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The classification of integration aspects regarding systems in healthcare organizations

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BACHELOR THESIS

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Abstract

Background - Despite extensive research over many years, system integration is still one of the most critical issues healthcare organizations face today. Due to the increase in information systems implemented by healthcare organizations, the application landscape has turned into isolated islands that need to be integrated. This prevents the optimal use of medical resources and the optimization of healthcare systems.
Objective - To mitigate this problem, healthcare organizations should be able to integrate their systems as efficiently as possible. In order to do so, it is crucial to know the different aspects of integration. Therefore, the objective of this research is to classify the integration drivers, types, difficulties, and technologies, as well as to identify integration prospects from a more practical perspective of IT consultants and healthcare organizations in the Netherlands.
Methods - Three consultants at Creq, an IT consultancy specialized in healthcare, were interviewed to gather information on system integration within healthcare organizations. In addition, we interviewed four representatives of healthcare organizations, to triangulate the data and get their perspective on integration as well.
Results - The seven interviews resulted in an overview of the system integration drivers, types, difficulties, and technologies within healthcare organizations in the Netherlands. In addition, the integration prospects were presented as stated by both IT consultants and healthcare organizations, to inform Creq about the future of integration.
Conclusion - From the results it could be derived that system integration can be classified in various ways, given that our research established another classification of integration types than the many already existing categorizations. Our classification is focused on healthcare organizations in the Netherlands within a practical context. Moreover, the interviews and the literature did not coincide on the integration technologies, yet their results were similar with regard to the integration difficulties. Lastly, it could be concluded that the integration philosophies of the healthcare organizations were all different. Given these conclusions, we gave Creq recommendations on focus points for system integration in healthcare organizations in the future.

Contents

1 Introduction

In the first section, the background and problem statement on system integration in healthcare organizations will be presented. The next section describes the host organization of this thesis, as they were the motivation behind this research. Based on these sections, the aim of the study will be outlined along with the research questions that we used. Lastly, a brief overview of the thesis is given.

1.1 Background and problem statement

Technology made its way into every industry and it seems like there is an endless amount of systems to use for organizations. For a sector such as healthcare, there are a lot of advantages, as everything is possible in one system or another, meeting their own specific needs and demands. However, there is also a big disadvantage: the integration of those diverse systems.

System integration has been a topic of research for many years, as the first definition of integration was already stated in 1969 by Lorsch and Lawrence (1969). Even though there have been many studies since then, integration is still seen as one of the most critical issues that organizations face today (Giachetti, 2004), and the healthcare sector is no exception. Wu and Trigo (2021) stated that due to the increase in information systems implemented by healthcare organizations, the application landscape has turned into isolated islands that need to be integrated. This lack of information sharing and interoperability prevents the optimal use of medical resources (Yang et al., 2010). Moreover, optimizing the healthcare systems can only be realized if the systems are integrated and working together (Harkke et al., 2003).

1.2 Host organization: Creq

Creq is an IT consultancy based in the Netherlands and specialized in long-term healthcare. It is a small company consisting of twelve consultants who aim to innovate and optimize processes within healthcare organizations. Their focus lies on, but is not limited to, healthcare organizations that offer home and elderly care. As Creq advises and guides healthcare organizations regarding their problems in the IT department, they have developed extensive knowledge of the current IT problems that healthcare organizations are facing today. One of the issues that is the most pressing according to the consultants, is that of system integration. Therefore, this research was initiated to investigate this issue.

1.3 Aim of this study

As system integration is a current hurdle that healthcare organizations have to overcome when optimizing their application landscape, this is a domain that should be improved. However, before the integration of systems can be improved, the various aspects of integration have to be identified. This not only includes the different ways to integrate, but also the integration technologies that healthcare organizations can use, integration difficulties that arise, and prospects regarding integration in healthcare in the future. With the identification of these integration aspects, IT consultants can decide what to focus on to help healthcare organizations improve their system integration. In

turn, this will benefit healthcare organizations and consequently their care.

Therefore, this research aims to clarify system integration in the practical environment of healthcare organizations in the Netherlands.

This leads to the following research question:

> How can integration drivers, types, difficulties, and technologies regarding systems in healthcare organizations be classified?

Sub questions:

1. What do IT consultants identify as integration drivers, types, difficulties, and technologies in healthcare organizations?
2. What is the practical experience of healthcare organizations with regard to integration difficulties and technologies?
3. What aspects of integration should Creq focus on, according to both the IT consultants and the healthcare organizations?

1.4 Thesis overview

This thesis is divided into six chapters. The first chapter consisted of the introduction, an explanation of the host organization, and the aim of this study. In Chapter 2, the literature review regarding system integration is outlined. The methods we used to gather and analyze the data are explained in Chapter 3, of which the results are presented in the next chapter. In the fifth chapter, we discuss the results and compare them with the literature review to finally conclude the research in Chapter 6.

2 Literature review

In this section, the definition of system integration and the various integration types will be described, in Section 2.1.1 and Section 2.1.2 respectively. In addition, the integration technologies (Section 2.2) and difficulties (Section 2.3) are outlined as seen in the literature. Lastly, the system integration approaches will be presented in Section 2.4.

2.1 Definition of system integration

2.1.1 What is system integration?

In as early as 1969, Lorsch and Lawrence (1969) defined integration as "the process of achieving unity of effort among the various subsystems in the accomplishment of the organization's tasks in the strategic level." However, 40 years later, Armitage et al. (2009) stated in their literature review that from more than 70 terms and phrases regarding integration, about 175 definitions and concepts were yielded, where no universal definition or concept of integration was found. Giachetti (2004) came to the same conclusion. In addition, this was also concluded more recently by Rajabalinejad et al. (2020), as they found that integration has different meanings according to different disciplines. To this extent, we can conclude that the concept of integration can be interpreted in many ways. Therefore, it is necessary to state the definition of integration we used in this research. This thesis specifically focused on system integration, thus a definition of system integration will be used.

As the IT domain is rapidly changing and system integration inevitably evolves with it, it is only rational to follow the most recent definition as used in academic literature. Consequently, the definition we use in this research is the following:

> "System integration, or integration at the system level, refers to the integration of components, elements or subsystems, or human interactions in order to realise a system that accomplishes the system objectives." (Rajabalinejad et al., 2020)

In the remainder of this thesis, integration and system integration are interchangeable, but the meaning will be as stated above. Systems and applications are used interchangeably as well.

2.1.2 Types of integration

Within the concept of integration as previously defined by Rajabalinejad et al. (2020), there exist various types of integration. These types of integration are all summarized in Table 2, along with the corresponding references. An explanation of the integration types is given below.

First of all, Themistocleous, Irani, and Love (2004) defined one difference in integration, namely loose integration and tight integration. They gathered specifications of loose and tight integration from different sources and presented those in a table to give an overview of the two types. This table can be seen in Appendix A.

The classification of loose and tight integration can roughly be compared to the difference in integration that Volkoff et al. (2005) have derived, which is the difference between process integration

and data integration. Process integration concerns the tighter connection and the standardization of processes between organizations, which is more or less the same as tight integration. Data integration, on the other hand, involves the use of combined data and the standardization of data between organizations, which can be compared to loose integration.

Another distinction is made by Gulledge (2006), as he defined the types of integration Big I and Little I, where the 'I' stands for Integration. Gulledge (2006) stated that Big I is integration where the data of a set of business processes is processed by one application without using an interface, while Little I does use some form of interfacing.

