the chance for a platform to gain a competitive advantage.

2.3 On platform openness

Platforms can either be fully open to outside users, fully closed or anywhere in between. This section discusses factors associated with digital platform openness, found in academic literature. First, reasons for using a closed platform strategy are discussed (subsubsection 2.3.1). Subsequently, internal motivations for an open strategy are provided in subsubsection 2.3.2, followed by a description of external reasons why a platform may be opened (subsubsection 2.3.3). Finally, subsubsection 2.3.4 discusses some of the negative effects associated with platform openness.

2.3.1 Reasons for pursuing a proprietary platform strategy

Academic literature highlights several options for why platform owners pursue proprietary strategies. These strategies are shown in Table 1.

Organizations that succeed in the establishment and maintenance of a successful closed platform, have no need to share returns and thus benefit from returns of the success of the platform and often higher margins (West, 2003).

Secondly, they may succeed in locking-in its users (West, 2003; Roesch et al., 2019), i.e. it is less attractive for users to transfer to a different platform (Tiwana, 2014). Once a platform becomes larger, it becomes increasingly attractive to users. The more users invest in a platform, the bigger the barrier becomes to transfer to a different platform. The provider of this platform gets an increasingly powerful position that may result in a sustained competitive advantage (De Reuver et al., 2011).

A third advantage of a proprietary approach is that it becomes more difficult to imitate the platform. Copying of a platform by a different platform owner, to build a new platform is a threat called forking (Karhu et al., 2018). Forking is detrimental to the value of the focal platform. Open platforms are more prone to copying and forking because their core resources and associated intellectual property rights are openly shared. Proprietary platforms do not share their platform core with outside parties, making them less susceptible to such malicious activities.

Fourthly, proprietary platforms have the advantage that the platform owner has tight control over the platform, interfaces and modules. Developing and maintaining the platform does not require coordination with outside parties. This makes these platforms less vulnerable to sluggishness as a result of coordination or political manoeuvring resulting from involvement of different parties and interests (West, 2003; Eisenmann et al., 2009).

It should be mentioned that successfully managing a proprietary strategy is often only possible for one or two parties that have a dominant market position (West, 2003).

2.3.2 Internal factors for platform openness

This thesis defines *internal factors for platform openness* as the motivations that a platform owner may drive towards adopting an open platform strategy.

Openness one the one hand means that a platform shares its resources with other parties. On the other hand, it also means that a platform may become interoperable with other platforms in the industry. Several advantages may come from choosing an open strategy. Table 2 presents some of the most prominent advantages of platform openness that were found in scientific publications, which we will address here.

Most of the advantages in Table 2 are interdependent of each other. By opening the platform to external parties, a platform owner lets external parties add complements to the platform. This enhances the overall functionality and attractiveness of the platform to both end-users as well as to complementor providers.

First of all, Gebregiorgis and Altmann (2015) find that an open platform is attractive to third party developers. This leads to an increased use of the platform by complementor developers (van Angeren et al., 2016) and variety in developers (Tiwana, 2014), giving rise to an increase in the number and variety of services and applications developed for the platform (Boudreau, 2010). The large offer of complementary services makes the platform more attractive to end-user (West, 2003). Similarly, a platform with a high number of end-users is attractive to third party developers because it leads to a greater potential market (Ondrus et al., 2015). This phenomenon of a self-enhancing loop of attractiveness to users is commonly referred to

Table 1: Motivations for choosing a proprietary platform strategy

Motivation for a proprietary strategy	Reference
High appropriation of financial returns	(West, 2003; Roesch et al., 2019)
User lock-in	(West, 2003; Roesch et al., 2019)
Difficult to imitate	(West, 2003)
Tight control, low need for coordination	(West, 2003; Eisenmann et al., 2009)

Table 2: Internal motivations for choosing an open platform strategy

Internal motivation for an open strategy	Reference
Attractive to third party developers (influencing also the factors below)	(Gebregiorgis and Altmann, 2015)
Increased number of complementors;	(van Angeren et al., 2016; Choi et al., 2019)
Increased diversity of complementors;	(Tiwana, 2014)
Co-creation by third-parties	(Ceccagnoli et al., 2012; Boudreau, 2010)
Increase in external innovation	(Boudreau, 2010)
Attractive to end-users	(West, 2003)
Network effects	(Parker et al., 2017)
Likelihood to reach a critical mass of actors	(Ondrus et al., 2015)
Enhanced flexibility to changing demands	(De Reuver et al., 2011)
Long-term evolvability	(Tiwana, 2014)
Sharing of costs for platform development and maintenance	(Eisenmann et al., 2009)
Higher quality platform resulting from feedback by developer community	(Eisenmann et al., 2009)
Share the development of new technologies that emerged on other, compatible platforms	(Boudreau, 2010)

Table 3: External factors for open platform approach

External factor for an open strategy	Reference
Lack of market share	(West, 2003)
Demand to open up by users and complementors is too high	(West, 2003)
A competitor's standard becomes the dominant standard	(West, 2003)
A regulator enforces openness to break market dominance	(Zhu and Iansiti, 2007; The Economist, 2019b)

Table 4: Negative effects from an open platform approach

External factor for an open strategy	Reference
Increases fear of competition among complementors	(Nikayin et al., 2013)
Reduces revenues and profits for platform owner	(Eisenmann et al., 2009; Parker et al., 2017)
Introduces coordination costs	(Wareham et al., 2014)
Disincentives for complementors to innovate	(Boudreau, 2012; Choi et al., 2019)
Low quality complements can harm the platform	(Wessel et al., 2017)
Risk of forking	(Karhu et al., 2018)

as network effects (Parker et al., 2017). The importance of network effects has been previously described in chapter 2. The presence of network effects leads to a higher adoption rate. This for instance can be of importance when a platform launches as Ondrus et al. (2015) showed that openness can ensure that a platform reaches a critical mass of users.

Other motivations to open up a platform is that openness can result the combination of a platform owner that leverages third party complementors leading to higher quality complements resulting from co-creation between the platform owner and the complement developer (Ceccagnoli et al., 2012). What is more, De Reuver et al. (2011) show that openness can lead to higher flexibility to adapt to changing demands and thus to greater long-term evolvability (Tiwana, 2014). Eisenmann et al. (2009) stress that openness can lead to better quality of the overall platform, due to the feedback of the community of users. Finally, Boudreau (2012) finds that platforms can use the developments of other, compatible, platforms to strengthen their own platform.

2.3.3 External factors for platform openness

Sometimes, it is not the platform owner that is willing to open up a platform but external factors that force a platform to evolve to a more open platform. One reason that a platform decides to open up is due to a lack of market share. Opening up a platform will enhance the platform's appeal, giving the platform owner the opportunity to increase its revenues from the sales of complementary offerings (West, 2003). A second reason, also mentioned by West (2003), is that the demand from users and complementors to open up is too high for a platform owner to retain a proprietary strategy. Thirdly, it may happen that a rival's platform's standard becomes the market-dominant standard. In this case, it becomes infeasible for the focal platform owner to maintain a proprietary standard, and the platform owner will have more success following the competitor's standard, inherently making it open to other parties. Fourthly, when a platform becomes too dominant (often characterised by user lock-in and high entry-barriers for competitors), policy-makers may force a platform to open up. A policy-maker may break this dominant position by enforcing interoperability (Zhu and Iansiti, 2007) or by sharing its data (The Economist, 2019b). This gives policy-makers the opportunity to create market dynamics that allow for competition between platform owners and between complementors.

These external factors are presented in Table 3 below.

2.3.4 Negative effects of having platform openness

Besides the positive effects of platform openness (see Table 2), openness also introduces negative consequences to the platform owner. Those consequences are shown in Table 4, and are elaborated on here.

One of the downsides of platform openness is that fierce competition between complementors can result in a negative attitude among complementor developers, thereby hindering innovation of novel services on the platform (Nikayin et al., 2013). This introduces to disincentives for complementors to develop offerings for the platform (Boudreau, 2012; Choi et al., 2019). A second disadvantage is that in an open platform, a platform owner is no longer the sole party to appropriate rents from sales of services on the platform (Eisenmann et al., 2009; Parker et al., 2017). Instead, financial gains are shared across ecosystem participants. Thirdly, open platforms require coordination between different participating and interacting actors (Wareham et al., 2014). A fourth negative side-effect of openness is that the presence of low-quality complements can harm the overall perceived quality of the platform, as found by Wessel et al. (2017). Finally, open platforms are at risk of forking (as discussed above) (Karhu et al., 2018).

3. Analysis

The findings from literature on platform architecture configurations and on platform openness were combined in a design artefact. This artefact has the purpose of concisely showing what design options actors face concerning the platform's architecture prior to the development of a digital platform. The design of this artefact is discussed in subsection 3.1.

Following the design of the artefact, the concept artefact was validated by means of semi-structured interviews. The purpose of validation was to identify design trade-offs relating to design choices for the openness of the platform architecture.

3.1 Concept artefact development

First, subsubsection 3.1.1 explains the assumptions underlying the artefact, followed by presenting the design in subsubsection 3.1.2.

3.1.1 Assumptions

An important decisions that an organization faces concerning the establishment of a digital platform, is choosing the mode of platform ownership (Ondrus et al., 2015; Saadatmand et al., 2018; De Reuver and Keijzer-Broers, 2016). Studying these modes of ownership is not part of this research, therefor assumptions have been made towards this factor.

For this study, it is assumed that a proprietary party is the platform owner (not a federation of parties or a government authority). This platform owner has the desire to establish a digital platform and is solely responsible for making the design choice for the platform's openness.

3.1.2 Design and development

Two designs were considered to represent the architectural design choices and how they relate to platform openness: (1) a conceptual model revealing influence relationships (used for instance by Nikayin et al. (2013) for the establishing theories on relationships between factors for instance by), and (2) a design chart. This latter option has been inspired by the work of Nickerson et al. (2013), who develop a structured way for developing taxonomies through design science research. Using a chart to denote different configurations for digital platforms has also been done by De Reuver and Keijzer-Broers (2016), Blaschke et al. (2019) and Mukhopadhyay and Bouwman (2019).

A design chart was selected as the concept artefact for this part of the research. This method was considered to have several advantages over option 1. First of all, it proved to be difficult to objectively sketch certain factors and consequences using the first model without taking a biased perspective. For instance, would a decision for industry openness have a positive or negative effect on the locus of control depends whether you take the viewpoint of a proprietary platform owner, an open source platform owner or that of a complementor. Since this image aims to take a neutral standpoint, this introduced complications. The design chart allowed for a more objective description of the consequences and factors related to openness. A second advantage of the design chart over the influence diagram is that it allowed more easily to include all design options in one comprehensive overview. The influence diagram required to sketch multiple diagrams for the various design options of the architecture.

3.1.3 chart presentation

Figure 5 shows the design options that platform owners can choose from.

The table in Figure 5 should be used as follows: a platform owner is requested to make a decision on each of the dimensions. For instance, a platform owner might choose a proprietary approach to the core-dimension, a selectively open approach to the interface openness-dimension, with schart interfaces from the interface standards-dimension. This means that the platform owner (or the interview respondent) has four options for the first dimension, and three options for the latter two dimensions.

3.2 Validation set-up

This section deals with discussing how the concept design was validated. subsubsection 3.2.1 explains the selection of respondents, subsubsection 3.2.2 discusses the interview protocol and subsubsection 3.2.4) elaborates on the approach taken to analyze the interview transcripts to derive conclusions.

3.2.1 Overview of the respondents

The selection of the respondents is important for effective usage of semi-structured interviews because the quality of the feedback depends on the knowledge of the respondents. A selection of interviewees was made, based on their experience and roles in the domain of information systems in the Dutch primary care domain. The subjects were elected to cover a broad range of perspectives on information systems in the domain under study. The following fields of expertise were chosen to be included in the interviews:

- field-experts with affinity with the multi-actor dynamics with respect to decision-making processes and policy-interventions in the primary care domain. This group is denoted with a *P*, denoting *policy* in Table 5;
- developers of IT-applications for the primary healthcare domain, for their technical knowledge on the development of healthcare applications. This group is denoted with a *T* for *technology* in the table below;

Architecture dimensions	Design choices			
	Option 1	Option 2	Option 3	Option 4
Core	Proprietary (West, 2003)	Resource openness (Kazan et al., 2018) (Blaschke et al., 2019) (West, 2003)	Meta-platform (Mosterd, 2019) (Hein et al., 2019) (Bygstad & Hanseth, 2018)	Gateways (Eisenmann et al., 2009) (Ondrus et al., 2015)
Interface openness	Proprietary interfaces (Gawer, 2014) (Mukhopadhyay et al., 2019)	Selectively open (Gawer, 2014)	Open interfaces (Tee & Woodward, 2013) (Mukhopadhyay et al., 2019)	
Interface stability	Non-stable interfaces (Brunswicker & Schechter, 2019) (Cabigiosa et al., 2013)	Stable interfaces (Brunschwicker & Schechter, 2019) (Baldwin & Clark, 2000) Yoo et al., 2010). (Cabigiosa et al., 2013)	Industry-standard interfaces (Cennamo et al., 2019) (Cabigiosa et al., 2013) (Baldwin & Clark, 1997)	

Figure 5: Concept for design chart for openness of the platform architecture

- c-level managers of IS-vendors in the primary healthcare domain, for their strategic perspective on positioning IS in the domain under study. This group is represented by the *M* for *management* in the table;

- healthcare practitioners, these are caregivers that have a demonstrated affinity with information technology. Those are denoted by the *H*, standing for *healthcare*.

Table 5 shows an (anonymized) overview of the respondents. The *I* stands for *interviewee*. To protect the respondents' confidentiality, it was decided to use codes to denote the interviewees.

3.2.2 On the interview protocol

An interview protocol was used to guide the semi-structured interviews, in order to enhance the comparability of the results and to ensure that the same topics were addressed in all interviews. The interview protocol is included in Appendix A of this article.

3.2.3 Interview characteristics

All interviews were conducted in the second half of December 2019 and the first half of January 2020. A total of eight respondents participated in the semi-structured interviews. The discussions had the form of one-on-one discussions between the researcher and the interviewee. On one occasion, it was a one-on-two discussion because both the respondents could only meet at the same time. This was the case for PI1 and PI2. The interviews had an average duration of *73 minutes (minimum 60 min.; maximum 94 min.*).

3.2.4 On the analysis methodology

The interview transcripts were first printed and hand-coded twice to develop an initial impression of the responses. For this, an open coding approach was used. No prior codes were defined. The coding was informed by the interview transcripts and the with the end goal of identifying trade-offs and preferences relating to the openness of a platform architecture in mind. This initial coding process resulted in 164 codes.

Hereafter, the transcripts were included in

Table 5: Overview of the respondents of the semi-structured interviews

Code	Organization type	Role	Other relevant experience(s)	#years in primary healthcare
PI1	IS vendor; Interest group for IS developers in healthcare	Manager business development; board member	Similar functions at other IS developers for primary care; national board for supporting cooperation of IS suppliers in primary care	>20
PI2	Interest group for IS developers in healthcare	Director	Representative for interest organization for health insurance companies	15-20
TI1	IS vendor in primary healthcare	Head of IS products	Similar position at other IS vendors	>20
TI2	IS vendor in primary healthcare	IT-architect	10 years as software architect	2-5
TI3	IS vendor in primary healthcare	Product (application) owner	n/a	2-5
MI1	Supplier of webpages for caregivers and personal digital health environments	Director	n/a	20
MI2	Information system supplier in the Dutch primary care domain	Director	15+ years experience in management rolls, mainly in banking and IT and healthcare and IT	2-5
HI1	Combined practice for general practitioner and pharmacy	Pharmacy doctor	Active role in providing feedback on the quality and operations of information systems in primary healthcare	15-20

the software Atlas.ti. The argument for using a software is that it contributes to a more objective and systematic way of analysing and interpreting the transcripts (Barry, 1998) and it enhances the transparency of the analysis (Paulus et al., 2017). In Atlas.ti, the interviews were examined for each dimension of the design chart. The results of the interviews are firstly discussed separately for the three dimensions. Finally, the implications of the overall results are discussed.