Even more integration types are defined by Giachetti (2004):

- Coordination - this addresses the two problems of task dependencies and goal alignment.
- Interoperability - this is the ability of one application to access or use data generated by another system.
- Data sharing - this is where two or more subsystems exchange data with each other.
- Connectivity - this is defined as the linkage between systems, applications, and modules. Connectivity ensures that data and/or messages can be sent from one system to another system. However, it does not necessarily mean that it can be interpreted correctly.

These integration types are of a different dimension than those of Themistocleous, Irani, and Love (2004) and Gulledge (2006). For example, a loose integration could entail interoperability and connectivity, but also data sharing or coordination. Moreover, connectivity is simply insurance that data can be sent to another system, which is the case in all integration types. Therefore, the integration types defined by Giachetti (2004) could be used in relation to other integration types.

Lastly, there is a difference between horizontal and vertical integration (Suri et al., 2017; Madni and Sievers, 2014). The description of these kinds of integration is shown in Table 1. Contandriopoulos et al. (2004) discussed specific applications of those integration types in healthcare, which can also be seen in Table 1.

Type of integration	**Description**	**Application in healthcare**
Horizontal integration	The collaboration of two or more organizations. (Suri et al., 2017; Madni and Sievers, 2014)	The collaboration of similar organizations, like hospitals. (Contandriopoulos et al., 2004)
Vertical integration	The collaboration of system (components) within an organization. (Suri et al., 2017; Madni and Sievers, 2014)	The integration of healthcare systems within an organization. (Contandriopoulos et al., 2004)

Table 1: Horizontal and vertical integration.

All in all, there are numerous types of integration, as summarized in Table 2. This illustrates once again the importance of defining integration as a whole. In this research, the horizontal and vertical integration by Suri et al. (2017), Madni and Sievers (2014), and Contandriopoulos et al. (2004) will be used because they have been used in multiple studies and have an apparent application in healthcare.

Types of integration	**References**
- Loose integration - Tight integration	Themistocleous, Irani, and Love (2004)
- Process integration - Data integration	Volkoff et al. (2005)
- Big I - Little I	Gulledge (2006)
- Coordination - Interoperability - Data sharing - Connectivity	Giachetti (2004)
- Horizontal integration - Vertical integration	Suri et al. (2017); Madni and Sievers (2014); Contandriopoulos et al. (2004)

Table 2: Summary of the types of integration.

2.2 System integration technologies

There has been extensive research done on technologies used for system integration. In Table 3 the top five system integration technologies are shown, along with the number of times it was mentioned. The full list of technologies as well as the references to the papers that were used can be seen in Appendix B. Important to note is that the papers were gathered using an informal search and not a structured search. Every paper in Appendix B was thoroughly read to bring any mentioned technologies to light. An explanation of the top five integration technologies is described below.

System integration technology	**Number of papers it is mentioned in**
API	37
XML	26
CORBA	22
HL7	18
EAI	18

Table 3: System integration technologies and the number of papers they are mentioned in.

2.2.1 API

API is the abbreviation of Application Programming Interface, which Linthicum (2000) defined as: "welldefined mechanisms that are built to connect to some sort of recourse, such an application server, middleware layer, or database." He also stated that "APIs allow developers to invoke the services of these entities in order to obtain some value." (Linthicum, 2000) These definitions will be used in our research.

2.2.2 XML

XML is the abbreviation of eXtensible Markup Language. Achard et al. (2001) stated that XML is a lightweight Standard Generalized Markup Language (SGML), which is "the international standard for defining descriptions of the structure and content of different types of electronic documents." In other words, XML is the same as SGML, but without the more complicated and less used parts of SGML. XML is used to apply the definition of a set of tags to documents, so a standard to describe the structure of a document (Achard et al., 2001).

2.2.3 CORBA

CORBA is the abbreviation of Common Object Request Broker Architecture. According to Themistocleous and Irani (2002a), CORBA is an "open distributed object technology that enables remote object creation and remote object invocation". It is independent of the used platform and can provide standard object-oriented interfaces (Themistocleous and Irani, 2002a).

2.2.4 HL7

Health Level 7 (HL7) is, in fact, a standard-setting organization and they have developed communication protocols widely used in the healthcare sector in the United States. The standards developed by HL7 provide the possibility for electronic data exchange (Dolin et al., 2001).

2.2.5 EAI

EAI is the abbreviation for Enterprise Application Integration. An explanation of this integration technology is given in Section 2.4.2. [1]

2.3 Difficulties of system integration

Even though there exist many system integration technologies, as described in the previous section, there remain numerous difficulties that interfere with the application of integration. These integration difficulties are summarized in Table 4.

One of the main difficulties regarding integration is the diversity of the systems within healthcare organizations (Khoumbati and Themistocleous, 2006; Sabooniha et al., 2012). The information systems have been created by different software suppliers to each serve different aspects of an

[1] EAI is mentioned as an integration technology in the literature, but can also be defined as an approach for integration. That is why EAI is explained in Section 2.4.2.

organization (Xu et al., 2000). This resulted in the usage of hundreds of systems, all for different purposes (Khoumbati and Themistocleous, 2007; Mykkänen, 2007). All these systems have their own technologies, languages, functions, and standards to handle their data (Themistocleous, Irani, and Love, 2004; Sabooniha et al., 2012). Moreover, data in healthcare systems are considered to be highly complex and heterogeneous, which increases the complexity of the integration as well (Budgen et al., 2007; Chu and Cesnik, 2000; Hasselbring, 2000; Khoumbati, Themistocleous, and Irani, 2003; Kitsiou et al., 2006; Mykkänen, Porrasmaa, Rannanheimo, et al., 2003; Mykkänen, 2007; Themistocleous, Irani, and Love, 2004; Volkoff et al., 2005; Wu and Trigo, 2021). In addition, the systems were usually not meant to communicate and collaborate with other systems because of their independence, which complicates system integration (Hasselbring, 2000; Khoumbati, Themistocleous, and Irani, 2003; Themistocleous, Irani, and Love, 2004; Kalakota and Robinson, 1999). This all led the general application landscape of healthcare organizations to be very segregated and hard to integrate (Xu et al., 2000; Wu and Trigo, 2021; Katehakis et al., 2002).

A problem that is related to the diversity of the systems is that the amount of data in systems in healthcare organizations is immense (Wu and Trigo, 2021). The data is also very diverse, which can be overwhelming (Budgen et al., 2007), as well as cause data corruption and inconsistency (Chu and Cesnik, 2000). This is also the result of the growth of the systems themselves, as they need to serve thousands of users, who all generate large amounts of data (Mykkänen, 2007).

As healthcare organizations deal with those amounts of data, the issue of security and privacy is prominent as well (Khoumbati and Themistocleous, 2006; Khoumbati, Themistocleous, and Irani, 2006). It is reported that many healthcare systems have problems with security (Haux et al., 2001; Littlejohns et al., 2003). This is even more the case when systems are integrated and share the data with other systems (Budgen et al., 2007). In the healthcare sector this is particularly important, as their data is highly sensitive, especially now that more data is being stored in the cloud (Liang et al., 2017).

Considering the amount of data, applications, and systems within a healthcare organization, standards could help to exchange the data within or between organizations (Rombout, 2017). However, there remains confusion about the technologies and standards available (Khoumbati, Themistocleous, and Irani, 2006; Kitsiou et al., 2006; Sanchez et al., 2020). This led to the difficulty of choosing the best integration approach for an organization (Kitsiou et al., 2006).

Another difficulty that is mentioned more often is the human factor in integration. As discussed by Tulu et al. (2003), the acceptance of (new) information systems by physicians is critical for its success. This was also concluded by Grimson et al. (2000), as they stated that the main challenge is cultural, not necessarily technical. For example, Themistocleous and Irani (2001) found that in their case study, many managers and employees did not want to share their data, as they feared they would lose control and eventually their job. Related to this problem is the lack of knowledge by IT personnel as well as healthcare professionals (Lopez and Blobel, 2009). Mykkänen (2007) also reports that the education of users and computer staff is regarded as problematic. Moreover, whether the users perceive and recognize the benefits of technology and systems is one of the most important aspects of the effectiveness of the technology (Hariyati et al., 2018; Owusu Kwateng et al., 2021). Therefore, the interaction of the technology and the users should be taken into account

as well (Ammenwerth et al., 2003).

However, this leads to a third difficulty with regard to system integration: the different requirements of technology among users (Madni and Sievers, 2014; Sabooniha et al., 2012). This also ties back to the diversity of the systems, because as each system serves a different purpose, the requirements for the systems used by different stakeholders differ as well. The consequence is that there exist numerous approaches, each of which cannot be the whole solution on its own (Grimson et al., 2000).

In addition, a well-known problem is that healthcare organizations lack resources with respect to other industries (Khoumbati, Themistocleous, and Irani, 2006; Egan and Liu, 1995; Grimson et al., 2000; Li and Markowski, 2006; Khoumbati and Themistocleous, 2006; Wu and Trigo, 2021; Mykkänen, 2007; Ammenwerth et al., 2003). This is especially concerning considering that organizations spend a minimum of 40% of their IT budget on integration problems (Puschmann and Alt, 2001). In addition, time is a resource that is considered to be scarce as well, as it is "critical for the efficient operation of all systems, and the majority of e-business and supply chain applications require real-time incorporation" (Jayaram et al., 2000). However, integration technologies usually require some time to implement (Giachetti, 2004). Consequently, healthcare organizations have fallen behind on the adoption of information technology (Grimson et al., 2000) and their goal of shared healthcare by using integration (Kitsiou et al., 2006).

The lack of resources in healthcare organizations also led to a slow adoption rate of IT, compared to other sectors (Khoumbati, Themistocleous, and Irani, 2006). As mentioned by Grimson et al. (2000), in many cases the data flowing through such organizations continues to be processed manually, for which they name various reasons, such as lack of standards and lack of political will. They conclude that the result is a general lack of awareness of the benefits of IT (Grimson et al., 2000).

The last problem that is more specific to healthcare organizations, is the risk of data failure and operation failure. This could lead to a "tremendous negative impact on medical institutions" (Sayyadi Tooranloo and Saghafi, 2021).

In conclusion, as stated by Themistocleous and Irani (2001): "Integrating business processes is not a simple task but complex procedure that requires the analysis, understanding and correlation of all business processes."

2.4 System integration approaches

With the known technologies and difficulties in system integration, the approach to achieving a smooth process of integration could be derived. Research on integration has shown several ways to achieve integration.

2.4.1 Enterprise Resource Planning (ERP)

In the 1990s, Enterprise Resource Planning (ERP) technology was proposed as an integration approach (Themistocleous, Irani, and Love, 2004). ERP was meant to integrate all departments of an organization into one single system (Giachetti, 2004). In healthcare, the ERP systems were

Difficulty	**References**
Diversity of systems	Khoumbati and Themistocleous (2006); Khoumbati and Themistocleous (2007); Mykkänen (2007); Themistocleous, Irani, and Love (2004); Budgen et al. (2007); Chu and Cesnik (2000); Hasselbring (2000); Khoumbati, Themistocleous, and Irani (2003); Kitsiou et al. (2006); Mykkänen, Porrasmaa, Rannanheimo, et al. (2003); Themistocleous, Irani, and Love (2004); Volkoff et al. (2005); Themistocleous, Irani, and Love (2004); Kalakota and Robinson (1999); Xu et al. (2000); Wu and Trigo (2021); Sabooniha et al. (2012); Katehakis et al. (2002)
Amount of data	Wu and Trigo (2021); Budgen et al. (2007); Chu and Cesnik (2000); Mykkänen (2007)
Security and privacy	Khoumbati and Themistocleous (2006); Khoumbati, Themistocleous, and Irani (2006); Haux et al. (2001); Littlejohns et al. (2003); Budgen et al. (2007); Liang et al. (2017)
Confusion around standards and technologies	Rombout (2017); Khoumbati, Themistocleous, and Irani (2006); Kitsiou et al. (2006); Sanchez et al. (2020)
Human factor	Tulu et al. (2003); Grimson et al. (2000); Themistocleous and Irani (2001); Lopez and Blobel (2009); Mykkänen (2007); Hariyati et al. (2018); Ammenwerth et al. (2003)
Difference in requirements	Madni and Sievers (2014); Sabooniha et al. (2012); Grimson et al. (2000)
Lack of resources	Egan and Liu (1995); Grimson et al. (2000); Li and Markowski (2006); Khoumbati and Themistocleous (2006); Khoumbati, Themistocleous, and Irani (2006); Wu and Trigo (2021); Mykkänen (2007); Ammenwerth et al. (2003); Puschmann and Alt (2001); Jayaram et al. (2000); Giachetti (2004); Grimson et al. (2000); Kitsiou et al. (2006)
Slow adoption rate IT	Khoumbati, Themistocleous, and Irani (2006); Grimson et al. (2000)
Risk of data and operation failure	Sayyadi Tooranloo and Saghafi (2021)

Table 4: Difficulties of system integration within healthcare organizations.

used to "manage [...] data and processes, and to provide an integrated infrastructure" (Grimson et al., 2000). For example, SAP developed an ERP system specifically for healthcare organizations, called SAP IS-H (Stefanou and Revanoglou, 2006). However, many disadvantages come with the implementation of an ERP system. First of all, ERP systems are complex and non-flexible (Themistocleous, Irani, and Love, 2004). Moreover, they cannot automate all the business processes, so the organizations are forced to change their business strategy according to the ERP system (Themistocleous and Irani, 2001). Lastly, organizations keep using other systems alongside the ERP system (Themistocleous and Irani, 2001) because no system can serve all the components of a healthcare organization (Sabooniha et al., 2012). This means that integration still needs to take place (Khoumbati, Themistocleous, and Irani, 2003), but ERP systems are not meant to integrate with other systems (Brown, 2000; Pender, 2000; Schoenefeld and Vering, 2000). Therefore, Stefanou and Revanoglou (2006) concluded: "practically, an absolutely homogeneous information systems platform is not really an option for today's complex and dynamic business environment."

2.4.2 Enterprise Application Integration (EAI)

Because of the discussed disadvantages of ERP systems, organizations have moved toward Enterprise Application Integration (EAI) (Themistocleous and Irani, 2002a), as they realized that it was a cheaper solution for integration (Khoumbati, Themistocleous, and Irani, 2003). EAI is a middleware approach with an integration framework to combine technologies to integrate systems within an organization and between organizations (Sabooniha et al., 2012; Edwards and Newing, 2000). One of the first sectors that used EAI was, in fact, the healthcare sector (Khoumbati, Themistocleous, and Irani, 2003). The first reason for this is that healthcare organizations usually consist of more departments in comparison to organizations in other industries (Khoumbati, Themistocleous, and Irani, 2003). Secondly, healthcare organizations' lack of resources made EAI a more appropriate option than other integration approaches (Khoumbati, Themistocleous, and Irani, 2003). Despite the numerous other benefits mentioned by Khoumbati, Shah, et al. (2007) and Themistocleous and Irani (2002a), they also outline several disadvantages. For instance, EAI requires certain skills that employees often lack (Themistocleous and Irani, 2002a). Moreover, no EAI technology solves the whole integration problem (Themistocleous, Irani, and Love, 2004). And finally, even though EAI is considered to be the less expensive option between ERP and EAI (Khoumbati, Themistocleous, and Irani, 2003), EAI still has a high level of investment (Themistocleous and Irani, 2002a).