3.3 Validation results

From the semi-structured interviews, two types of answers to this question arose. First, several *trade-offs* were mentioned to be favourable or unfavourable for a digital platform in primary healthcare. Secondly, the interviews revealed *design tensions*, i.e. trade-offs that require striking a balance between paradoxical needs (Tiwana, 2014).

3.3.1 Trade-offs on design choices for architectural openness

The openness of a platform architecture in first-line healthcare was conceptualized as design choices relating to different degrees of platform openness on three dimensions: the platform core, the openness of the interfaces and whether the interfaces remain stable over time and complementors or whether they comply with industry-standards.

Figure **??** shows the design choice chart with the preferences expressed by the interview respondents highlighted in blue. In the chart, the core is divided over two dimensions instead of one. Concerning the core of the platform, the respondents mostly preferred a meta-platform to facilitate the most essential functionality. This way, redundancy in development efforts would be limited, simultaneously leading to greater interoperability and efficiency. An open source approach was suggested to the meta-platform to stimulate incentives to keep innovating the meta-platform. At the same time, respondents wanted to retain proprietary platform cores 'underneath' the meta-platform. This was said to stimulate competition and, consequently, innovation. For the interface openness dimension, there was a strong preference for selectively open interfaces. This preference can be attributed to the need for quality control. Respondents prefer openness of interfaces but at the same time state that there must be sufficient control over the complements that couple to the platform. On the final layer, the interface stability, there was a clear preference for stable interfaces. While industry-standard interfaces are theoretically thought to be useful to stimulate innovation, in practice the field-experts feared that political dynamics would hinder the establishment of industry standards, which in fact limits innovation.

Table 6 shows the most prominent and strongly supported trade-offs on the openness of the architecture of a platform in first-line healthcare.

Openness for the core is supported by most respondents. More specifically, field-experts prefer to have the most critical functionality to be included in a meta-platform. This is said to enhance innovation and to enhance ease of use. In addition, resource openness is suggested to provide incentives to continuously keep improving the meta-platform - in absence of competition on the level of the meta-platform.

Some risks are associated with openness. A requirement is that there should be clear allocation accountability to the functionality in the ecosystem. In addition, a requirement for a meta-platform is that there must be means to enforce parties to comply to the standards of the meta-platform. Moreover, a meta-platform is thought to be difficult to implement.

For the interfaces, field-experts are strongly in favor of openness but to a limited extent. Openness is desired because it comes with more innovation. But openness on the interface requires cautiousness.

First of all, openness is said to be only desired for non-critical functionality. Certain functionality (e.g. the medication monitoring) are thought to be too sensitive to outsource to external developers. Furthermore, the platform owner should be able to retain control over the apps in the ecosystem to limit possible negative effects of low quality or malicious apps. Finally, two important constraints were mentioned: (1) there must be quality control to guarantee the quality of health related applications. Second (2) there must be means to ensure security of the applications and the data they manage.

On the stability of the interfaces, remarkable conclusions were drawn. Industry wide-standards were thought to come with the greatest rate of innovation but this presumption was contradicted by the interviewees. As a result of political dynamics, parties protecting their own interest and a lack of transparency, innovation is actually limited by the speed of the adoption of industry-standards. For this reason, the field-experts preferred interfaces only stable to the focal platform over industry-wide interfaces.

In summary, openness is desired for a platform architecture but only to a certain extent. Openness is beneficial because it stimulates innovation. But openness can only be good for first-line healthcare when it takes measures to ensure quality, security, ease-of-use and it is limited to non-critical functionality. In addition, due to the political character of the industry, it is not likely that a shared solution, in the form of a meta-platform or industry-wide standards will become the solution for the entire domain in The Netherlands. The implications of these findings will be discussed in section 4.

3.3.2 Tensions in the design trade-offs

In the trade-offs are also contradicting needs. These are worth stressing as these provide challenging questions for how platform owners should try to balance contradicting needs for finding a desired degree of platform openness in first-line healthcare. The tensions were derived from the analysis in this chapter:

4. Discussion

This discussion mentions limitations (subsection 4.1), contributions of this study (subsection 4.2) and finally it presents opportunities for future research 4.3.

Figure 7 shows an iterated version of the design choice table, together with the preferences that were most strongly expressed by respondents.

4.1 Limitations

Some limitations to this study need to be recognized. One is that this thesis takes an installed-base ignorant approach to designing a platform-based ecosystem in Dutch primary healthcare. Additional research is needed to find out *how* to transform the current organization of information systems towards a platform way of organizing information systems in the domain.

Architecture dimensions	Design choices		
	Option 1	Option 2	Option 3
Core openness	Proprietary	Resource openness	
Core interoperability	Meta-platform	Gateways	
Interface openness	Proprietary interfaces	Selectively open	Open interfaces
Interface stability	Non-stable interfaces	Stable interfaces	Industry-standard interfaces

Figure 7: Iteration to the design table based on the interview results and the preferred options in bright blue

Secondly, this thesis describes a high level of abstraction, while it does not take into account implementation of a digital platform with respect to the information infrastructure. It was mentioned repeatedly that there is significant technical debt in the domain under study, some caregivers still store data on-premise on servers running outdated operating systems that are susceptible to data breaches (e.g. Windows 7). It would be interesting to bridge the gap between the findings form this study and practical implementation.

A third limitation is that perhaps not all relevant viewpoints were identified concerning trade-offs of openness on platform architectures. Illustrative to this limitation is that the respondents foremost discussed their opinion on what was 'in the best interest of healthcare'. While this perspective is laudable, it is plausibly also incomplete because it does not reflect strategic behaviour of parties searching for economic gains. Given that the domain under study currently faces a lack of transparency and willingness to cooperate, it is likely that there are also actors that have a more proprietary perspective than the interviewees of this study.

Fourth, there is a challenge in distinguishing a digital platform perspective on standards for interfaces and the standards for information exchange that currently exist in the primary care domain. The definition and adherence to standards for information exchange and for data semantics form a daily challenge in primary healthcare. These however should not be confused with standards for interfaces to couple modules to platforms in digital platform-based ecosystems. It would be interesting and useful to combine the perspectives on standards for information transactions and the functional coupling of information systems.

4.2 Contributions

This study makes three contributions.

Ex-ante design of digital platforms By studying how a platform can be designed ex-ante, this study responds to calls from De Reuver et al. (2018) and Schreieck et al. (2016). This is done by clarifying what design choices platform owners face prior to the establishment of a platform. By revealing design choices on the architecture, experts were able to express trade-offs on how they would think a digital platform may benefit IS in the application domain.

In addition, it was found that there is conceptual ambiguity for how researchers study configurations for platform architectures. For instance, (Blaschke et al., 2019) also discusses configurations for digital platform architectures but chooses a selection of architectural dimensions different to this research. A product of this thesis is a concise overview of design options for the architecture of a platform. While this thesis does not solve the aforementioned conceptual ambiguity, it proves to be suitable for identifying design tensions within the context of healthcare. This table may be tested more frequently, expanding also to other application domains to find out whether new choices and dimensions may be added or adjusted to the table.

Digital platform design in the healthcare domain By revealing trade-offs in the design of a digital platform in healthcare, this thesis extends on the works of Fürstenau et al. (2018) and Grisot et al. (2018). Both studies are concerned with how digital platforms should be designed, with an interest in application to healthcare.

Fürstenau et al. (2018) was interested in what design trade-offs platform owners experience for the design of a digital platform in healthcare. They ask to extend studies on platform design in healthcare for different countries.

The study reveals tensions between a desire for openness and cautiousness towards maintaining control, accountability and also with respect to stakeholder dynamics (least common denominator dynamics and political dynamics) in the design of a digital platform.

Digital platform architectures and openness Third, this thesis extends scientific work on the relationship between platform architecture and platform openness. Both Blaschke et al. (2019) and Kazan et al. (2018) requested future researchers to expand understanding on the relationship between configuring a platform architecture and meeting strategic goals.

This thesis has extended the works of Blaschke et al. (2019) and Kazan et al. (2018) by showing how potential platform owners can clarify design trade-offs by considering different design choices for a platform architecture. Whereas Kazan et al. (2018) reasons on the strategic goals in relation to the platform architecture in hindsight, this thesis takes an ex-ante approach. Moreover, the usage of design dimensions was inspired by the design taxonomies from Blaschke et al. (2019). While both (Blaschke et al., 2019) and Kazan et al. (2018) use design configurations for the platform architecture to classify platforms in hindsight, this thesis extends the application of design choices for dimensions of the architecture by using these design choices prior to the development of a digital platform. Inspired by these classifications, this thesis showed that it is possible to use such design choices to reveal tensions relating to strategic goals of platform owners.

4.3 Recommendations

Several recommendations for future research emerge from this study. First, to study governance mechanisms that can mitigate the effects attributed to openness of a platform architecture. It was repeatedly mentioned that openness may lead to lower control over quality and data-management.

Second, also relating to governance, it is interesting to examine what incentives can be used to continuously innovate the platform. Respondents said they may be in favor of a situation with only one platform. However, they fear the negative consequence that there will be little incentives to keep improving this platform.

Third, how to organize decision-making and limit least-common-denominator dynamics. Making decisions on the architecture of information systems often involves agreement by multiple parties. Both in the current situation, as in the situation of a meta-platform or industry-wide interfaces, least-common-denominator dynamics are either perceived or expected. How can strategic behaviour be managed in such a digital platform-based ecosystem.

A fourth topic to study is the establishment or design of standards. Respondents said that standards for data transferring and for APIs are desired, but that they are difficult to implement. Standards can be defined *de jure* or *de facto*. It would be interesting to study what methods for standard definition would be effective for Dutch primary healthcare.

Later on, it will be interesting to study whether the suggested effects of platform openness prove to be true. For instance, has openness in fact led to more innovation? Or, has openness led to a loss of control and quality of software supporting primary healthcare?

5. Conclusion

The main question this study set out to answer, was:

> *How can digital platform architectures be configured to facilitate openness of a digital platform in the first-line healthcare domain in The Netherlands?*

Based on the interviews, a preferred design for the architecture was appointed, based on trade-offs relating to platform openness. The preferred design options are highlighted in blue in figure 7. Concerning the core of the platform, the respondents predominantly preferred a meta-platform to facilitate the most essential functionality (e.g. authentication, patient treatment logging). This way, redundancy in development efforts can be limited while simultaneously enhancing interoperability and efficiency. An open source approach was suggested to the meta-platform to stimulate incentives to keep innovating the meta-platform. At the same time, respondents wanted to retain proprietary platform cores 'underneath' the meta-platform. This was said to stimulate competition and, consequently, innovation. For the interface openness dimension, there was a strong preference for selectively open interfaces. This preference is attributed to the need for control on the quality of complements. Respondents prefer openness of interfaces but at the same time state that there must be sufficient control over the complements that couple to the platform. On the final layer, the interface stability, there is a preference for stable interfaces. While industry-standard interfaces were thought to be useful to stimulate innovation, in practice the field-experts feared that political dynamics would hinder the establishment of industry standards, consequently limiting innovation.

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Other remarks

This research was conducted in combination with an internship position at Promedico Groep.

At no point in this research did Promedico interferred with this research.

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A. The interview protocol

Table 8: Interview protocol for the semi-structured interviews

Section	Construct	Slide	Purpose	Question	Comment(s)
OPENING (10 min)					
	Personal intro	Title; 1	Warm-up	• *Could you tell something about what you do at [company, role, duration]?*	Both researcher and participant; institute; research
	Explain conditions		Consent	• *Do you give consent that this interview will be recorded, etc.*	Start recording; sign document
	Interview overview	2	Information	• Explain the content for today's interview	Present content; tell duration
			Set 'ground-rules'	• Explain how you expect the interview to proceed	
	Intro thesis	3	Warm-up	• Provide an introduction to the thesis; motivation and goal; timeline; desired outputs	Motivation, goal, steps so far, next steps
	Objective interview	4	Set goal	• *Do you have any questions regarding the goal of this interview?*	Present the goals of the interview on the slide
CORE CONCEPTS (7,5 min)					
	Information document	Bridge; 5	Expectations and context	• *What are your initial thoughts on the introduction document?*	Ask probing questions; "when you first thought of it"
		6	Common understanding of platform	• *Where certain parts or definitions unclear to you?*	Discuss the components
			Validate thesis motivation and goal	• *Did you disagree with the definition or motivation; why?*	Try to identify unspecified assumptions
A DIGITAL PLATFORM IN PRIMARY HEALTHCARE (7,5 min)					
	Digital platform and architecture		Role of architecture and governance; how both can be designed deliberately	• Explain how the architecture must be understood and how certain parts of the architecture can be open/closed	Examples: Fully proprietary, Partly open, Fully open
	Perspective		Determining perspective	• Explain assumptions on ownership and perspective	Stress that we take a neutral standpoint
				• *What perspective do you feel most drawn to?*	Identify whether the interviewee may be biased by a standpoint
				• *What would be your ideas for the different roles in the ecosystem?*	Identify whether the interviewee is biased by an own perspective
		7	Bridge	• *Is everyone still okay/ up to speed?*	Check attitude
PLATFORM ARCHITECTURE PERSPECTIVES (30 min)					

Table 8: Interview protocol for the semi-structured interviews

Section	Construct	Slide	Purpose	Question	Comment(s)
	Design table	8; 9	Show concept table	• *What are your first thoughts on this description of a digital platform?*	Do they understand this; is it clear enough
	The **core dimension**	10	Does the core-dimension cover all relevant trade-offs	• *Do you have any remarks on the conceptualization of this dimension?*	Use examples Linux, Apple, Industry platform, smart-city platforms
			What trade-offs play a role?	• *What would be your preferred option? Why?*	Ask probing questions; enforce a choice!
				• *What consequences would you value most? Why? What are your biggest concerns?*	Ask probing questions; why/ why not. And what else?
	The **interface openness-dimension**	11	Does this dimension cover all relevant trade-offs	• *Do you have any remarks on the conceptualization of this dimension?*	Use examples: smart-city platform
			What trade-offs play a role?	• *What would be your preferred option? Why?*	Ask probing questions; enforce a choice!
				• *What consequences would you value most? Why? What are your biggest concerns?*	Ask probing questions; why/ why not. And what else?
	The **core interface standards-dimension**	12	Does this dimension cover all relevant trade-offs	• *Do you have any remarks on the conceptualization of this dimension?*	Use examples: smart-city platform
			What trade-offs play a role?	• *What would be your preferred option? Why?*	Ask probing questions; enforce a choice!
		13		• *What consequences would you value most? Why? What are your biggest concerns?*	Ask probing questions; why/ why not. And what else?
		14		Bridge	• *Any final comments on the interview thusfar? Introduce the meaning of a data-platform*
	Data-layer	15	Develop understanding of perceptions of data-openness	• *In case the platform provider would open up data; what option would you prefer?*	Stress that we do not take into account legal issues
				• *Why? What are the arguments? Why not?*	
	Wrapping up the core of the inter-view	16	Check whether any topics have remained unaddressed	• *Do you feel like we missed out on an important topic? What are your biggest concerns?*	Let them really say anything that comes to mind
WRAP UP (10 min)					

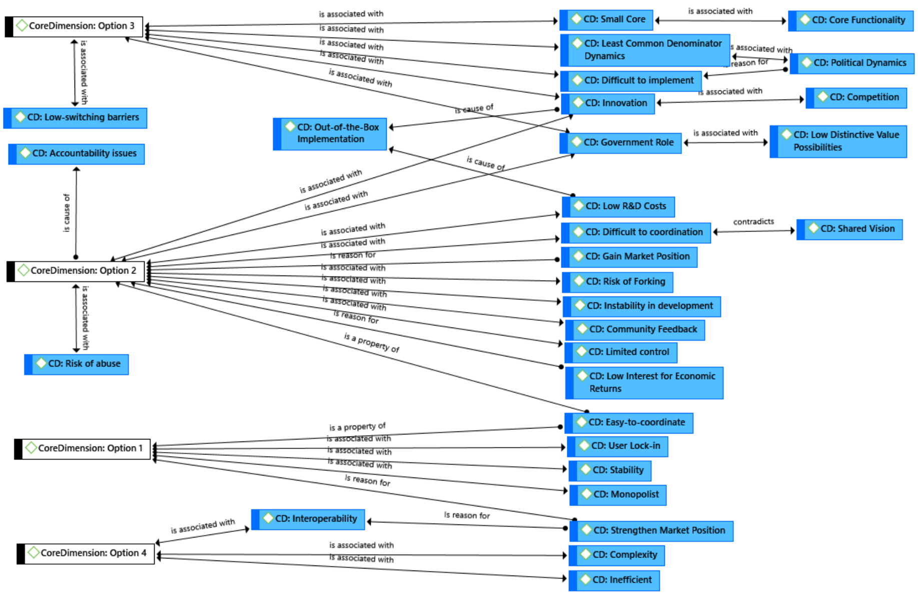

Figure 8: Graph representing core dimension trade-offs

Table 8: Interview protocol for the semi-structured interviews

Section	Construct	Slide	Purpose	Question	Comment(s)
	Interview closure			• *Do you have any further com-ments or recommendations?*	
				• *What did you like and dislike about the thesis research?*	
				• *Do you want a transcription of this interview? To check it?*	Exchange contact information
			Thank you for your time		

B. Network graphs

Below, the networks are represented that were generated from analyzing the codes associated with the interview transcripts in Atlas.ti.

Figure 9 shows the components in green. The design options are shown in black. Similar to the core-dimension, one component was added. For some components, it was explicitly mentioned that they are important to this dimension in general, these components are linked to the black-node 'InterfaceOpenness General'. This latter node is what is first discussed here. Subsequently, the trade-offs expressed in relation to the other design options are presented.

Figure 10 shows the nodes (codes) in yellow and the design options in black. Again, one component was added to the diagram because the interviews revealed that some codes relate to the dimension of interfaces standards in general. This node, 'InterfaceStandards General' (in

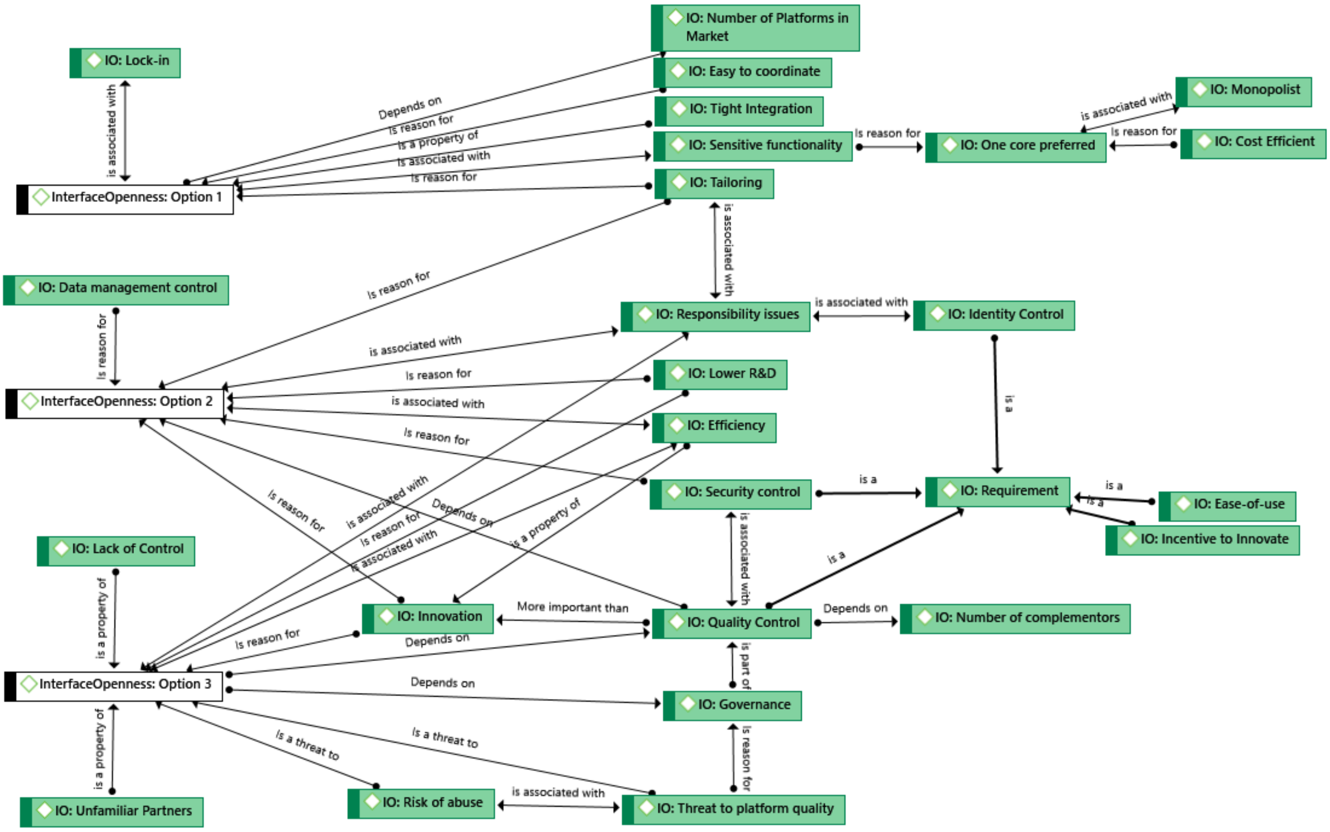

Figure 9: Graph representing interface openness dimension trade-offs

28

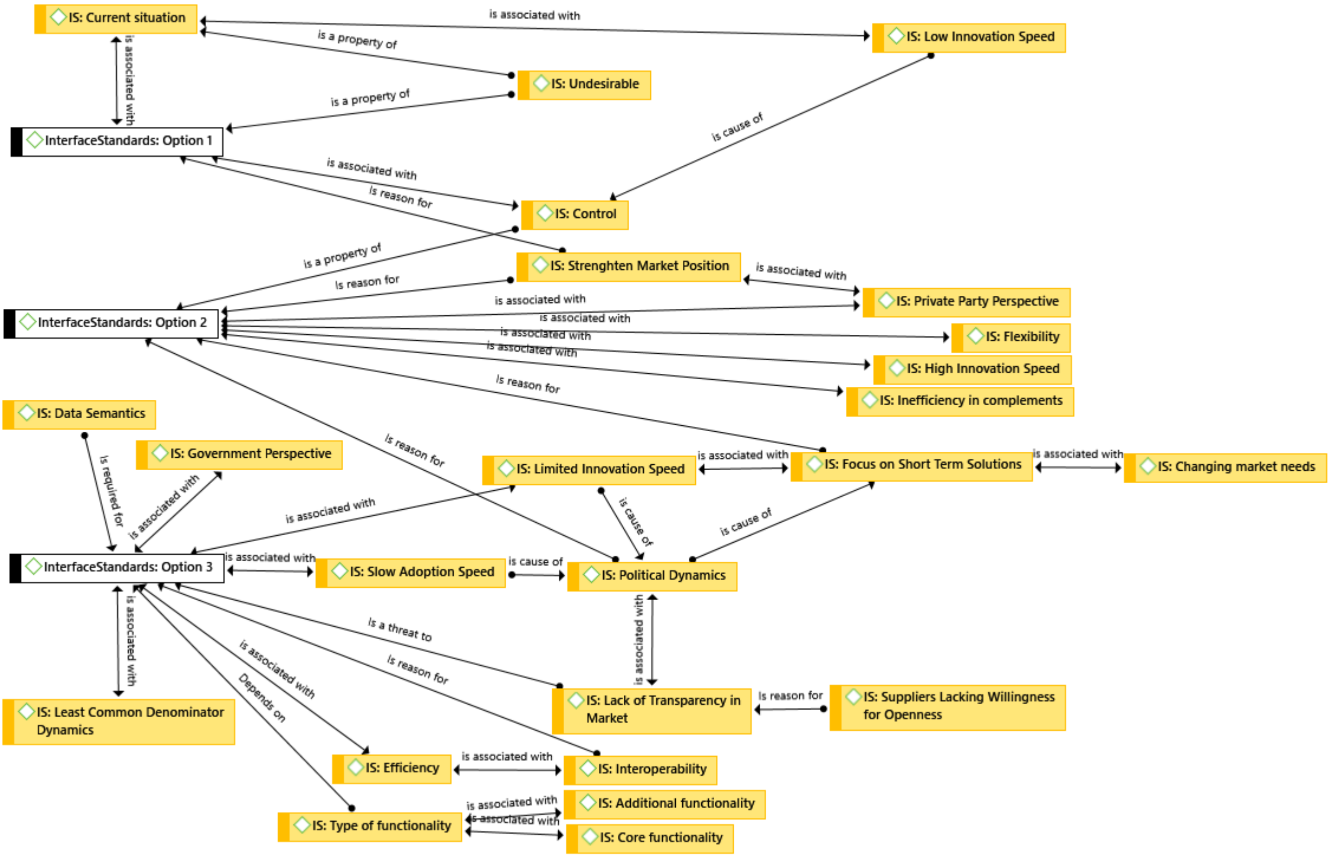

Figure 10: Graph representing interface stability dimension trade-offs

figure ??, is also shown in black.

Table 6: Most important trade-offs on the openness of the platform architecture

Design dimension	Trade-off	Explanation
Core openness	Innovation	Respondents are clearly in favor of more innovation in IS in first-line healthcare. They associate innovation with resource openness and a meta-platform. This suggest that openness of the core is valued over closed systems;
	Least common denominator dynamics	There are no mechanisms to enforce parties to comply or be discarded from the system;
	Political dynamics	A meta-platform will be difficult to implement due to the involvement of various parties protecting their own interest;
	Core functionality	The most important functionality should be arranged through a meta-platform;
	Ease-of-use	A common way of working is important to IS in first-line healthcare. A platform solution cannot come at the cost of a scattering of IS and applications;
	Accountability	With openness of the core in healthcare, there must be clear allocation of ownership and accountability of the functionality in the ecosystem;
	Difficult to implement	A meta-platform is desired but considered difficult to implement;
Interface openness	Quality control	There must me measures to ensure quality of the platform and of the complements;
	Innovation	There is a need for incentives to stimulate innovation;
	Security control	There must be means to ensure security of data in the platform and the complements in its ecosystem;
	Sensitive functionality	Field-experts are reluctant in opening parts of the IS that deal with sensitive functionality in terms of healthcare;
	Control	Platform owners should be able to keep control over the ecosystem, to shut off applications that show malicious behaviour;
	Quality of complements and platform	Experts fear that low quality or malicious apps or may harm the quality of the platform.
Interface stability	Political dynamics	Parties act in their own best interest, resulting in a focus on short term solutions and scattering of initiatives. This makes it difficult to reach agreement on an industry-wide solution;
	Lack of transparency	Parties are not transparent but remain closed to protect their market position;
	Limited innovation speed	Innovation speed is limited due to difficulty in coordination involved parties towards industry-standards.

Table 7: Overview of the design tensions found in chapter **??**

#	**Tension**
Tension 1	*There should be incentives and a structure that allows innovation by different parties, while retaining sufficient control over core functionality;*
Tension 2	*There must be a structure that allows innovation, while also clearly ascribing accountability, i.e. ownership and responsibility;*
Tension 3	*There must be common ways of working (meta-platform or industry-standards), while limiting political dynamics and least common denominator dynamics;*
Tension 4	*Allowing openness for external developers to develop innovative services and products, while being able to ensure control over quality, data-management and security;*
Tension 5	*Giving outside developers access to develop complementary services, while limiting the risk of abuse and the risk of loss of quality;*
Tension 6	*Allowing openness to stimulate innovation while keeping tight control over functionality associated with high sensitivity to healthcare;*
Tension 7	*Industry-wide standards would be most efficient for innovation but they are paradoxically unsuitable for innovation due to political dynamics;*
Tension 8	*Software vendors prefer a proprietary standards over industry-standards in order to strengthen their market position, while it at the same time limits the pace of innovation;*
Tension 9	*Industry-standard interfaces are preferred, mostly for generic functionality while software suppliers prefer proprietary (stable) interfaces for competing on a platform level on other functionality;*
Tension 10	*Industry-standards are considered promising but software vendors are not keen to strive for transparency of their own interfaces.*

B

Supporting information to the methodology section

This appendix provides additional information to chapter 3. The sections below mainly involve elaborations on the methods and approach to the sub research questions.

B.1. Sub research question 1

This section provides background information to the methods described in the main document.

B.1.1. Intended outcomes of the first stage of design science research

For understanding what output is useful in the first stage of DSR, scientific literature on DSR was consulted. Table B.1 shows how different DSR researchers have described the output of the first stage of DSR.

Table B.1: Important concepts as input for the design project drawn from literature

Reference	**Important information to gain concerning the environment of an IS design research**
(Kuechler and Vaishnavi, 2008; 2012; Vaishnavi and Kuechler, 2004)	soft context information: concerning organizational and social structures, and concerning criteria for selecting between design decisions
(Gregor and Jones, 2007)	*purpose and scope:* meta-requirements, goal and scope of the system *constructs:* to describe the artifact, language and phenomena that are relevant to the design project.
(Hevner et al., 2004)	*related to people:* roles, capabilities, characteristics *related to organizations:* strategies, structure and culture, processes *related to technology:* infrastructure, applications, communications architecture, development capabilities
(Peffers et al., 2007)	Defining the problem and its complexity, description of (meta-) requirements

B.1.2. Discussions with field-experts

This section explains how the discussions with field-experts were conducted, for the first stage of this research.

Over a period of four weeks, eight one-on-one (and once a one-on-two) discussions were organized with field experts. These experts all worked at companies that develop information systems for primary care providers. An overview of the represented roles in the sample of field experts can be seen in Table 4.1. Each discussion followed a similar approach, in corresponding order:

- *Introduction to the motivation for this thesis research.* The respondents were introduced to the motivation for this thesis, that is (1) the healthcare challenges and (2) the assumed challenges for information systems supporting this domain, such as described in section 1.1. The respondents could provide their feedback on these alleged trends and the role of a digital platform in this domain.
- *Slides to present the topics that will be covered.* Guided by a few slides, the subjects were briefed about the goal of this stage of the research, i.e.: (1) developing an understanding of the system of information systems in the primary care domain, (2) identifying the main motivations for innovating this system and (3) eliciting requirements for a better organization of information systems for the primary care domain. Slides were used for standardizing the information that was given to all subjects in the sample.
- *The experts' reflections on the current landscape of IT in primary healthcare in The Netherlands.* Responding to the foregoing, the experts expressed their perception of the challenges and opportunities that face the information systems supporting the primary care domain. The findings are reported in Table 4.1.
- *Presenting conceptual visual representations of the current system* The perceived dynamics and interrelationships between actors and information systems in the primary care domain were captured in conceptual visualizations (see for instance figures 4.1, 4.3 and D.1). These figures were presented to the subjects and iterated after each discussion.
- *Discussing the main motivations for transforming the current system.* Based on the preceding steps, the subjects were requested to express the main motivations they perceived for whether the current organization of information systems is in need of change.
- *Suggestions for changes and additions to the current topics* All discussions ended with questioning the participants whether he/she had any concluding suggestions or whether some important topics, relating to information systems in this domain, were not covered in the discussion.
- *Iteration.* It should be noted that -in line with the Grounded Theory approach- the contents of some of visuals that were presented in later discussions changed throughout the course of the weeks in reaction to feedback that was provided in preceding discussions with field experts.