2.4.3 Other approaches

Since EAI is not considered to be the end-all solution either, several studies have presented their approach to system integration. An important thing that is mentioned more often is that requirements have to be the basis for the design decision of integration solutions (Mykkänen, Porrasmaa, Korpela, et al., 2004; Kitsiou et al., 2006), which are described and summarized by Khoumbati, Themistocleous, and Irani (2005). Moreover, some examples of integration approaches are the smooth migration approach (Streekmann and Hasselbring, 2008), the MINT approach (Streekmann, Steffens, et al., 2006), Self-Improving System Integration (SISSY) (Bellman et al., 2019), and many others. Themistocleous and Irani (2002a) have summarized some approaches, which are shown in Appendix C. However, it has been concluded by multiple studies that not one integration approach or solution can solve the whole integration problem (Madni and Sievers, 2014;

Mykkänen, Porrasmaa, Korpela, et al., 2004; Sabooniha et al., 2012; Khalifa et al., 2001; Kitsiou et al., 2006).

2.5 Classification of system integration

As mentioned before, this research aims to classify integration technologies and difficulties as seen in the practical environment in the healthcare sector in the Netherlands.

A more general classification of integration has been done before by Themistocleous, Irani, and Love (2004), who classified the system types that are integrated. In addition, they classified various integration technologies based on certain evaluation criteria: application elements, integration layers, and system types. Each technology is then evaluated on every criterion. These classifications can be seen in Appendix D.

However, the classification created by Themistocleous, Irani, and Love (2004) is a general description of integration. Therefore, Sabooniha et al. (2012) presented a more specific classification of integration in healthcare. They used a smaller amount of integration technologies and evaluated those according to functional and non-functional integration requirements. This can be seen in Appendix D as well.

But even though Sabooniha et al. (2012) have outlined and classified several integration technologies in the healthcare sector, the integration difficulties are not yet specified. Moreover, their research might not be generalizable to healthcare in the Netherlands in the 2020s. Thus, this research aims to depict a more specific picture of the integration technologies and difficulties in practice in the healthcare sector in the Netherlands.

3 Methodology

This chapter presents the methods used in this research. First, the study design is outlined in Section 1. Then in Section 3.2 the context and participants will be described. The analysis (Section 3.3) and evaluation of the interviews (Section 3.4) will be presented last.

3.1 Study design

The design of this study is visualized in Figure 1. First, to gather as much information on system integration as possible, we used two exploratory interviews with IT consultants at Creq, an IT consultancy specialized in the healthcare sector. The main purpose of the exploratory interviews was to collect data on integration in healthcare organizations. As seen in Figure 1, a confirmatory interview was then conducted to check whether the information was correct and whether there was still some information missing. During these interviews, we did not follow a specific interview protocol, as we wanted them to come up with the current aspects of integration they noticed in their environment.

After the interviews with the IT consultants, we conducted four confirmatory interviews with healthcare organizations. These interviews were conducted to test the results of the interviews with Creq employees in the practical environment of a healthcare organization. These interviews did not follow an interview protocol either, except for some preliminary topics that were used: integration difficulties they had seen, systems and connections they use or want to use in the future, and any integration prospects or philosophies they had. As we wanted to know whether the consultants at Creq covered everything on system integration, we did not show the results of those interviews to the representatives of the healthcare organizations beforehand, to prevent response bias. By doing so, we ensured data triangulation, since both Creq employees and healthcare organizations were used to contribute to the validity of the results.

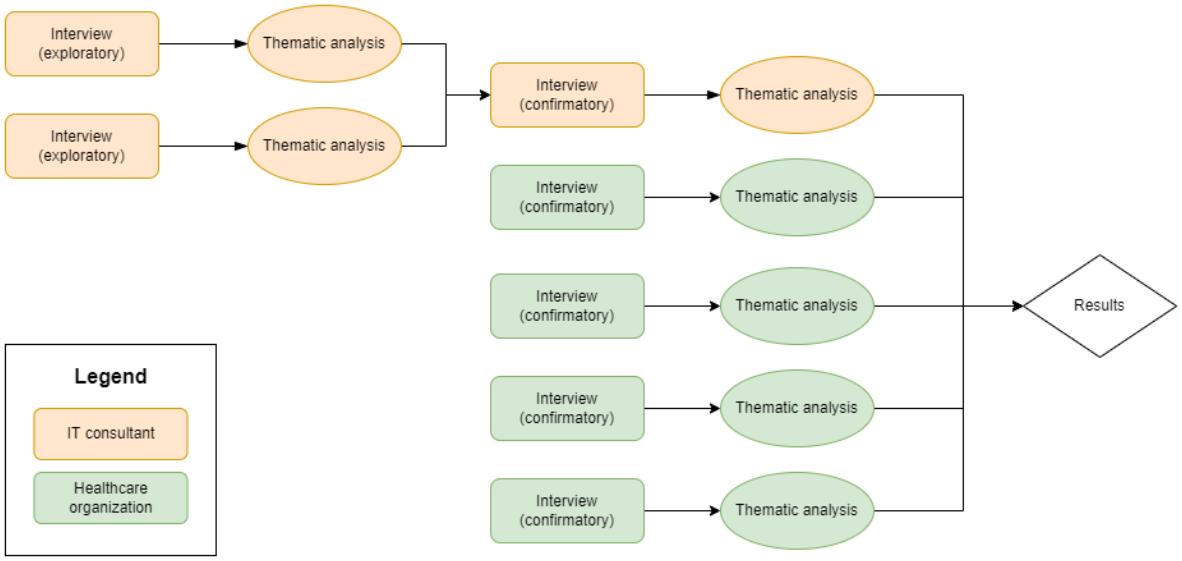

Figure 1: A visualization of the study design of this thesis.

3.2 Context and participants

3.2.1 Creq

The first three interviews were conducted with IT consultants employed or managing at Creq. As Creq is an IT consultancy specialized in healthcare, they are a great source of information about system integration within the healthcare sector. The characteristics of the consultants are shown in Table 5.

The first exploratory interview was held with one of the two partners who founded Creq. As a consultant and manager, he has had a lot of practical experience with integration in healthcare organizations.

The second exploratory interview was conducted with a senior consultant employed at Creq. He has worked at Creq for 4 years and therefore has a little less experience with the topic. However, he has had multiple projects regarding integration in the healthcare sector and therefore has gained practical knowledge about the subject.

Lastly, we conducted a confirmatory interview with the other partner of Creq, which means that he has often dealt with integration in healthcare organizations as well.

Participant	**Position at Creq**	**Gender**	**Experience with IT in healthcare**	**Type of interview**
1	Partner	Male	16 years	Exploratory
2	Senior consultant	Male	4 years	Exploratory
3	Partner	Male	16 years	Confirmatory

Table 5: Characteristics of the interviewed IT consultants at Creq.

3.2.2 Healthcare organizations

The second part of the data gathering consisted of interviews with healthcare organizations in the Netherlands. All interviews were of a confirmatory nature because the goal was to check whether the representatives of healthcare organizations would come up with other information than the IT consultants at Creq. The first three interviews were conducted in the location of the corresponding healthcare organization. The last and fourth interview, however, was held online. As can be seen in Table 6, all representatives that we interviewed held an IT position within their organization, as they would know the most about system integration within a healthcare organization. The characteristics of the individual organizations will be elaborated on below.[2]

[2]All organizations gave permission to use their name in this thesis.

HC1: Evean
Evean is a healthcare organization that offers specialist nursing, care, guidance, and home care in North-Holland. Evean is a subsidiary of a bigger company named Espria, but every subsidiary can make its own decision, for example on the systems that they use.[3]

The interviewee is the information manager at Evean and he follows the developments in IT and optimizes the information domain. In addition, he is the linking pin from Evean to the service center of Espria. One-third of his job is regarding communication between healthcare organizations and almost half of his work is coming from the service center.

HC2: Pieter van Foreest
Pieter van Foreest is a healthcare organization that offers elderly a broad and flexible package of services in the field of housing, care, treatment, and welfare near Delft, Midden-Delfland, Pijnacker-Nootdorp, and Westland.[4]

The interviewee is the service manager ICT at Pieter van Foreest. He leads IT projects and can, for example, advise on policies.

HC3: Kennemerhart
Kennemerhart is an elderly care organization situated in North-Holland. They have residential locations as well as treatment centers and they offer home care.[5]

The interviewee is the team manager IT at Kennemerhart and he has worked in IT in the healthcare sector for 20 years.

HC4: Cardia
Cardia is a Christian, elderly care organization in the region Haaglanden. They are small and aim to offer care that fits their clients' lifestyles.[6]

The interviewee is the IT coordinator at Cardia and she is responsible for business operations and projects within the IT department.

In the remainder of this thesis, we will refer to the healthcare organizations using their abbreviations: HC1, HC2, HC3, and HC4.

[3]Based on the information on the website. Retrieved June 7, 2022, from `https://www.evean.nl/`
[4]Based on the information on the website. Retrieved June 7, 2022, from `https://pietervanforeest.nl/`
[5]Based on the information on the website. Retrieved June 7, 2022, from `https://www.kennemerhart.nl/`
[6]Based on the information on the website. Retrieved June 7, 2022, from `https://cardia.nl/`

Participant	Organization	Position	Gender	Experience in IT in healthcare	Type of interview
HC1	Evean	Information manager	Male	22 years	Confirmatory
HC2	Pieter van Foreest	Service manager IT	Male	10 years	Confirmatory
HC3	Kennemerhart	Team manager IT	Male	20 years	Confirmatory
HC4	Cardia	IT-coordinator	Female	14 years	Confirmatory

Table 6: Characteristics of the interviewees from the healthcare organizations.

3.3 Analysis of interviews

3.3.1 General

Given that the interviews took place within a time span of several weeks, the interviews were first analyzed on their own. This means that for every interview the following method was used before the data of the interviews was put together.

The interviews were analyzed according to the thematic analysis of qualitative data by Braun and Clarke (2006). Based on that thematic analysis, Bree and Gallagher (2016) created a guide to using Microsoft Excel for thematic analysis, which was used in this research as well. Following that guide, we first transcribed the recording of the interview. After that, we moved the data to Microsoft Excel, where every new line went into a new cell. Then, every cell was given an ID, which was the row number, and an initial code for their specific theme. After we gave every cell a code, we reviewed the data a second time to see whether the code was still fitting after the first review. Then the data was moved to a new worksheet based on their given theme. Every cell was reviewed and downsized to only useful information. When that was finished, the data was again given a code, but this time according to sub-themes that arose from the data instead of choosing them beforehand. Cells were then merged based on their common sub-theme. Following this, the data was reviewed once again to see whether the themes were still fitting the data.

While doing this for every main theme, it sometimes occurred that a specific cell was not given the correct main theme at the beginning, so some cells were moved to other themes. When all cells from the main themes were divided into sub-themes, we created the key points per sub-theme. Finally, all key points were moved to another worksheet, where we reviewed and downsized them one last time.

In this analysis, a combination of both inductive and deductive thematic analyses was used. For the main theme, the deductive analysis was more practical, since the themes were known before the interviews were conducted. For the sub-themes, however, the inductive analysis was more obvious, because the sub-themes were not yet known and therefore could arise from the data without making any assumptions. This was the same for all conducted interviews.

3.3.2 Creq

Beforehand, four main themes were chosen for the interviews with the IT consultants: integration problems, integration solutions, thesis ideas, and irrelevant. While giving every cell a code, a fifth theme arose: definitions and explanations. During the second interview, two new main themes came up, in addition to the existing main themes of the first interview. The additional main themes were: drivers and trends.

Once the first and second interview were analyzed, we moved the key points of both exploratory interviews to a new worksheet once again. The reasoning for this was to combine the key points of both interviews. While doing this, we changed a few sub-themes to fit both key points and some were merged as they were about the same theme.

The third, confirmatory interview was analyzed according to the same approach as the second interview. The main themes remained the same, but some sub-themes were added as they arose during the analysis. We moved the key points of this interview into the same worksheet as the combined key points of the first two interviews, to merge all key points into one dataset.

3.3.3 Healthcare organizations

The interviews conducted with the healthcare organizations were analyzed according to the same method as the interviews with the IT consultants at Creq. The main themes as derived from the first interviews remained mostly the same for these interviews: irrelevant, integration problems, integration solutions, definitions and explanations, and systems and connections. As can be seen, the main theme 'thesis ideas' was removed, because the goal of the thesis was already concluded. Moreover, the theme 'systems and connections' was added, as we wanted to gather integration prospects about future systems and connections.

The main themes remained the same during the thematic analysis of all interviews. As mentioned before, the interviews were all analyzed on their own, and after that we combined the key points of the interviews in one worksheet.

3.4 Evaluation of interviews

Once the thematic analysis of all interviews was complete, the result was one spreadsheet for the consolidated key points of the interviews with Creq and one for the consolidated key points of the interviews with the healthcare organizations. Then, we divided the results section into different categories, based on the research question.

We were interested in the practical appearance of certain aspects of system integration in the healthcare sector. Therefore, the sub-themes were reviewed and for every sub-theme, it was evaluated whether or not it was mentioned by the IT consultants or the healthcare organizations. The IT consultants were merged into one entity, as they were all from the same company and we wanted to avoid duplicate statements or opinions. The healthcare organizations, however, remained separate individuals, as it was important to examine their individual experience with system integration.

There were no preliminary sub-themes added to the results. In other words, a sub-theme was added only when it was mentioned in one of the interviews.

4 Results

In this chapter, the results of the interviews conducted with both IT consultants and representatives of healthcare organizations are presented. They have been divided into the following categories: integration drivers and types (Section 4.1), integration technologies (Section 4.2), integration difficulties (Section 4.3), and integration prospects (Section 4.4). For every category, we evaluated what was mentioned and by whom it was mentioned.

4.1 Integration drivers and types

Table 7 shows the various drivers and types for integration. In this context, integration drivers are defined as reasons for integration. Integration types are defined as what needs to be integrated to fulfill the goal of the integration driver.

	Creq	**HC1**	**HC2**	**HC3**	**HC4**	**Total**
Integration drivers						
Less dependency on software supplier	X					1
Working in the cloud	X					1
Control over own data	X					1
Shortage of care	X					1
Ideas from healthcare organizations themselves	X					1
Integration types						
Connection between systems within an organization	X		X			2
Process optimization	X		X			2
Master data and control information	X		X			2
Sharing information between healthcare organizations	X					1
One platform with multiple integrated applications			X			1

Table 7: Integration drivers and types as mentioned by Creq and/or healthcare organizations.

As can be seen in Table 7, only the IT consultants focused on naming specific drivers for integration. Interestingly, the spokesman for HC2 did identify integration types and, without knowing the types mentioned by the IT consultants beforehand, named three of the already identified integration types and even one extra type. The other healthcare organizations mentioned some of the integration types as well, but since they did not necessarily identify them as integration types, they are not included in this table.