Table 4.1 shows what topics emerged in the conversations. These discussions with field experts were used for constructing a description of the current state of the information infrastructure in the primary care domain in The Netherlands.

B.1.3. Results from meta-requirement elicitation

The meta-requirements below were inferred from the reflections on the as-is situation, in chapter 4.

Table B.2: Overview of meta-requirements for design

Req. code	Name	Rationale *The new system should ...*
R1	Low switching barriers	*... allow easy switching of IS services to caregivers and patients.* Easy switching to other software suppliers gives patients and caregivers the possibility to make use of the best software available to serve their needs. Furthermore, easy switching should give software developers the incentive to keep improving their products and services, not doing so will harm their competitive position.
R2	Simulate innovation	*... allow adoption of novel technological solutions* Technological developments provide novel solutions to improve patients' health (e.g., IoT, blockchain technology). The information systems that support care givers should be able to adopt such innovations. This requires the system to be loosely coupled (Yoo, 2012)
R3	Safety	*... be safe as to not jeopardize patients' and practitioners' sensitive data.* First of all, personal data should be stored safely to comply with standard data-protection regulation. Secondly, trust is know to be one of the largest determining factors for people's adoption of new information technologies. Safety is thus also prerequisite for adoption of the new design.
R4	Flexibility	*... be flexible* In the current organization, when there is a changing need from the care domain, a new solution gets build. This solution is often tightly integrated with existing information systems. In the long run, this leads to technical debt. A new system should provide flexibility to adjust to changing needs
R5	Simplicity	*... be simple* The current organization is characterized by large heterogeneity in terms of involved actors, systems, and interrelationships. Simplicity is an promising feature, that can create an environment that is suitable for the emergence of innovations that can easily be coupled to the existing systems (Tiwana, 2014)
R6	Enable holistic care	*... enable coordination of different care givers around a patient.* Combined efforts of different care providers centered around a patient will lead to more effective diagnosis and treatment of patients' medical complaints. Transferring information between different care givers will allow them with more complete overview of the patient's medical history and complaints to inform caregivers for their treatment plan.

B.2. Sub research question 2

Two literature reviews were conducted for the second stage of this research. The approaches to these researches are discussed in this appendix.
For both reviews, only the academic database of Scopus was used as a resource for scientific articles. The articles in Scopus were submitted to a peer-review process, this is believed to enhance the credibility of these reviews over the database of Google Scholar. The database of Web of Science was not found to provide useful additional literary articles over Scopus.

B.2.1. Review approach for platform architectures

The aim of this literature review was to identify what configurations of platform architectures researchers have discussed. To this end, literary databases were searched for such descriptions of digital platform architectures that have a similar level of abstraction as the one defined in chapter 5. Figure B.1 shows how the selection of the articles was made.

Several criteria were used for the search process. First, the articles had to discuss at least two different configurations on one of the selected dimensions. This means that they should for instance at least compare two different approaches of sharing platform interfaces with outside developers (or not sharing it, as one

Reference	Architecture	Openness
(Baldwin et al., 2009)	✓	
(Blaschke et al., 2019)	✓	
(Eisenmann et al., 2009)	✓	✓
(Ghazawneh and Henfridsson, 2013)	✓	
(Karhu et al., 2018)	✓	
(Kazan et al., 2018)	✓	
(Mosterd, 2019)	✓	
(Ondrus et al., 2015)	✓	
(Pon et al., 2015)	✓	
(Spagnoletti et al., 2015)	✓	
(Tiwana, 2014)	✓	✓
(Yoo et al., 2010)	✓	✓
(Baldwin and Clark, 2000)		✓
(Brunswicker and Schecter, 2019)		✓
(Cabigiosu et al., 2013)		✓
(Cennamo and Santaló, 2019)		✓
(Gawer, 2014)		✓
(Mukhopadhyay and Bouwman, 2019)		✓
(Parker et al., 2017)		✓
(Tee and Woodard, 2013)		✓
(Teixeira, 2015)		✓
(West, 2003)	✓	✓

Table B.3: Articles included in the literature review attributed to a subject

of the options). Concerning the date of the article, no selection criterion was used. Interestingly, it was found that most articles on digital platforms often refer to scientific literature dating back from before the 2010s.

B.2.2. Literature review approach for platform openness

The method for the literature review on openness was less structured. Search queries on digital platform openness revealed a wide range of articles, of varying content. For this part of the review, mostly forward and backward snowballing was conducted on highly cited papers on digital platform openness. Snowballing started off from the works of Tiwana (2014), Eisenmann et al. (2009) and De Reuver et al. (2018b).

B.3. Sub research question 4

This section substantiates the methods section in the chapters 3 and 7.

B.3.1. Interview protocol

The interview was designed to gather feedback on the design table (the concept artefact), as well as to see whether the design table was a useful means for understanding trade-offs for openness, with a focus on the Dutch first-line care domain. To enhance comparability of the feedback and insights provided by the respondents, a set of questions were formulated to guide the discussions. The researcher was allowed to deviate from this set of questions when relevant new insights emerged during the discussions. Table B.4 in section B.3 shows the questions used. This table was constructed to cover a set of themes.

The opening part of the interview was designed to introduce the interviewees to the study. Here, the researcher explained the motivation for this thesis. Besides introducing the respondents on the topic, it was also included so respondents could express their opinion on the current state-of-affairs of the organiza-

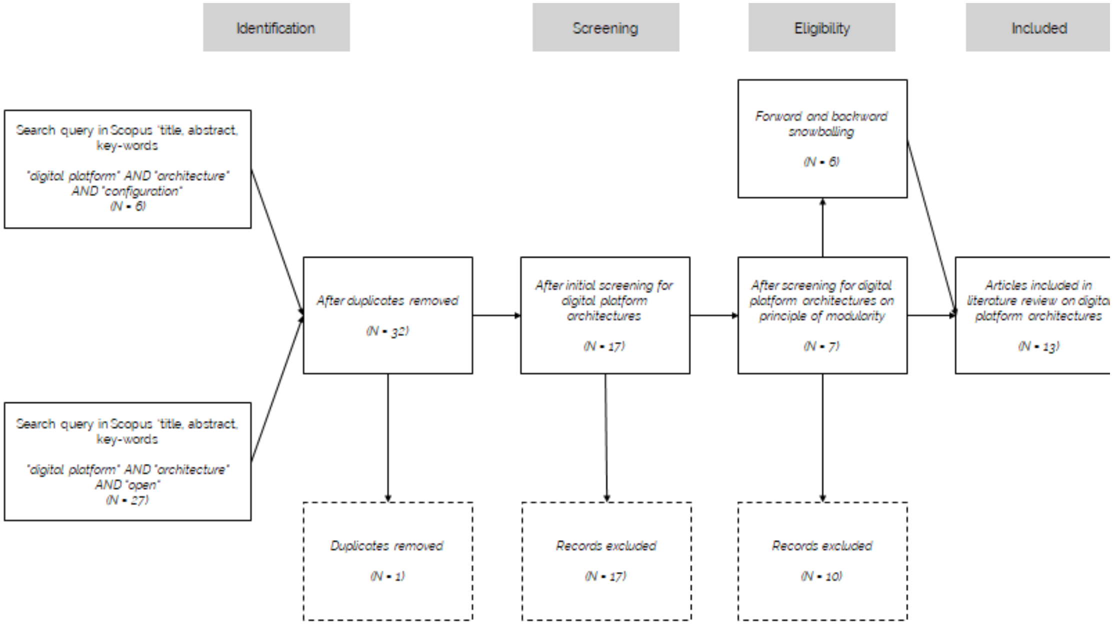

Figure B.1: Overview of literature search approach for platform architectures

tion of information systems in first-line care. Secondly, the core concepts were explained and discussed to ensure all respondents and the researcher had a similar understanding of the subjects that were discussed. The third part of the interview discussed any assumptions inherent to the concept design table. Fourthly, the core of the interview was the presentation and discussion on the design choice table. Here, the respondents got to see the design table and the options for the different design dimensions (as discussed in section 6.3). It was decided not to take an a priori standpoint on the directions to the effects of the different configurations, meaning that all factors and consequences related to the design options were stated independent of interpretation of (dis-)advantage to involved parties. The final part of the interview involved a cooling down phase, where the interview zoomed out to the overall scope of the design table and the research so respondents could reflect on the discussion and mention any insights that had not come forward earlier in the discussion.

The interviews were supported by an information document and by a PowerPoint presentation. These supporting materials are included in the appendix (H and G) of this thesis. These materials were included for the interviewees to develop an initial understanding of the origin of this research.

A few days in advance of the interview, the respondents received a concise document, explaining the scope and purpose of this thesis research. This document also clearly stated the goal of the semi-structured interviews. This information document did explain that the interview would involve discussing configurations for architecture openness, but it did not show any information concerning the concept artefact.

The interviews were supported by a PowerPoint presentation. The motivation for using a slide presentation to substantiate the discussion, was to provide all respondents with similar information. If all information would have been sent in advance, a risk loomed that some respondents could become biased or misinterpreted some of the information related to the concept artefact. These slides have been included in this thesis in appendix H.

During the first interview, the interviewee mentioned that slide 12 (the interface standards-dimension) was somewhat confusing. It was suggested to show an additional platform in the image explaining option

2 (the middle image in Figure 6.5). This suggestion was included and this image has been adjusted before the following interview.

Moreover, it was found during multiple discussions that respondents were really interested in 'what functionality it was that was included in the core'. This question was previously identified as one of the key trade-offs needed to be made by a platform owner prior to the launch of a platform (see Table C.1). It was decided to make take a example that could consistently be used in all interviews; the core comprised treatment logging, authentication and identification.

Table B.4: Interview protocol for the semi-structured interviews

Section	Construct	Slide	Purpose	Question	Comment(s)
OPENING (10 min)					
	Personal intro	Title; 1	Warm-up	• *Could you tell something about what you do at [company, role, duration]?*	Both researcher and participant; institute; research
	Explain conditions		Consent	• *Do you give consent that this interview will be recorded, etc.*	Start recording; sign document
	Interview overview	2	Information	• Explain the content for today's interview	Present content; tell duration
			Set 'ground-rules'	• Explain how you expect the interview to proceed	
	Intro thesis	3	Warm-up	• Provide an introduction to the thesis; motivation and goal; timeline; desired outputs	Motivation, goal, steps so far, next steps
	Objective interview	4	Set goal	• *Do you have any questions regarding the goal of this interview?*	Present the goals of the interview on the slide
CORE CONCEPTS (7,5 min)					
	Information document	Bridge; 5	Expectations and context	• *What are your initial thoughts on the introduction document?*	Ask probing questions; "when you first thought of it"
		6	Common understanding of platform	• *Where certain parts or definitions unclear to you?*	Discuss the components
			Validate thesis motivation and goal	• *Did you disagree with the definition or motivation; why?*	Try to identify unspecified assumptions
A DIGITAL PLATFORM IN PRIMARY HEALTHCARE (7,5 min)					
	Digital platform and architecture		Role of architecture and governance; how both can be designed deliberately	• Explain how the architecture must be understood and how certain parts of the architecture can be open/closed	Examples: Fully proprietary, Partly open, Fully open
	Perspective		Determining perspective	• Explain assumptions on owner-ship and perspective	Stress that we take a neutral standpoint
				• *What perspective do you feel most drawn to?*	Identify whether the interviewee may be biased by a standpoint
				• *What would be your ideas for the different roles in the ecosystem?*	Identify whether the interviewee is biased by an own perspective
		7	Bridge	• *Is everyone still okay/ up to speed?*	Check attitude
PLATFORM ARCHITECTURE PERSPECTIVES (30 min)					
	Design table	8; 9	Show concept table	• *What are your first thoughts on this description of a digital platform?*	Do they understand this; is it clear enough

Table B.4: Interview protocol for the semi-structured interviews

Section	Construct	Slide	Purpose	Question	Comment(s)
	The **core dimension**	10	Does the core-dimension cover all relevant trade-offs	• *Do you have any remarks on the conceptualization of this dimension?*	Use examples Linux, Apple, Industry platform, smart-city platforms
			What trade-offs play a role?	• *What would be your preferred option? Why?*	Ask probing questions; enforce a choice!
				• *What consequences would you value most? Why? What are your biggest concerns?*	Ask probing questions; why/ why not. And what else?
	The **interface openness-dimension**	11	Does this dimension cover all relevant trade-offs	• *Do you have any remarks on the conceptualization of this dimension?*	Use examples: smart-city platform
			What trade-offs play a role?	• *What would be your preferred option? Why?*	Ask probing questions; enforce a choice!
				• *What consequences would you value most? Why? What are your biggest concerns?*	Ask probing questions; why/ why not. And what else?
	The **core interface standards-dimension**	12	Does this dimension cover all relevant trade-offs	• *Do you have any remarks on the conceptualization of this dimension?*	Use examples: smart-city platform
			What trade-offs play a role?	• *What would be your preferred option? Why?*	Ask probing questions; enforce a choice!
		13		• *What consequences would you value most? Why? What are your biggest concerns?*	Ask probing questions; why/ why not. And what else?
		14		Bridge	• *Any final comments on the interview thus far? Introduce the meaning of a data-platform*
	Data-layer	15	Develop understanding of perceptions of data-openness	• *In case the platform provider would open up data; what option would you prefer?*	Stress that we do not take into account legal issues
				• *Why? What are the arguments? Why not?*	
	Wrapping up the core of the inter-view	16	Check whether any topics have remained unaddressed	• *Do you feel like we missed out on an important topic? What are your biggest concerns?*	Let them really say anything that comes to mind
WRAP UP (10 min)					
	Interview closure			• *Do you have any further comments or recommendations?*	
				• *What did you like and dislike about the thesis research?*	
				• *Do you want a transcription of this interview? To check it?*	Exchange contact information
				Thank you for your time	

B.3.2. Coding of interview transcripts

The coding of the transcripts is described in appendix E.

C
Overview of Design Choices from literature

Table C.1 shows what design tensions have been mentioned in scientific research on digital platforms.