The integration types can be interpreted as the order in which healthcare organizations can accomplish integration. This means that the connection between systems within an organization, the first type, should be done first before moving on to another type of integration. The last type of integration, one platform with multiple integrated applications, cannot be put into this order. That is

because it actually belongs to the first type as well, even though it was not identified as such by HC2.

What is not shown in Table 7, is that only HC2 questioned the need for integration. All other healthcare organizations and the IT consultants were convinced of the demand for integration. HC2 did come to the same conclusion in the end.

4.2 Integration technologies

In Table 8 the integration technologies that were mentioned in the interviews are presented. They are divided into common and uncommon. In this research, common means that either the healthcare organization uses the technology or one of the IT consultants at Creq knows that it is a common technology. Uncommon is defined as something that is not seen in the healthcare sector by either the healthcare organizations or the IT consultants at Creq.

Some of the named technologies are not necessarily a technology, such as point solution, XML, and HL7. However, the term technology is in this research used as 'a way to integrate', as this was the case in academic literature as well (see Appendix B).

	Creq	**HC1**	**HC2**	**HC3**	**HC4**	**Total**
Common						
API	X	X	X	X	X	5
Service bus	X			X		2
Power BI	X	X				2
Power apps	X	X				2
HL7	X			X		2
XML	X			X		2
Point solution	X					1
'Fire and forget'	X					1
Service automation					X	1
Uncommon						
ERP	X		X	X		3
Blockchain	X					1
Service wrappers	X					1
RPA	X					1

Table 8: Integration technologies as mentioned by Creq and/or healthcare organizations.

Notable is that API is the only technology that is mentioned in all interviews, while all other technologies were mentioned at least two times less. Moreover, the healthcare organizations were less likely to talk about technologies that are uncommon than about the common technologies within their organization, since only ERP was mentioned by them and none of the other uncommon technologies. What is more, the integration technologies were not often mentioned in general, with respect to the integration difficulties and prospects.

Nonetheless, the integration technologies that were mentioned the most are elaborated on below. An explanation of all integration technologies can be found in Appendix E.

API (5/5)
API was the integration technology mentioned most frequently by far. This is not surprising, as both HC3 and HC4 wish to only have APIs, and HC2 and HC1 encourage APIs as well. Moreover, HC1 mentioned that one of their software suppliers only creates API connections. The IT consultants also think that APIs are gaining ground as an integration technology. However, HC2 thinks that APIs are going to be replaced as well, since there will always be a new technology that is going to be better than the current best or most used technology.

ERP (3/5)
Even though HC2, HC3, and the IT consultants all named ERP as an integration technology, they agreed that it is not the optimal integration technology. As HC3 said, the reason for this is: "*ERP... yes for that moment, but after that, it is not long until the ERP has to be integrated with something else.*"[7] That is why they believe ERP is not necessarily the solution to integration. The IT consultants at Creq have not seen a good example of ERP in healthcare and do not approve of the concept either. However, HC3 thinks that it might make it easier, as there are fewer systems to be integrated.

4.3 Integration difficulties

The difficulties that occur during integration as mentioned in the interviews can be seen in Table 9. These are difficulties that are experienced by healthcare organizations or seen by IT consultants at Creq.

	Creq	**HC1**	**HC2**	**HC3**	**HC4**	**Total**
Diversity of systems	X	X	X	X	X	5
Dependency on software suppliers	X	X	X	X	X	5
Privacy regulations	X	X	X	X		4
A lot of standards and trust frameworks	X	X		X		3
Change aversion	X			X	X	3
Healthcare is lagging in technology adoption (immature IT department)	X			X	X	2
Bigger picture lacks	X			X		2
Validation	X		X			2
Unknown ownership			X		X	2
Policies are hard to establish			X		X	2
Lack of resources		X	X			2

Table 9: Integration difficulties as mentioned by Creq and/or healthcare organizations.

[7]The quotes from the interviews are translated to English, as the original quotes were Dutch.

What is striking about the difficulties shown in Table 9 is that all difficulties were mentioned by at least two interviewees and many difficulties were even mentioned three times or more. The difficulties that were named the most are further explained below. An explanation of all integration difficulties can be found in Appendix F.

Diversity of systems (5/5)
All interviewees mentioned *diversity of systems* as an integration difficulty. According to the IT consultants, every healthcare organization has different needs and requirements, which leads to adaptions to the systems they are using. Moreover, software packages themselves often have different philosophies on how to display or manage data, which complicates the integration of the systems. HC2 agreed to this, as he mentioned that the systems are too diverse and do not have uniformity of language. HC3 gave an explanation for this: "*This is because [. . .] institutions continue to specialize and differentiate.*" According to HC1, the consequence of having many, diverse systems, is that the costs are higher and the architecture becomes inflexible.

Dependency on software suppliers (5/5)
All interviewees mentioned *dependency on software suppliers* as an integration difficulty as well. The reason for this is, as one of the IT consultants said, that lock-in threatens to occur. This refers to the healthcare organizations often having only a few options with regard to software suppliers, which makes them dependent on the one that they choose. Whenever a software supplier does not have a connection that a healthcare organization would like or need, they cannot simply divert to another supplier. As HC2 said, the organizations are therefore dependent on the software supplier to, for example, develop APIs or to adhere to certain healthcare standards, like HL7.

Privacy regulations (4/5)
The difficulty *privacy regulations* is mentioned by four out of five organizations and therefore also frequent. One of the IT consultants explained that privacy is a horizontal problem, as it is a requirement that organizations have to follow in all types of integration. Especially now that regulations regarding security and privacy are getting stricter, as mentioned by HC4, the integration of systems is becoming more difficult as well. HC3 explained that privacy is even more important in the healthcare sector. HC2 gave the example of two-factor authentication, which creates extra work and conditions for system integration.

4.4 Integration prospects

During the interviews, all interviewees were encouraged to name their prospects for integration in healthcare organizations. For example, healthcare organizations were asked what their wishes or plans are for future connections and systems within their organization. Both of these questions give insights into the prospects of integration, to answer sub-question 3: "What aspects of integration should Creq focus on at the moment, according to both the IT consultants and the healthcare organizations?". The integration prospects are divided into those of Creq and those of the healthcare organizations.

4.4.1 Creq

Less dependency on software suppliers
Even though it is experienced as a difficulty that healthcare organizations are dependent on software suppliers, the IT consultants at Creq believe that this is becoming less and less the case. They think that the healthcare organizations themselves are becoming more aware of the problem, which is supported by the fact that all healthcare organizations named it as an integration difficulty. Because of this, one of the IT consultants mentioned that healthcare organizations realize that integration possibilities are a requirement when choosing software, not merely a 'nice-to-have'.

The role of Power BI
One of the IT consultants noticed that, nowadays, Power BI (or BI tooling in general) is not just for management reports, but for their staff as well, particularly healthcare staff. This might become more of a trend in the future.

Privacy by design
As a society, we value privacy and security, even more so in the past years, as the new privacy laws suggest. That is why, according to one of the IT consultants, privacy by design is becoming more important. According to him, privacy by design means that you design software in such a way that you cannot make data available to someone without justification, as it involves personal data.

Popularity of APIs
The IT consultants expect the use of APIs to grow even more in the near future. They think that in five to ten years, the knowledge of APIs and the exchange of data will be much more common, as the world is changing more towards message-based infrastructures with APIs. Especially the movement from batch connections to transactional connections contributes to this trend, given that API supports the latter.

4.4.2 Healthcare organizations

The integration prospects of the healthcare organizations can be divided into two categories: future projects and philosophies on integration. For both categories, the results per organization will be presented.