Table C.1: Platform design tensions found in literature

Tension	**Explanation**	**Reference**
Platform ownership	Who will be the platform provider? That can be either one firm or multiple firms.	(De Reuver and Keijzer-Broers, 2016; Saadatmand et al., 2018)
Launch strategy	A platform needs to attract both end users and service providers. Attracting both sides can create network effects that help the platform to increasingly become attractive to users. This phenomenon is also referred to as the *chicken-and-egg* problem, both sides of users need to be on board for the platform to become valuable.	(De Reuver and Keijzer-Broers, 2016; Evans and Schmalensee, 2010; Tiwana, 2014)
Platform subsidizing	Platform owners may consider to subsidise one side of users so they can harvest rents from another side of users. For instance, subsidizing complementors may enhance the attraction of end-users, the platform owner may gain revenuews from the end-users to copmensate for the subsidies.	(Tiwana, 2014)
Competitiveness	The transformation of a system towards a platform-oriented solution can cause a shift in the competitive environment in the domain where it is positioned (Constantinides et al., 2018). A firm can either choose a *competition*, *co-optition* or *collaboration* strategy (Ondrus et al., 2015). Moreover, Boudreau (2012) find that moderate competition may enhance innovation on a platform, too much competition, however, may harm the innovative capacity of a platform.	(Boudreau, 2012; Constantinides et al., 2018; Ondrus et al., 2015)
What goes in the core?	What functionality is included in the core of a platform, and what functionality is excluded? Often times this decision hangs upon two 'axis'; whether reusability of the functionality is high or low and whether the usage of the functionality is widespread or not.	(Tiwana, 2014)
Appropriability and adoption	This term denotes the platform owner's capacity to harvest revenues from the sales of complements from the platform. If a platform gains a high portion of revenues from app sales, it may become less attractive for complementors to add additional applications to the platform.	(Eisenmann et al., 2009; West, 2003)
Generativity and control	Complementors compete on the quality and differentiation of complements. On the other hand, the platform owner benefits from cohesion within the platform ecosystem. High differentiation can offer (1) high generativity but it may also lead to loss of cohesion on a platform. High differentiation can also lead to (2) high heterogeneity of applications in a platform, which has shown to possibly cause in increased variance in the quality of applications/services on a platform. Platform owners should try to balance a level of control while maintaining the benefits of generativity (Saadatmand et al., 2019). A downside of generativity may come from low-quality complements that may jeopardize the overall perceived quality of the platform (Constantinides et al., 2018). As will be discussed later, there are strategies that platform owners can adopt to limit the possible emergence of low-quality components for instance through quality checks and certifications (Boudreau and Hagiu, 2009; Constantinides et al., 2018).	(Constantinides et al., 2018; Tiwana et al., 2010)
Stability versus evolvability	Stability of the platform's core is important for making it feasible for complementors to develop applications. On the other hand, a platform should be able to evolve to react to changes in the environment.	(Brunswicker and Schecter, 2019; Mukhopadhyay and Bouwman, 2019; Tilson et al., 2010; Tiwana et al., 2010; Wareham et al., 2014)
quality versus quantity of on-boarded complementors	A high number of applications is attractive for end-users but it may also be a the cost of the quality of the applications. Low quality complements can be detrimental for the overall quality of the platform.	(Mukhopadhyay and Bouwman, 2019)
Shared identity versus autonomy	While platforms benefit from stability and a shared identity on the platform, complements can best have autonomy over the development of products and services.	(Saadatmand et al., 2019; Wareham et al., 2014)
Platform openness	Platform openness refers to whether complementors are enabled to develop new applications that can be added to the platform. Openness is needed for generativity but too much openness can lead to loss of control and loss of quality of the platform	(De Reuver and Keijzer-Broers, 2016; Eisenmann et al., 2009)

D

Stakeholder analysis

D.1. Overview of stakeholders

Table D.1 below gives an overview of all stakeholders that are considered within the scope of this study. The most left common shows the stakeholder groups. As the landscape involves a wide-variety of actors, among which some fulfill similar roles and functions, the stakeholders are mentioned in stakeholder groups, rather than individual entities. The content in the cells was derived from discussions with field experts (see section 3.1).

The table can be interpreted as follows. The 'role' denotes the stakeholders groups' role related to information systems in the primary care domain. 'Interest' concerns the interest the group has to interact with the system of information systems in primary healthcare. 'Resources' denote the means that the groups have to influence the situation of IS within the system under study. Finally, the interests and power (related to the groups' resources) are classified for being either low, medium or high.

The most interesting findings derived from this table were discussed in the main report in chapter 4, section 4.2.

Stakeholder group	Role	Interest(s)	Resource(s)	Interest (H-L)	Power (H-L)
IS suppliers (a.o. Promedico, Pharmapartners, Compugroup) reference(s):	Information system supplier, IS developer	Sell and exploit information systems	Software development knowledge	High	High
Patient reference(s):	User	High quality care at low costs; privacy of data	Select what health services to use	High	Low
Ministry of H,W&S reference(s):	Regulatory; Funding	Access to healthcare for citizens; high quality primary care domain at low costs	Impose regulation; Provide financial support	High	High
Municipality reference(s):	Regulatory; Funding	High quality healthcare at lowest costs; Citizens' general wellbeing	Funding of caregivers	High	Medium
European Union reference(s):	Regulatory; Funding	High quality healthcare in EU; Integrity of pharmaceutical industry in EU	Impose EU-wide regulations	Medium	Medium

Stakeholder group	Role	Interest(s)	Resource(s)	Interest (H-L)	Power (H-L)
Insurance companies (a.o. Zilveren Kruis, Menzis) reference(s):	Supporting; Funding	Low expenses on healthcare support	Influence patients' attitude towards health services; influence on pricing of professional care and medicine	High	Medium
Interest group for insurance companies (Zorgverzekeraars Nederland) reference(s): `https://www.zn.nl/336986134/Organisatie`	Interest group	Represent the interest of insurance companies	Express the interest of insurance companies in discussing health support policy-making	High	High
Interest group for IS suppliers in healthcare (NedXis) reference(s): `https://www.nedxis.nl/`	Coordination of IS suppliers	Coordinating and overarching IS suppliers in the primary care domain in NL	Informal coordination of IS suppliers	High	Low
Interest group for IS users in healthcare (a.o. NedHIS) reference(s):	Supporting	Representing the interest of users of a XIS	Collected opinions on XISs	High	Medium
Interest group for medical information exchange through medical index (VZVZ) reference(s): `https://www.vzvz.nl/over-vzvz`	Facilitator				
Interest group for standards for information exchange (Nictiz) reference(s): `https://www.nictiz.nl/over-nictiz/`	Standardization organisation	Provide clarity on what standards exist for information exchange concerning primary healthcare	Advising IS suppliers on the usage of standards	High	Medium
Overarching group for IS suppliers (OIZ) reference(s):					
Interest group for care providers (a.o. KNMP, LHV) reference(s):					
Independent primary healthcare providers (a.o. general practitioner, physiotherapist, pharmacist, GGD) reference(s):	User	Patient well-being; security of income; high quality IS at low costs	Selecting what IS to use	Medium	Low
Care centres reference(s):	Overarching care providers	High quality care at low costs; alignment of affiliated healthcare providers	Advising on selecting what IS to use	Medium	Low
Care groups reference(s):	Overarching care providers	High quality care at low costs; alignment of affiliated healthcare providers	Strongly advise on selecting what IS to use	Medium	Low-Medium
Healthcare network providers (a.o. GZNs: e.g. eZorg)	Facilitator	Exploit network for transferring healthcare related information	Contracts with IS suppliers for sharing information in medical domain	High	Low

Stakeholder group	Role	Interest(s)	Resource(s)	Interest (H-L)	Power (H-L)
reference(s):					
Regular internet network provider (a.o. KPN) reference(s):	Facilitator	Exploit network for transferring information	Facilitation of (secure) network for data sharing	Low	Medium
Pharmaceutical wholesale reference(s):	IS user	High revenue from medicine sales	Regulate medicine costs and supply together with health insurance companies	Medium	Medium
Pharmaceutics records regulators (a.o. G-standaard, NMVS: National Medicine Verification System) reference(s): `https://nmvo.nl/over-ons/`	IS supplier	Keep track of what medicines are produced and sold	Monitoring of medicine demand, supply and usage	Low	Low
Independent complement developers reference(s):	Complementors	Develop digital health services	IS development knowledge	High	Low
reference(s):					

Table D.1: Overview of the stakeholder groups and their interests and power positions towards the system under study

D.2. Grouping stakeholders on their power and interest

Figure D.1 classifies the stakeholder groups from Table D.1 to their respective power and interest position. This classification helps in determining what stakeholders should be incorporated in decision making processes concerning transformations of the information system infrastructure of the primary health domain, and how to approach these stakeholders.

Interest in this regard refers to the interest a party may have in a good working organization of information systems in the healthcare domain. Similarly, *power* concerns the actors' means to affect how these information systems are organized. The arrows that are positioned to the left side of some of the stakeholders indicate whether a trend was observed that the stakeholder is moving towards another quadrant in the grid.

To fill out this grid, the following approach was used. During conversations with field experts (section 3.1), this grid was shown and these experts provided their substantiated feedback why a certain stakeholder should be placed on a specific place in the grid.

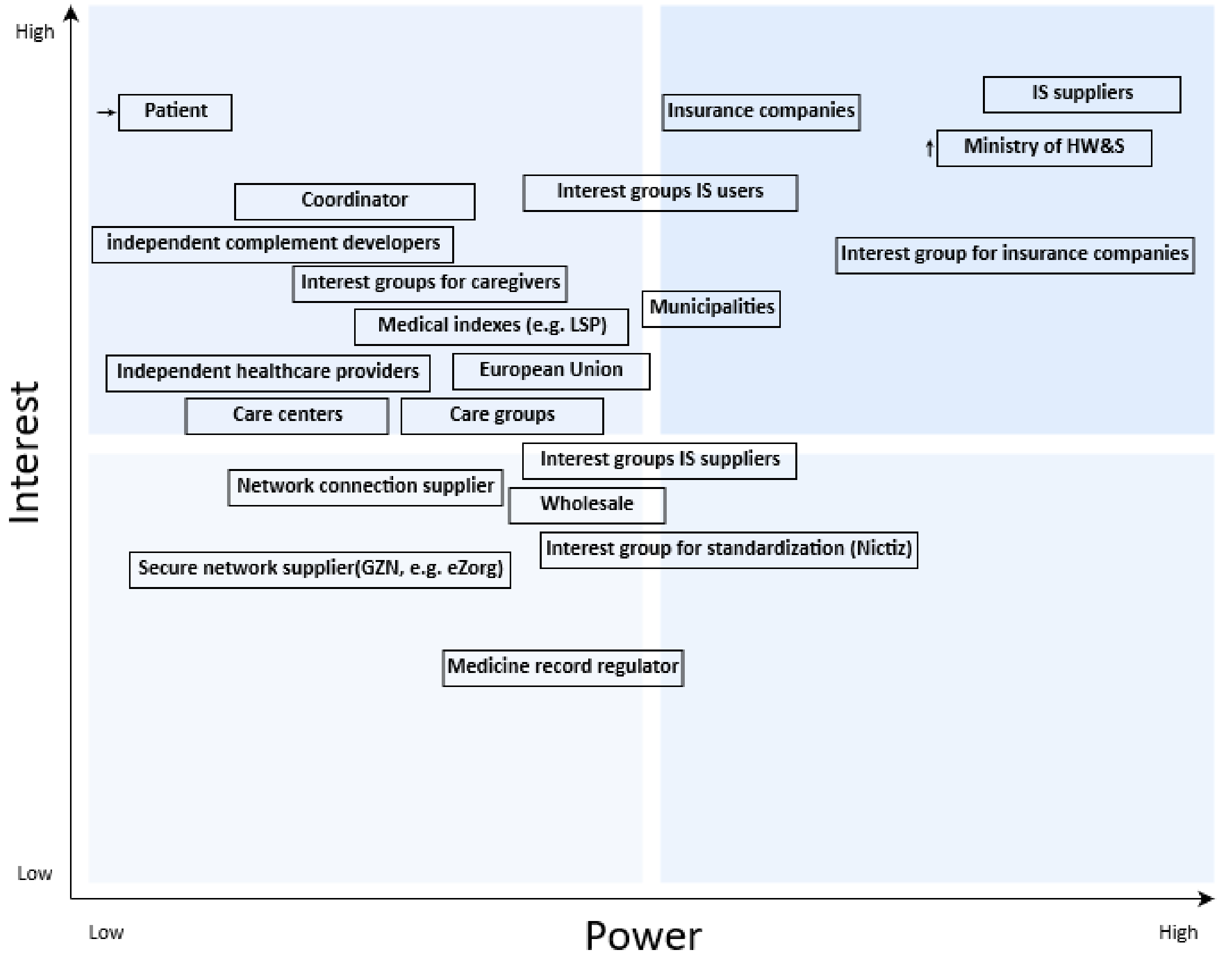

Figure D.1: Power interest grid

E

Explanation of the Atlas.ti analyses

This appendix shows an overview of the codes and the characteristics for the three dimensions.

E.1. Core dimension

E.1.1. Coding of transcripts

First, the parts of the interview transcripts relating to the core-openness dimension were coded. These were coded twice, first through open coding and secondly through axial coding. Axial coding involved making clear distinctions on the comments that referred to specifically to the design options, the relationships between concepts and grouping the codes related to those similar concepts. For this part, also sketches were made for how the concepts were interrelated (for instance 'Concept A *is a reason for* Concept B). These codes were interpreted by developing a network using Atlas.ti.

Open coding for this dimension initially resulted in 66 codes. After considerations, five codes were merged because they were found to indicate the same factors. Furthermore, six codes were removed for varying reasons: legal constraints was mentioned as a factor to influence the current system but that falls outside the scope of this thesis (chapter 1). For option 4 (gateways), some said that it was easy to implement (MI2), while others contradicted this statement, saying that it is complex to implement due to the absence of a sense of ownership for such a gateway structure and that it is not an efficient way for achieving interoperability (MI1). In other cases, the codes had a *density* of zero, meaning that they were not associated with any other codes, therefor these codes were excluded. Finally, 34 codes were included in the analysis.

These codes were plotted in a network, to visually illustrate how components and trade-offs are related in the perception of the interviewees. Figure 7.1 shows the network that was developed for the core dimension. The nodes in the figure represent the codes, together with their *groundedness* (the number of times mentioned) and *density* (the number of relations to other codes). In black-and-white, the four design options are represented. A fifth block was added to this selection: Healthcare general interest. Some concepts were specifically referred to by respondents to be in the general interest of healthcare, because they were considered essential for the primary care domain.

Preferably, codes that were mentioned more than once (groundedness > 1) would be included in the analysis because these codes seem to take a prominent place among the trade-offs expressed by respondents, however, this was not always possible. It should be mentioned that the group of respondents was limited to eight persons. As a result, it has happened that some codes were only mentioned by one of the respondents. Whenever these codes provided an interesting perspective, they have been included in the analysis. This comment accounts for the analysis of all parts of the interview.

Code	Grounded	Density
CD: Accountability issues	3	1
CD: Awkard to User	1	0
CD: Changing Market Needs	2	1
CD: Closedness	2	1
CD: Community Feedback	1	1
CD: Competition	2	1
CD: Complexity	1	1
CD: Core Functionality	8	1
CD: Current Situation	8	7
CD: Difficult to coordination	2	3
CD: Difficult to implement	5	2
CD: Ease-of-Use	6	2
CD: Easy-to-coordinate	1	2
CD: Entry Barriers	2	1
CD: Focus on Short-term Solutions	1	2
CD: Gain Market Position	1	1
CD: Government Role	2	4
CD: Healthcare General Interest	16	8
CD: High Switching-barriers	1	1
CD: Inefficient	3	2
CD: Innovation	11	5
CD: Instability in development	1	1
CD: Interdepence among suppliers	2	1
CD: Interoperability	2	2
CD: Lack of perceived urgency to innovate	1	1
CD: Least Common Denominator Dynamics	5	3
CD: Legal Constraints	1	0
CD: Limited control	2	1
CD: Low Distinctive Value Possibilities	1	2
CD: Low Interest for Economic Returns	1	1
CD: Low R&D Costs	1	2
CD: Low-switching barriers	2	1
CD: Monopolist	1	1
CD: Need for Transparency	1	1
CD: One core preferred	9	3
CD: Out-of-the-Box Implementation	1	2
CD: Political Dynamics	4	3
CD: Quality Control	3	1
CD: Quality Core	1	0
CD: Realistic	1	0
CD: Reliability	1	1
CD: Risk of abuse	1	1
CD: Risk of Forking	1	1
CD: Risk of Loss of Quality	1	0
CD: Scattering of Initiatives	1	3
CD: Sensitive Data	1	0
CD: Shared Vision	1	1
CD: Skilled Users	1	0
CD: Small Core	4	2
CD: Stability	1	1
CD: Strengthen Market Position	2	2
CD: User Lock-in	2	1
CoreDimension: Option 1	12	5
CoreDimension: Option 2	27	13
CoreDimension: Option 3	17	6
CoreDimension: Option 4	7	4