Future projects
During the interviews, the representatives of the healthcare organizations were asked to state their intentions regarding connections or systems they wish or plan to have in the future. First, we will elaborate on a wish that all organizations have, after which we will go into the plans of the individual organizations.

All organizations
All healthcare organizations that were interviewed mentioned that they wanted to collaborate more with other healthcare organizations. Even though the collaboration is still quite regional, as mentioned by HC1, HC3 stated that they believe the cooperation to be better both for society and for profits. HC4 agrees with this, as they are not sharing information with others yet, but they want to do so in the future. HC2 explained that they are currently working together with hospitals

and other healthcare organizations to improve the exchange of data, for example, to exchange information on referrals faster.

The Dutch government is stimulating the communication between healthcare organizations by subsidizing various programs. We will describe some of the current programs that were mentioned by either the healthcare organizations or IT consultants below.

- PGO

PGO stands for 'Persoonlijke Gezondheidsomgeving' in Dutch, which translates to 'Personal healthcare system'. As explained by HC1, a PGO is a system where citizens can see all information that the integrated healthcare organizations have on them. This program is issued by the government to clarify for citizens what information about them is used. However, HC1 has personally not seen any healthcare organization that uses a PGO as of yet.

- ZIBs

ZIBs is the abbreviation of 'ZorgInformatieBouwstenen' in Dutch, which translates to 'healthcare information building blocks'. According to HC1, ZIBs are fixed groups of items, for example, certain items of personal data, which you can transfer to another system using a protocol. This is meant to simplify the exchange of data between healthcare organizations.

- Nuts

Nuts is a platform developed by a software supplier that also develops healthcare systems. The platform, said HC1, is especially for VVT organizations. VVT stands for 'Verpleeg- en Verzorgingshuizen en Thuiszorg' in Dutch, which translates to 'nursing homes and home care'. Nuts is created to help VVT organizations exchange information.

- Landelijk Schakelpunt (LSP)

Landelijk Schakelpunt (LSP) is an infrastructure created to share medical information. According to HC1, the medication records are connected to LSP, to eventually be shared with another healthcare institute when needed. For example, whenever a citizen has to go to the hospital, the hospital can request the medication records via LSP. Every citizen has to permit LSP to do this.

All of the government-issued programs described above are meant to improve the data exchange between healthcare organizations. However, HC1 mentioned that even though healthcare organizations were trying to communicate more because of these programs, there are many regulations to adhere to that complicate this process. That is why he has not seen any healthcare organization in his circle use, for example, a PGO. What is also interesting to mention is that HC2 believes that the government should have a more controlling role in the regulations for healthcare, despite the programs and regulations the government already implements.

HC1
As of now, HC1 mostly has connections that are merely files that are imported and exported. Some connections are APIs, but none of them are real-time connections. Moreover, most connections are common, yet HC1 explained that there is always something tailor-made.

In the future, HC1 would like a connection from ONS to Zorgdomein. Furthermore, the connection from CareXS to ONS is not yet working optimally, so they want to improve that as well. HC1 also wants to use some sort of middleware in the future, but at this moment that is only an idea that still needs to be worked out.

HC2
HC2 has some API connections, but mostly import and export or even manual connections. However, they are in the process of creating a decision tree for developing connections. This means that they are trying to make a set of rules to help choose between certain technologies, standards, and contracts for every type of connection. In addition, HC2 is creating an API connection between SmartAim and ONS and implementing an additional Electronic Health Record (EHR) called Ysis, which also requires many connections to be made.

HC3
At the moment, most connections at HC3 are with text files and XML, but they have API connections as well. In addition, HC3 uses middleware to transform text files into API logic to connect two of their main systems called Ysis and ONS.

Right now, HC3 is expanding its Identity and Access Management (IAM) with generic mailboxes in HelloID, adding rights to teams within Office 365, and creating accounts in subsystems. Furthermore, they would like to have a service bus architecture in the future, to have one platform that keeps track of all connections.

HC4
As opposed to the other healthcare organizations, HC4 has mostly API connections and only one batch connection used for Power BI. Right now the Power BI tooling is only used for management reports, but it is a wish of the IT department to use Power BI for the healthcare employees as well. HC4 would also like to implement an IAM. Currently, they are in the process of using the system AFAS as their master data system.

Philosophies on integration
Alongside their ideas for the future, most of the healthcare organizations have some philosophies on connections, sharing information, and integration itself. These philosophies give insight into what healthcare organizations think is important for the future of integration as well.

HC1
The interviewee at HC1 aspires to put all systems under one software supplier, even if that means that they are dependent on that supplier. The reason for this is that he thinks an organization is always dependent on a software supplier if they don't make their own software. Moreover, when software is in their own environment, they have more freedom but it also costs more money and

time to manage it. With a single software supplier, they will make sure that everything is updated and handled correctly.

HC2
As mentioned before, the interviewee at HC2 thinks that API is going to be replaced as an integration technology, since there will always be a new technology that is going to be better than the current best or most used technology.

HC3
During the interview with HC3, it came to light that he believes that, in the future, healthcare organizations will make their data more available to use. This means that other applications and systems can use the data more easily.

HC3 would also like a software buyers market instead of a software suppliers market because the organizations would have more influence and would be more in charge. This is something he also tries to pass on to other healthcare organizations, to unite as a community. Lastly, HC3 does not build software, so they always use software suppliers to ensure continuity.

HC4
The interviewee at HC4 mentioned that they are in the process of using AFAS as their master data system, to ensure data integrity. Secondly, HC4 aims to have mostly API connections instead of import and export or other types of connections.

5 Discussions

This section revolves around the comparison between the literature and the results of our research. In addition, we derive several explanations for the most relevant results. The same categories are used as in Section 4: integration drivers and types (Section 5.1), technologies (Section 5.2), difficulties (Section 5.3), and prospects (Section 5.4). After that, we present the recommendations for Creq with regards to system integration in healthcare organizations in Section 5.5. Finally, the limitations of this study are outlined in Section 5.6.

5.1 Integration drivers and types

Noteworthy from the interviews with the healthcare organizations is that the topic of integration drivers and types only occurred once. There are several possible explanations for this result. First of all, the focus of the interviews with the healthcare organizations was on the integration difficulties, technologies, and prospects, instead of on the integration drivers and types. Secondly, one of the difficulties that the IT consultants identified was that the bigger picture is lacking in healthcare organizations. This means that when organizations integrate systems, they can neglect to consider whether the way they are integrating is the optimal way. This ties back to the inability to name drivers. Since healthcare organizations often lack to see the bigger picture, they are also unaware of the drivers for integration. The IT consultants noticed this shortcoming, as they are able to analyze the organizations from an external perspective, while the organizations are more focused on their own internal difficulties.

In the interviews with the IT consultants, the drivers and types did occur. However, they named other types of integration than any of the types that were mentioned in the literature. Nonetheless, the differentiation between horizontal and vertical integration defined by Suri et al. (2017), Madni and Sievers (2014), and Contandriopoulos et al. (2004) can be applied to the types of integration that the interviewees defined, which is presented in Table 10. It can be concluded that integration can be categorized in various ways, as our research gave another classification than the many already existing classifications.

Type of integration from interviews	**Horizontal or vertical integration**
Connection between systems within an organization	Vertical integration
Master data and control information	Both
Sharing information between healthcare organizations	Horizontal integration
Process optimization	Both
One platform with multiple integrated applications	Both

Table 10: The horizontal and vertical integration applied to our integration types.