Figure E.1: Codes included for the core dimension analysis

E.1.2. Current situation and general interest derived from transcripts

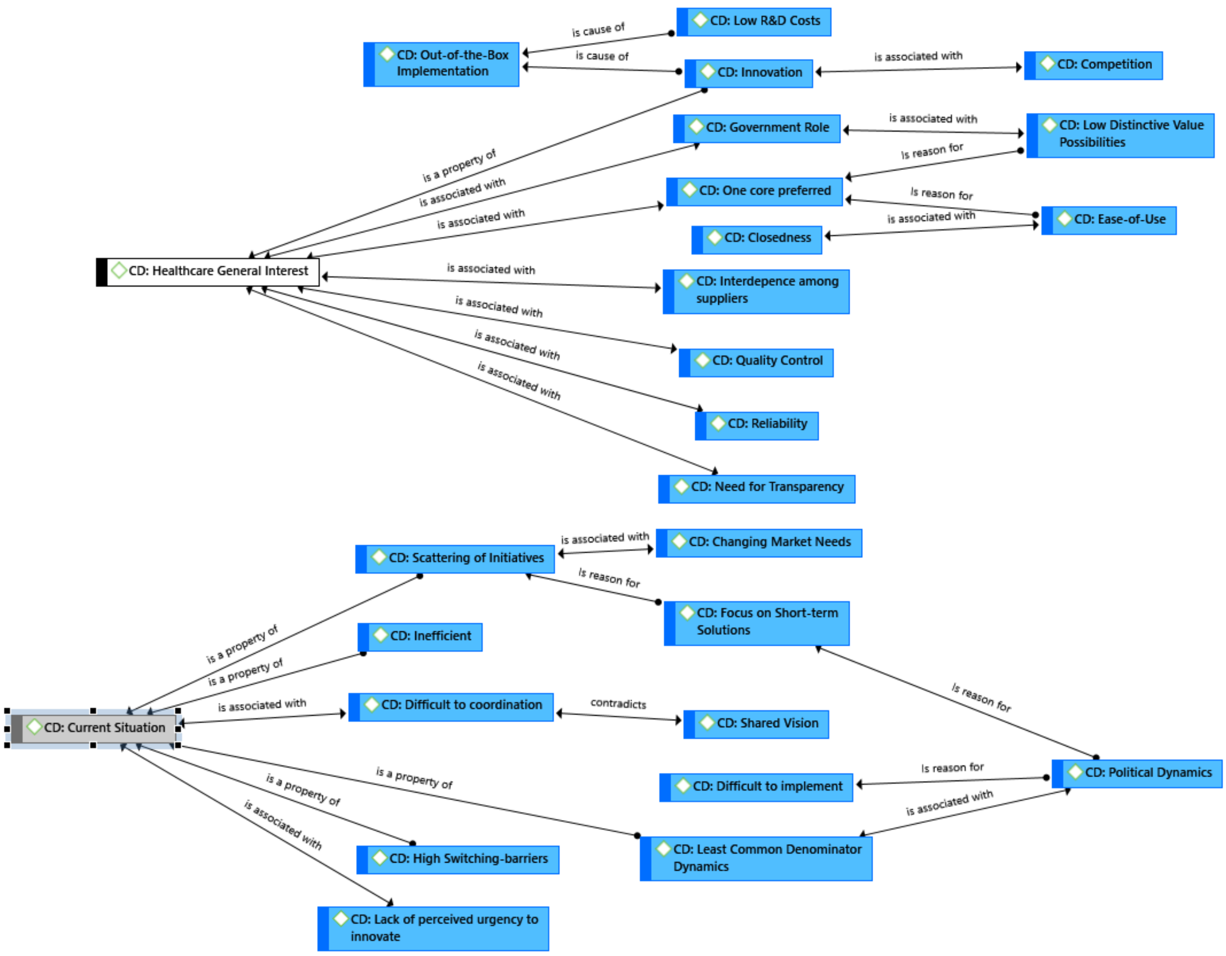

Figure E.2: Network graph for the current situation and trade-offs in the general interest relating to the openness of the core

E.2. Interface openness dimension

E.2.1. Coding of transcripts

The approach to analyzing this dimension was the same as for the core-dimension. This process initially resulted in 39 codes for this part of the interview. In Atlas.ti, axial coding was performed to identify linkages among components. After this, twelve components were removed due to vagueness of the codes and because the codes could not be attributed to other components. Again, a network was developed to graphically show how the components for the interface-openness dimension relate. This network is presented in Figure 7.2.

Figures 7.2 and E.4 show the components in green. The design options are shown in black. Similar to the core-dimension, one component was added. For some components, it was explicitly mentioned that they are important to this dimension in general, these components are linked to the black-node 'InterfaceOpenness General'. This latter node is what is first discussed here. Subsequently, the trade-offs expressed in relation to the other design options are presented.

	Code	Grounded	Density
•	InterfaceOpenness General	6	4
•	InterfaceOpenness: Option 1	10	7
•	InterfaceOpenness: Option 2	17	9
•	InterfaceOpenness: Option 3	21	10
•	IO preference: Option 2	6	0
•	IO: Cost Efficient	1	1
•	IO: Current Situation	1	2
•	IO: Data management control	2	1
•	IO: Ease-of-use	1	1
•	IO: Easy to coordinate	1	1
•	IO: Efficiency	1	3
•	IO: Governance	3	4
•	IO: Identity Control	2	2
•	IO: Incentive to Innovate	1	1
•	IO: Innovation	8	4
•	IO: Lack of Control	3	1
•	IO: Lock-in	1	1
•	IO: Lower R&D	1	2
•	IO: Monopolist	1	1
•	IO: Number of complementors	1	1
•	IO: Number of Platforms in Market	1	1
•	IO: One core preferred	4	3
•	IO: Openness	3	0
•	IO: Preference Option 3	2	0
•	IO: Quality Control	23	8
•	IO: Requirement	6	6
•	IO: Responsibility issues	1	4
•	IO: Risk of abuse	5	2
•	IO: Security control	5	4
•	IO: Sensitive functionality	2	2
•	IO: Success	1	0
•	IO: Tailoring	3	3
•	IO: Threat to platform quality	2	3
•	IO: Tight Integration	1	1
•	IO: Unfamiliar Partners	3	1

Figure E.3: Codes included for the interface openness dimension analysis

E.2.2. Current situation and general interest derived from transcripts

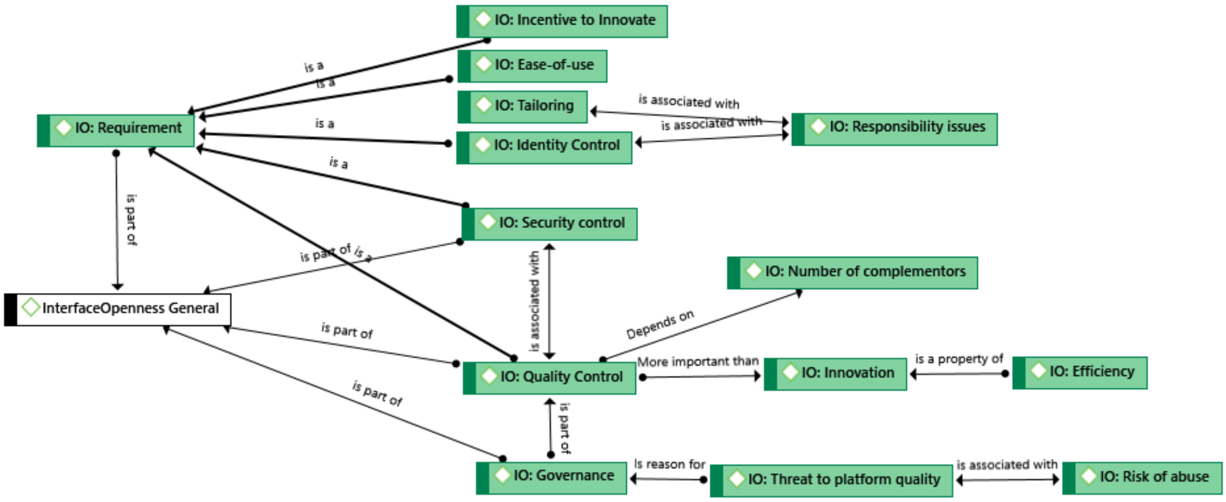

Figure E.4: Network graph for the current situation and trade-offs in the general interest relating to the openness of the interfaces

E.3. Interface stability dimension

E.3.1. Coding of transcripts

This section presents the analysis of the interfaces standards dimension and the insights it provided relating to platform openness, architecture and design trade-offs. The transcript were again analyzed in Atlas.ti. First, linkages among codes were sketched on paper. Later the codes and their relations were iterated and drawn in a network image in Atlas.ti. The network image, visualizing the relations among the components is presented in Figure 7.3. Finally, 29 (initially it were 35) codes were included in the round of coding.

Figures 7.3 and E.4 show the nodes (codes) in yellow and the design options in black. Again, one component was added to the diagram because the interviews revealed that some codes relate to the dimension of interfaces standards in general. This node, 'InterfaceStandards General' (in figure Figure E.6, is also shown in black.

Code	Grounded	Density
InterfaceStandards General	3	2
InterfaceStandards: Option 1	6	4
InterfaceStandards: Option 2	11	8
InterfaceStandards: Option 3	19	9
IS: Additional functionality	2	1
IS: Changing market needs	2	1
IS: Constraint	1	1
IS: Control	3	3
IS: Core functionality	4	1
IS: Current situation	3	3
IS: Data Semantics	2	1
IS: Desired properties	0	1
IS: Efficiency	2	2
IS: Flexibility	1	1
IS: Focus on Short Term Solutions	1	4
IS: Government Perspective	1	1
IS: High Innovation Speed	2	1
IS: Inefficiency in complements	1	1
IS: Innovation	1	0
IS: Interoperability	2	2
IS: Lack of Transparency in Market	3	3
IS: Least Common Denominator Dynamics	1	1
IS: Limited Innovation Speed	3	3
IS: Low Innovation Speed	1	2
IS: Political Dynamics	5	5
IS: Preference Option 3	3	0
IS: Private Party Perspective	3	2
IS: Slow Adoption Speed	2	2
IS: Strenghten Market Position	2	3
IS: Suppliers Lacking Willingness for Openness	1	1
IS: Switching Opportunities	1	3
IS: Type of functionality	2	4
IS: Undesirable	2	2

Figure E.5: Codes included for the interface stability dimension analysis

E.3.2. Current situation and general interest derived from transcripts

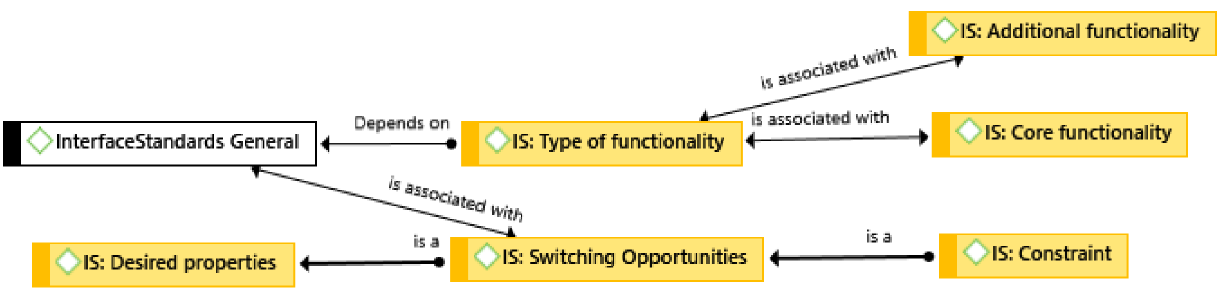

Figure E.6: Network graph for the current situation and trade-offs in the general interest relating to the stability of the interfaces

F

Reflections on the usage of the Design chart

This section deals with discussing whether the design chart was a feasible solution to discussing trade-offs relating to openness of the architecture of a digital platform in primary healthcare. To this end, it also discusses what modifications to the chart resulted from the interviews.

F.1. Usefulness of the concept artefact design

Usage of the concept artefact was considered a useful means to identify trade-offs for platform openness in the Dutch primary care domain. Firstly, the respondents expressed similar concerns on relating topics, supporting the initial observation by the researcher that the respondents had a similar understanding of the concepts introduced by the researcher. There was some difference in the level of technical knowledge (and affiliation with the material) between the different interviewees but this was not too significant to be considered a limitation to the usage of the chart. A second argument why the chart was considered helpful, was that the interviews resulted in extensive and rich discussions on openness in the healthcare domain, as expressed for instance by TI2 in the quote below. Thirdly, there was both overlap in the responses the interviewees expressed as well as insights that were only provided by a single respondent. The latter observation also suggests that the interviewees had the same level of abstraction in mind during the discussions.

F.2. Suggestions for modifications

Several suggestions to clarify the chart were made by the respondents, these are reported in Table F.1. Most notably, it was recognized that there was some discrepancy between the options 1 and 2, and the options 3 and 4 of the *core-dimension*. While options 1 and 2 concern a platform-level decision, options 3 and 4 relate more towards an ecosystem-decision and are involved with the question of interoperability of different platforms. This comment was acknowledged and taken into account for iterating the concept design.

Based on the interviews, several modifications have been made as a first iteration to the concept artefact. The iteration of the design chart is presented in Figure F.1

F.3. Final remarks concerning the artefact design

Several comments are worth noting concerning the design of the artefact:

- **Strengths**

Table F.1: Suggestions for modifying the concept design chart

Concept	Suggestion	Interview	Modified y/n
Core-dimension	There is a difference between options 1 and 2 compared to 3 and 4; options 1 and 2 describe only one platform, while 3 and 4 have more to do with interoperability between different platforms	PI1, PI2 and MI21	This distinction was acknowledged by the researcher and mentioned in subsequent interviews
Interface-openness dimension	Some of the sketched consequences have confusing consequences, e.g.: option 1 (low generativity), option 2 (high generativity), option 3 (high generativity). It would be more useful to show the degrees to which they differ (so option 2 would become 'medium generativity')	PI1	Acknowledged by the researcher and adjusted for later interviews
Interfaces in general	It was mentioned that for the primary health-care domain, interfaces can be interpreted from a 'functionality-perspective' and from a 'data-transferring perspective'. Both perspectives are important to address. Data-transferring is an important topic in the care domain, one with which current IS-developers struggles to find agreement on a solution	MI1	No, this is included in the discussion
Consequences in general	It was remarked that most consequences relate to economical trade-offs, while for the care domain other consequences may be important	TI2	This suggestion was acknowledged but not included, this concerns the goal of this research, identifying trade-offs important for the primary care domain

Architecture dimensions	Design choices		
	Option 1	Option 2	Option 3
Core	Proprietary	Resource openness	
Core interoperability	Meta-platform	Gateways	
Interface openness	Proprietary interfaces	Selectively open	Open interfaces
Interface stability	Non-stable interfaces	Stable interfaces	Industry-standard interfaces

Figure F.1: Iteration to the concept artefact design

Based on the course of the interviews, the following strengths can be attributed to the artefact. First of all, (1) the design chart proved to be an appropriate means to discuss the design of a platform-based ecosystem, revealing a variety of trade-offs and preferences relating to platform openness. Secondly (2), it was usable both by respondents that were unknown to digital platform architectures (PI2) as well as to people more experienced in the field of digital platforms (for instance TI1 and TI2). A third (3) aspect that is considered a strength is that the chart was easy-to-use. Fourth (4), the chart provides a concise conceptual overview of theory on platform architecture and platform openness.

- **Weaknesses**

  One weakness that can be attributed to the design chart (1) is that it is a rather simplistic representation of the design choices. The chart allows only for a tight distinction between the options, whereas in reality maybe a combination of options is also possible. For instance, a platform can both incorporate industry-standards for some functionality, while it has proprietary, non-stable interfaces for other functionality.

  A second (2) aspect is that the chart does not take into account the role of data-transferring and semantics of the data that is gathered and stored. This would in particular have been interesting for the healthcare domain, as data- and information transferring is one of the key functions of information systems supporting this domain, and the current ways of data transferring and related technical standards are considered sub-optimal (MI1).

  Thirdly, (3) the core-dimension has four design options but they do not all unambiguously relate to each other. As previously said, the first two options and the latter two options are related. This had the implication that the respondents were inclined to choose only one of the four options, while a combination of either option 1 or 2, and either option 3 or 4 was also possible.

- **Feasibility**

  Concerning the feasibility of the artefact, both affirmative and adversative arguments can be appointed.

  Arguments supporting the feasibility of the artefact are (1) the fact that the chart proved capable of eliciting trade-offs relating to digital platform openness specific to the Dutch primary care domain. Furthermore, (2) the chart was easy to use. Thirdly (3) the chart takes a level of abstraction that allows for high-level design of a platform-based ecosystem level that seemed to be a relevant perspective for discussing trade-offs in this domain.

  Counterarguments for the feasibility of this chart are (1) that it takes a 'green-field approach', thereby neglecting the existing situation and stakeholders. Secondly, (2) it does not involve how the design options may be implemented, which in the case of the domain under study, is expected to be a difficult endeavor (as also expressed by MI2).

- **Untested assumptions**

  Finally, some underlying assumptions must be noted. First, in terms of ownership (1), it was assumed that one party is the owner and multiple platforms can coexist in parallel. In the interviews, it was repeatedly mentioned that it might be a preferred solution that only one platform exists in this domain (PI1, PI2, TI1, TI2, MI1, MI2). Also, (2) no assumption was made concerning the core functionality of the platform core. It was mentioned frequently that the design choice for the core-dimension would depend on the functionality that is included in the platform core (PI1, PI2, TI2, MI1, MI2). In the later interviews, it was consistently assumed that the core provided functionality for identification, authentication and patient treatment logging.

G

Information Package

Architectural openness for a digital platform in primary healthcare – studying design options

1. Preliminary summary of MSc thesis research

The Dutch healthcare domain is expected to face some complex challenges in the near future. First of all, an aging population increasingly relies on healthcare support. Secondly, a shift in burden of disease is observed, from short-term illness (incidents, infections) towards long term complaints (e.g., obesity, depression). This shifting burden of disease requires continuous care support and it requires holistic care, i.e. multiple caregivers that collaborate in providing efficient and effective patient care. Thirdly, the capacity of healthcare support cannot keep up with the demand for care. Finally, there is a need for cost-containment as the demand for healthcare increases.

At the same time, developments in information technology (e.g., IoT, blockchain, big data) provide solutions that could serve to solve these challenges by enabling better coordination and communication between care givers, tailored to patients' needs and by adopting technical solutions serving the patients' health – thus improving overall patient care by the primary care domain.

Currently, information systems (IS) supporting caregivers in primary healthcare seem slow at innovating and adopting technical solutions that may improve the care support. A shift towards a digital platform organization of ISs is proposed as a solution to the challenges that the domain faces.

Digital platform are considered software-based technical artefacts that provide certain core functionality, that is shared by different modules that interoperate with the platform Tiwana (2014). Furthermore, these platforms are surrounded by an ecosystem of (1) contributors that develop complementary services and products to the platform and (2) users that make use of the platform and its services. This structure allows the platform to flexibly adapt to changing needs and emerging technological developments, by development of new service offerings. Because a platform can cultivate the developments of a network of third party developers, they typically exert powerful innovation capabilities.

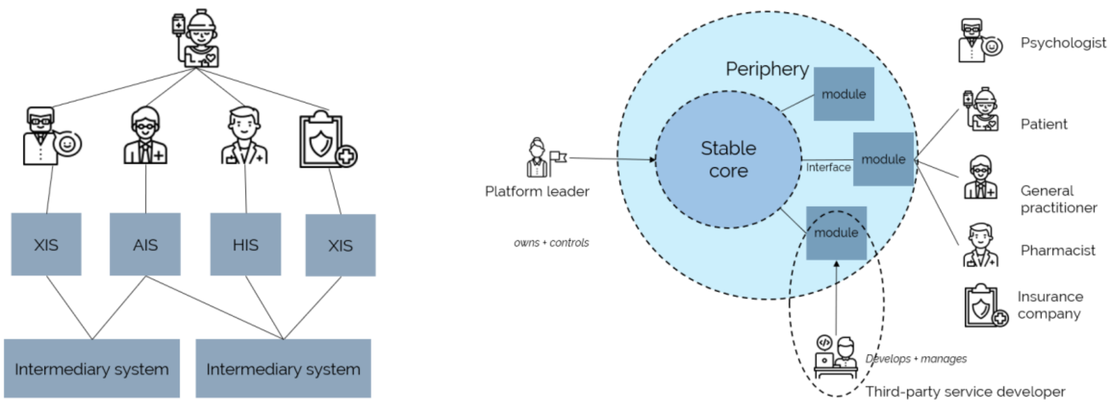

Fig. 1: Left: Simplistic visualization of current organization information systems in the primary care domain. Right: Visualization of a platform-based organization.

When developing a digital platform, an organization must deal with several strategic decisions that determine how the platform will evolve over short- and long-term. One of the most important choices concerns the level of *platform openness*.

Platform openness essentially is the degree to which external parties are allowed to use, develop services on- or commercialize the platform. Openness is an interesting property to study because it closely relates to the ultimate goal of introducing more innovation, reduces R&D costs and it increases flexibility of the information systems supporting the primary care.

The degree of platform openness may thus benefit the primary care domain, but it also introduces risks. What is more, platform openness can be achieved in different ways, through the organization of the platform's governance structure or by means of its architecture. For this study, I am interested in studying what choices organizations have for an architecture, allowing varying configurations for the platform's openness.

1.1 Platform architectures and openness

So how do we interpret the phenomenon of *platform architecture* and how can configurations of the architecture facilitate different degrees of platform openness? Moreover, what are the benefits and downsides of varying configurations of the architecture and its effect on the platform's openness? These questions will be covered 1) by providing an overview of the different choices that platform leaders can make concerning openness and 2) by describing what promises and risks are related to these configurations. All concepts, configurations and consequences of these configurations were derived from academic research on digital platforms.

Researchers seem to agree that the architecture of a platform-based ecosystem is based on the principle of *modularity*. Modularity is based on the principle that modules can be added to the core platform, while interdependence between the modules and the platform is intentionally reduced (Tiwana, 2014). A *module*, in this case, is "an add-on software subsystem that connects to the platform to add functionality to it (e.g., iPhone apps and Firefox extensions)" (Tiwana et al., 2010, p. 675).

Our understanding on the architecture of a platform is based on the description by Tiwana (2014), and is visually represented in figure 1 on the right side.

The architecture constitutes of:

- The Core
- Interfaces
- Modules

The platform owner can control the architecture of the core and the interfaces. How the modules are configured, is the realm of the *complementors* (i.e. application developers). Because the configuration of the modules cannot be influenced by the platform owner, this factor is not considered for this study.

These two components are thus considered as the *dimensions* that can be configured. For each of these components, literature shows different modes for how to organize them.

1.2 What is the 'core'?

The platform's core, which essentially is the platform, is managed by the platform owner. A platform owner can opt for different strategies for opening or closing the core

1.3 What are the 'interfaces'?

Other than opening up the platform at the core, platform leaders can also choose to open up by opening up the platform through the interfaces (Hein et al., 2018). But first, how are interfaces interpreted?

Interfaces determine how the different components interact with the core (Baldwin & Clark, 2000). The interface can, according to Gawer (2014, p. 1243) be seen as "a divider, but also a connector and a conduit of selected information facilitating interconnection". I adopt the perspective of Gawer (2014, p. 1243) concerning interface openness, as "the interface contains information that is accessible to external agents and usable by them to allow to build complementary innovation that is compatible with this interface".

2. Goal of this interview: application of a design table

From scientific literature, we have derived *design options*, i.e. different configurations of a platform's architecture, that allow varying degrees of platform openness. We are interested in the application of this design table and to see whether it can be used to make a decision for architectural openness for the primary care domain.

<u>**This design table and the rationale for the table will be presented during the interview.**</u>

The goal of this workshop is twofold:
1. To validate whether this table can be used to inform the design choices towards the development of a digital platform in the Dutch primary healthcare domain;
2. To develop an initial understanding of the trade-offs that industry-experts make for a digital platform in this domain.

The interview will leave room for the participants to share additional relevant insights.

This study is conducted in the context of the MSc program of Complex Systems Engineering & Management at Delft University of Technology, to obtain the degree in Master of Science.

This document serves as an introduction to a workshop on a design table for open architectures of digital platforms for the Dutch primary healthcare domain (NL.: Eerstelijnszorg). This table presents an overview of the options an organization has for openness of the architecture of a digital platform.

These workshops involve one-on-one (or one-on-two) discussions (semi-structured interviews) between the researcher (Mats) and industry-experts. The goal of the workshop is to reflect on the effectiveness of the preliminary design table and to study what insights the discussions yield towards designing a digital platform-based ecosystem in the primary care domain.

For comparability of the feedback presented by participants of the workshop, we will make use of a semi-structured interview format.

During the workshop, a slide deck will be presented. This slide-deck serves as a means to introduce some of the core concepts in my thesis and to explain the rationale behind this thesis. For instance, it discusses:
- 'How platform openness affects the short- and long-term development of a platform';
- 'What design options platform leaders have to influence the level of openness'

<u>No prior knowledge is required for this session other section 1 and 2 of this document.</u>

CONTENTS OF THIS DOCUMENT

A. About personal data and consent

Before the talk, I will ask the participants for their consent with terms concerning data gathering. Participants will receive a form (1 page), requesting their approval to use the information collected in the interviews. This form is in line with the guidelines of TU Delft's data protection department.

Processing of personal information
To comply with academic requirements and standards, this interview will be audio-recorded. The recording will be transcribed to text and the audio-recordings will be deleted after transcription. The transcriptions will not be made publicly available, it will only be archived for traceability purposes. Any information that may identify a participant (e.g. his/her name or organization) will only be available to the researcher and the graduation committee.

In addition, anonymised insights that emerge from the interview, may be used for the researcher's master thesis, (scientific) publication and/or other educational purposes. Also, in these publications, anonymised quotes may be used.

Consent
The participants will be explicitly asked for their consent to the terms of this interview. A copy of this consent-form is sent as an attachment to this document.

Rights of the participant
The participants have the right to request access to-, to rectification of- and to erasure of the personal data collected in this interview. Participants may at any moment choose to withdraw from the study. Complaints can be filed with Delft University of Technology's data protection department.

Contact details and affiliated institutions
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Affiliated research institute: Delft University of Technology (data protection department: privacy@tudelft.nl)

Other affiliated institutions: this master thesis is research is conducted as part of an internship at Promedico.

Additional background information about this thesis research

N.B.: You are not required to read this, this information is provided as background in case you are interested to know more about this thesis

3. Motivation for this Master thesis

The Dutch primary healthcare domain is characterized by a large number of involved actors and by a high variation in terms of information systems and network connections. Although these information systems have adequately supported caregivers, changing needs in healthcare introduce challenges to the way the information systems are organized.

3.1 Trends in healthcare

Several trends change the needs concerning information systems in the primary care domain:

1. An aging population with increased need for patient care while the capacity in terms of health support does not increase proportionally;
2. A shifting burden of disease (from short-term diseases to long-term chronic diseases, e.g. obesity, depression);
3. A need for holistic patient care (integration of different types of care);
4. A need for containment of costs on healthcare.

3.2 Developments in information technology

Currently, the information systems in the primary care domain are tightly vertically integrated and seem incapable of adapting to these changing needs for this domain.

What is more, developments in information technology offer new opportunities to support caregivers. For instance, wearable and implementable technologies, big data and blockchain technology offer new ways to improve healthcare support. However, in the current landscape of information systems for the care domain, it is difficult to integrate these technological innovations.

A new way of organizing the information systems supporting the primary healthcare domain is required; one that facilitates flexibility, interconnectivity of caregivers and that stimulates innovation. I propose that a digital platform-based ecosystem can serve these needs.

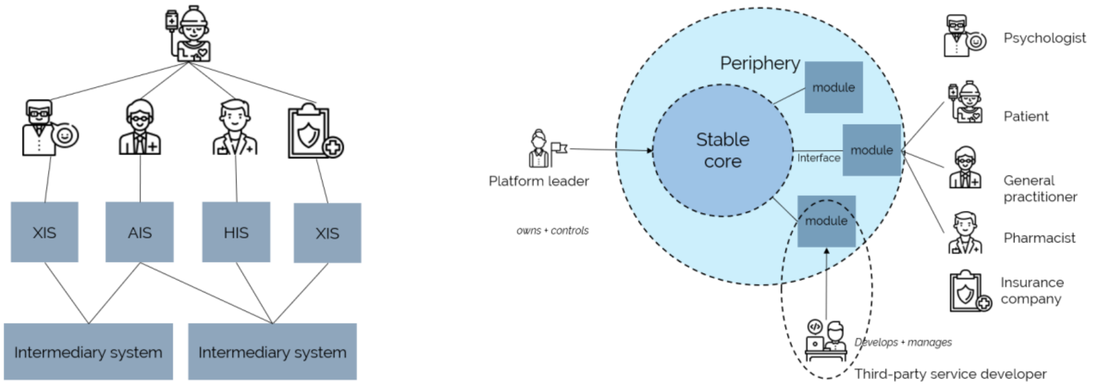

Fig. 1: Left: Simplistic visualization of current organization information systems in the primary care domain. Right: Visualization of a platform-based organization.

Box 1: On innovative services in the primary care domain and example applications

For this thesis, we assume that a lively and dynamic ecosystem of third-party service developers is beneficial to the primary healthcare domain. By leveraging the knowledge of third-party developers, we expect to see an increase in innovation efforts for the primary healthcare domain, developing services that benefit both the side of the care givers as well as the patients.

Example 1:
A developer designs an IoT-medicine box. This medicine box can accurately keep track of the patient's intake of medicine. This information may be shared with the patients' general practitioner, pharmacist and insurance. They can proactively adjust the required medication.

Example 2:
A patient makes use of his mobile phone camera to keep track of complaints concerning a mole on his/her skin. The picture can be send to a general practitioner. Simultaneously, this picture may be analysed, comparing it to pictures of moles of other patients. Information regarding this analysed picture can assist the general practitioner in making a decision that he/she can discuss with the patient.

4. Goal of this Master thesis

The ultimate goal behind this master thesis is to understand how an open platform-based ecosystem can be designed to support the Dutch primary healthcare domain. More specifically, we are interested in what design choices relating to *openness of architectures* organizations face prior to the establishment of a digital platform.

The intended outcome is to develop a concept design for how the architecture of digital platform can be configured, allowing varying degrees of 'platform openness'. This design will be a table presenting 'design options' for the architecture of the platform. This table can be used as a means for organizations that want to develop a platform to decide on an appropriate architecture. Furthermore, I am interested to understand how context-specific factors from the Dutch primary healthcare domain inform the mode of openness of a platform architecture.

4.1 Research approach

This master thesis follows a design science approach developed by Vaishnavi & Kuechler (2004). Design science is based on the idea to draw from a theoretical knowledge-base in the design of an artefact (Hevner et al., 2004). This approach concerns a sequence of steps:

- Starting from developing an understanding of the problem, to;
- drawing possible solutions from theoretical knowledge, to;
- developing a concept design;
- testing the design
- iterating on the design

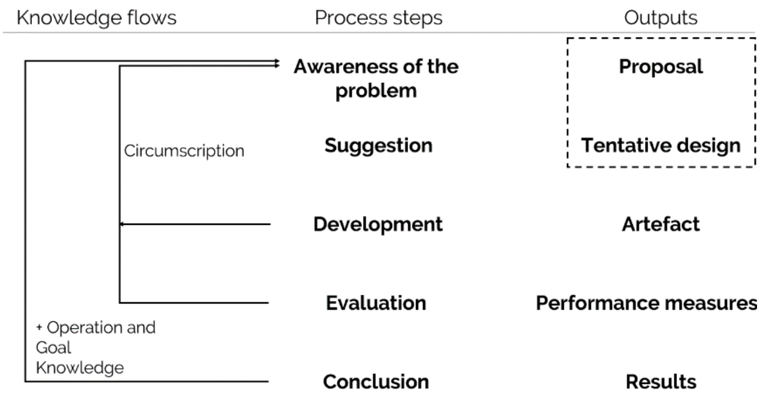

Fig. 2: Design cycle by Vaishnavi & Kuechler (2004)

4.2 Intended scientific contribution

From a scientific perspective, this master thesis has two goals. Firstly, we are interested in how organizations can be supported in the design of digital platforms. Most academic studies on digital platforms have focused on a retrospective analysis of existing platforms. Little research examines the ex-ante design of digital platforms. My research contributes to the scientific body-of-knowledge on digital platforms by identifying what architectural choices platform owners can make concerning the openness of platform architectures.

The second contribution relates to studying the design of digital platforms in the healthcare domain. Digital platforms exist in many different domains (e.g., telecommunication, automotive or banking) and how they are configured is dependent on the needs and requirements for their application domain. I intend to develop an understanding for the needs and the requirements for a digital platform in the primary healthcare domain. This contribution helps to building an understanding of the dynamics shaping digital platforms.

Thirdly, this research helps to build a better understanding of platform openness. Although platform openness has been addressed by multiple researchers, recent studies (De Reuver et al., 2018; Jacobides et al., 2017; McIntyre & Srinivasan, 2017) suggest to still develop a greater understanding of the phenomenon of platform openness (De Reuver, 2019; Research proposal Optimism).

Fourth and finally, De Reuver & Van der Wielen (2019) find that platform owners have a difficult time deciding on the appropriate level of openness. This study intends to contribute to alleviate this stress by concisely describing choices and means that platform owners have to choose a degree of openness for their platform ecosystem.

4.3 Intended practical contribution

From a practical perspective, I aim to contribute by unambiguously describing how a digital platform-based ecosystem may be designed in the Dutch primary healthcare domain, in order to make this domain more capable of effective and efficient patient-care. In addition, this thesis contributes to understanding what factors may hinder or stimulate innovation in information systems in primary healthcare.

5. How I define digital platforms and platform openness

For this study, I define digital platforms as a way of organizing information systems. A digital platform-based ecosystem revolves around a 'core' (the platform) to which modules can be attached that add functionality to the platform. This structure allows the platform to flexibly adapt to changing needs and emerging technological developments, by development of new service offerings. Because a platform can cultivate the developments of a network of third party developers, they typically exert powerful innovation capabilities.

When developing a digital platform, an organization must deal with several strategic trade-offs upfront. For instance, will the platform be organized by one party or by multiple? How will the platform divide the revenues from modules? In this thesis, I solely focus on the trade-offs relating to *platform openness*.

Platform openness essentially is the degree to which external parties are allowed to use, develop services on- or commercialize the platform. Openness is an interesting property to study because it closely relates to the ultimate goal of introducing more innovation, reduces R&D costs and it increases flexibility of the information systems supporting the primary care.

The degree of platform openness may thus benefit the primary care domain, but it also introduces risks. What is more, platform openness can be achieved in different ways, through the organization of the platform's governance structure or by means of its architecture. For this study, I am interested in studying what choices organizations have for an architecture, allowing varying configurations for the platform's openness.

Benlian et al. (2015) argue that platform openness is mainly a governance decision. Based on insights concerning platform architecture by Saadatmand et al. (2019) and Blaschke et al. (2019), we are interested in defining architectural decisions relating to platform openness.

6. Previous steps in this research

Previous steps in this research were concerned with:

1. Developing awareness of the problem
    a. Stakeholder-analysis
    b. Needs and requirements elicitation for future-proof information systems in the Dutch primary care domain.
2. Conceptualizing architectural openness of digital platforms

6.1 Awareness of the problem

This stage of the thesis was concerned with developing an understanding of the landscape of information systems supporting the Dutch primary healthcare domain. This part of the research resulted in the following insights, that are presented in figure 2.

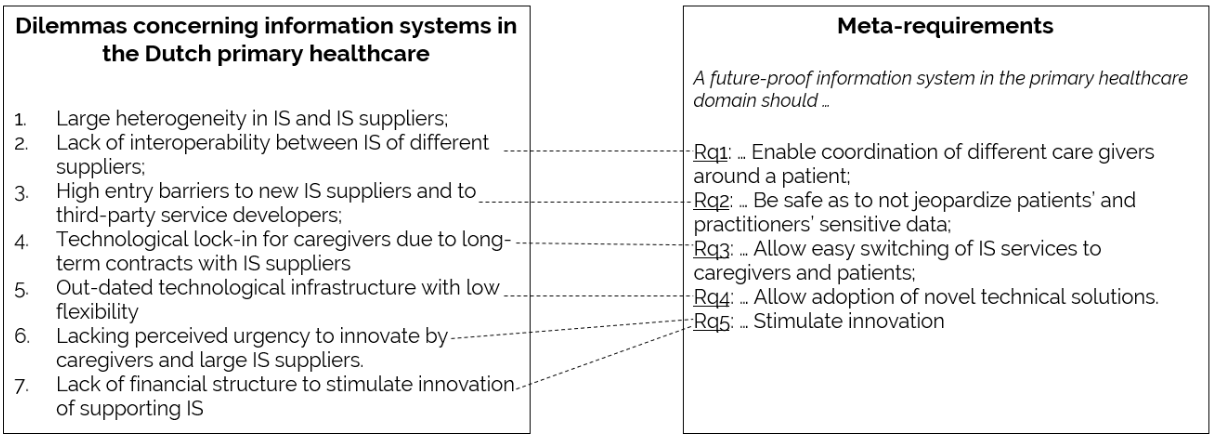

Fig. 2: Problem identification and Meta-requirements elicitation

A stakeholder analysis was conducted to understand what interest- and power-positions stakeholders hold that shape the dynamics within the domain under study. This analysis revealed that key-stakeholders that are most likely to affect the dynamics of this domain, are: IS suppliers, the Ministry of Health, Welfare & Sports, Insurance companies and Interest groups (NL.: belangenvereniging) for insurance companies. While this information gives some useful insights concerning the context of this study, the decision-making process concerning the landscape of information systems is not considered within the scope of this research.

6.2 Architectural openness of digital platforms

So how do we interpret the phenomenon of *platform architecture* and how can configurations of the architecture facilitate different degrees of platform openness? Moreover, what are the benefits and downsides of varying configurations of the architecture and its effect on the platform's openness? These questions will be covered by 1) providing an overview of the different choices that platform leaders can make concerning openness and by 2) describing what promises and risks are related to these configurations. All concepts, configurations and the consequences of these configurations have been drawn from scientific literature on digital platforms.

Researchers seem to agree that the architecture of a platform-based ecosystem is based on the principle of *modularity*. Modularity is based on the principle that modules can be added to the core platform, while interdependence between the modules and the platform is intentionally reduced (Tiwana, 2014). A *module*, in this case, is "an add-on software subsystem that connects to the platform to add functionality to it (e.g., iPhone apps and Firefox extensions)" (Tiwana et al., 2010, p. 675).

Our understanding on the architecture of a platform is based on the description by Tiwana (2014), and is visually represented in figure 1 on the right side.

The architecture constitutes of:

- The Core
- Interfaces
- Modules

The platform owner can control the architecture of the core and the interfaces. How the modules are configured, is the realm of the *complementors* (i.e. application developers). Because the configuration of the modules cannot be influenced by the platform owner, this factor is not considered for this study.

These two components are thus considered as the *dimensions* that can be configured. For each of these components, literature shows different modes for how to organize them.

6.2.1 What is the 'core'?

The platform's core, which essentially is the platform, is managed by the platform owner. A platform owner can opt for different strategies for opening or closing the core

6.2.2 What are the 'interfaces'?

Other than opening up the platform at the core, platform leaders can also choose to open up by opening up the platform through the interfaces (Hein et al., 2018). But first, how are interfaces interpreted?

Interfaces determine how the different components interact with the core (Baldwin & Clark, 2000). The interface can, according to Gawer (2014, p. 1243) be seen as "a divider, but also a connector and a conduit of selected information facilitating interconnection". I adopt the perspective of Gawer (2014, p. 1243) concerning interface openness, as "the interface contains information that is accessible to external agents and usable by them to allow to build complementary innovation that is compatible with this interface".

7. References

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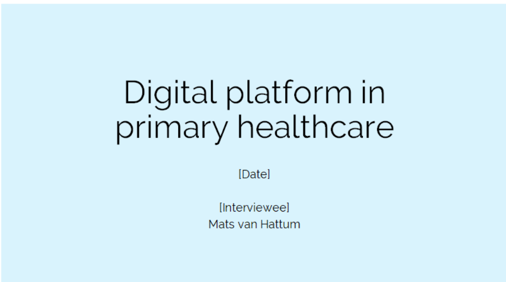
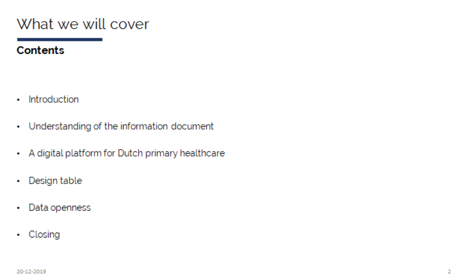
H
Interview slideshow

A PowerPoint presentation was used during the semi-structured interviews. The reason for using a presentation was to present all respondents with similar information for expressing their perceptions and trade-offs.



(a) Slide 1

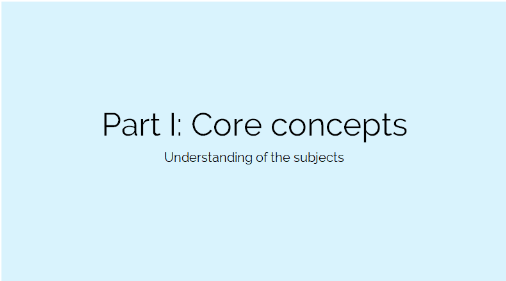


(b) Slide 2

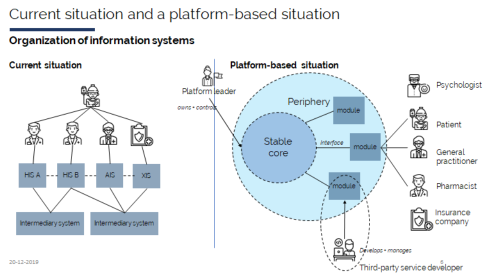
(c) Slide 3

(d) Slide 4

Figure H.1: Slides used for the interviews (part 1/3)

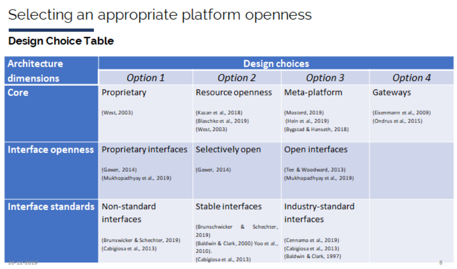


(a) Slide 5



(b) Slide 6

(c) Slide 7



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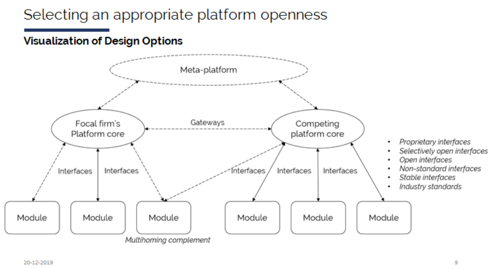
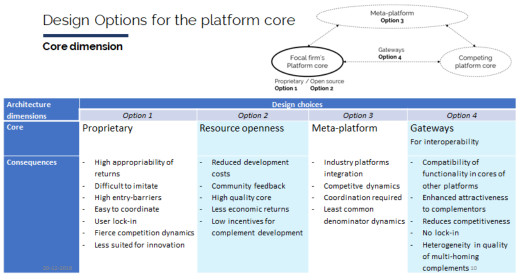
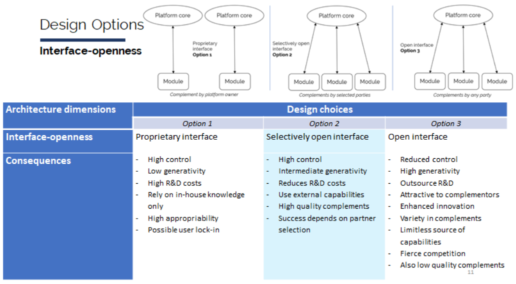


(e) Slide 9

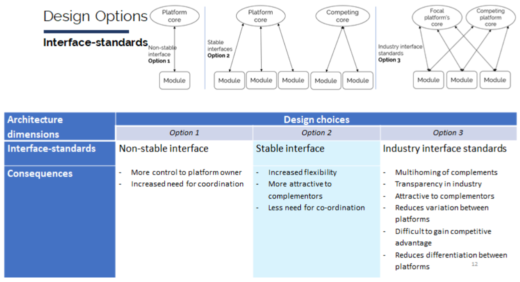


(f) Slide 10

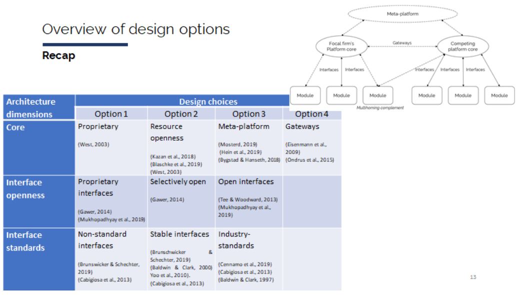
Figure H.2: Slides used for the interviews (part 2/3)



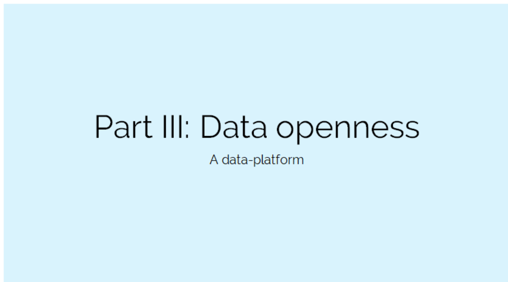
(a) Slide 11



(b) Slide 12



(c) Slide 13



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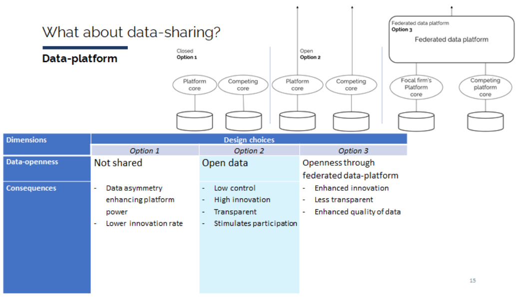
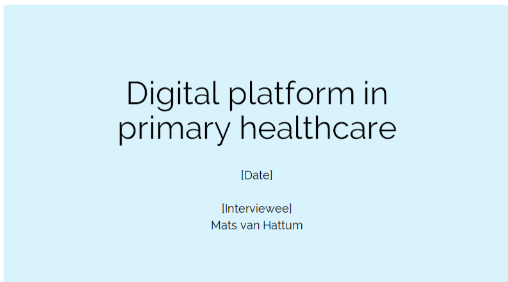


(e) Slide 15



(f) Slide 16

Figure H.3: Slides used for the interviews (part 3/3)

Consent form for semi-structured interviews

The consent form is included on the next page

Consent form Master Thesis: Openness of platform architectures for the primary healthcare

Consent form

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information dated ___/___/_____, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves participating in an interview that is audio-recorded. The audio-records will be transcribed to text. The recordings will be deleted after transcription	○	○
Use of the information in the study		
I understand that information I provide will be used for the researcher's master thesis, (possibly a) scientific research article and/or educational purposes	○	○
I understand that personal information collected about me that can identify me, such as my name of my employer, will not be shared beyond the study team.	○	○
I agree that my information can be quoted in research outputs	○	○

Signatures

______________________ ______________________ ________

Name of participant Signature Date

I have accurately read out the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

Mats van Hattum ___________________ ________

Researcher name Signature Date

Study contact details for further information:

Mats van Hattum

Tel.: 0634409933

Mail: M.T.vanHattum@student.tudelft.nl