From the current and future projects can be derived that almost all healthcare organizations are still in the second integration type as defined in this research, namely *process optimization*. This is because they have all been focusing on and improving connections and processes. Only HC3 has already moved to the third integration type, *master data and control information*, as they are using AFAS as their master data system.

However, HC3 is the only one that does not yet share information with other healthcare organizations, while all other organizations do. This might be the case because the organization decided to focus on master data instead. Yet, this difference means that the order of the integration types should be taken with caution.

5.2 Integration technologies

Table 11 presents the occurrence of the named technologies in the interviews and the top five technologies of the literature, as seen in Section 2.2.

		Interviews	**Literature**
1	API	X	X
2	XML	X	X
3	HL7	X	X
4	Service bus	X	
5	Point solution	X	
6	Power apps	X	
7	Power BI	X	
8	'Fire and forget'	X	
9	Service automation	X	
10	CORBA		X
11	EAI		X

Table 11: Comparison between the interviews and the literature regarding integration technologies.

The most striking result to emerge from the interviews is that two of the most mentioned technologies in the literature, CORBA and EAI, were not once mentioned in the interviews. A possible explanation is that the technologies might no longer be fashionable or popular to use, as one article about CORBA states (Henning, 2008). Another explanation could be that the focus of the interviews with the healthcare organizations was not necessarily on naming many technologies, but more on the integration difficulties that they encountered and which technologies were used when those difficulties occurred. On the other hand, the IT consultants were encouraged to name integration technologies and did not mention CORBA and EAI either. This difference cannot be explained by the research taking place in the Netherlands, as Dutch papers also mention EAI (Bollen, 2005; Verdouw et al., 2006). This applies to CORBA as well (Greefhorst and Balt, 2000), where Cornet and Abu-Hanna (2001) even mention CORBA in a healthcare context. This indicates a meaningful difference between literature and the practical context of healthcare organizations.

In addition, the results of the interviews contained six technologies that were not mentioned in any of the studied papers: service bus, point solution, power apps, Power BI, 'fire and forget', and service automation. This could be caused by the difference in terminology as technologies can sometimes have different names. For example, 'fire and forget' is a term for kinds of technologies that is more used colloquially and not a specific definition. Another explanation could be that the technologies are more recently created and adopted, which the literature has not yet investigated.

On the other hand, API was the most mentioned technology in both the interviews and in the literature (see Appendix B). The healthcare organizations all aspire to have API connections as well. Furthermore, the IT consultants believe that the popularity of APIs will grow even more in the future. API can therefore be identified as the most important integration technology of today, within the context of healthcare organizations.

Moreover, both standards XML and HL7 occurred in the literature as well as in the interviews. Apparently, these are standards that are commonly used when integrating systems within or between healthcare organizations.

Furthermore, *diversity of systems* is one of the difficulties that is mentioned by H2, H3, and all IT consultants. One could argue that an ERP system, i.e. one main system that serves all areas of the organization, could be the solution to this difficulty. However, as stated by HC3, this will only be a short-term solution, as eventually another system will need to be integrated with ERP, while an ERP system is said to be hard to integrate (Brown, 2000; Pender, 2000; Schoenefeld and Vering, 2000). That is why ERP is not seen as the optimal solution for integration, which is confirmed by the literature (Themistocleous and Irani, 2001; Khoumbati, Themistocleous, and Irani, 2003; Stefanou and Revanoglou, 2006).

5.3 Integration difficulties

Table 12 gives a clear overview of the integration difficulties mentioned in the literature and the interviews. The first seven difficulties were mentioned in both, while difficulties 8 to 11 were only mentioned in the interviews, and difficulties 12 and 13 only occurred in the literature.

		Interviews	**Literature**
1	Diversity of systems	X	X
2	Healthcare is lagging in technology adoption (immature IT department)	X	X
3	Privacy regulations	X	X
4	A lot of standards and trust frameworks	X	X
5	Change aversion	X	X
6	Policies are hard to establish	X	X
7	Lack of resources	X	X
8	Bigger picture lacks	X	
9	Dependency on software suppliers	X	
10	Validation	X	
11	Unknown ownership	X	
12	Amount of data		X
13	Risk of data and operation failure		X

Table 12: Comparison between the interviews and the literature regarding integration difficulties.

It is remarkable that out of the overall thirteen difficulties, seven were mentioned by both the literature and the interviewees. Moreover, only two of the difficulties mentioned by the literature were excluded from the interviews with the healthcare organizations. A reason for this could be that the sample of interviewees is relatively small, meaning that they could have missed difficulties that were in fact occurring within the healthcare sector in the Netherlands. Therefore, the missing identification of two out of the nine difficulties shown in the literature can be neglected. This indicates that the literature has a good view of the practical difficulties that occur in healthcare organizations.

On the other hand, the interviewees mentioned four difficulties that were not seen in any of the papers. A possible explanation could be that, according to the literature, these difficulties are not the most important ones. For example, *dependency on software suppliers* is mentioned by all interviewees, yet the IT consultants believe that this difficulty is decreasing in frequency and magnitude. However, the same cannot be said about the other unmentioned difficulties. Therefore, future research should further examine the difference in the named difficulties.

5.4 Integration prospects

Privacy regulations is already identified as a difficulty. However, the IT consultants believe that privacy by design is becoming more of an obligation. This could indicate that privacy regulations are becoming increasingly difficult in regard to integration in the future.

All healthcare organizations are in the process of collaborating or want to collaborate with other healthcare organizations. Even though the Dutch government is trying to improve this collaboration, the implemented regulations sometimes have the opposite effect, as it complicates the process for the organizations. This can also be seen in the difficulties that the interviewees have mentioned, as *a lot of standards and trust frameworks* and *privacy regulations* are mentioned as difficulties by three and four interviewees, respectively.

Interesting to note is that in the interview with HC1, the interviewee mentioned that he aspires to have all software from one software supplier. However, he also mentioned *dependency on the software supplier* as a difficulty. This means that it should be taken into account that the named difficulties should not necessarily be avoided at all costs. In this example, HC1 would rather put less effort into software from multiple software suppliers than be independent of a software supplier. Consequently, the difficulties could be further investigated to identify some sort of order of magnitude.

Another noteworthy result is that, even though all organizations are in the same sector within healthcare, which is long-term and elderly care, their integration philosophies all differ. An explanation for this could be the current projects that the organizations were working on, as they could have impacted their philosophies at that moment. For example, HC2 was working on a new API connection and could therefore believe that the importance of APIs was greater than before.

5.5 Recommendations for Creq

This section is related to the third sub-question: "What aspects of integration should Creq focus on at the moment, according to both the IT consultants and the healthcare organizations?" To answer this question, we will elaborate on the focus points that Creq could adopt to help healthcare organizations with their struggles with integration.

As mentioned before, API connections are currently the most wanted connections within healthcare organizations, while most have not yet implemented them. Seeing that this also occurs the most in the literature (see Appendix B), this is the kind of connection that Creq should focus on.

However, other integration technologies should also be considered. CORBA and EAI are both technologies that were mentioned relatively often in the literature but did not occur in any of the interviews. Yet, as presented in Section 2.4.2, the application of EAI is considered to have various benefits for healthcare organizations. For example, it is less costly than ERP (Khoumbati, Shah, et al., 2007), which is beneficial seeing that *lack of resources* is stated as a difficulty by two of the healthcare organizations. Moreover, EAI can improve management and support decision-making (Themistocleous and Irani, 2002a), which could improve the integration difficulty of *policies are hard to establish*.

As stated by Themistocleous and Irani (2002a), CORBA has numerous benefits for healthcare organizations as well. First of all, CORBA supports heterogeneous back-end environments (Rosen, 1998), which addresses the *diversity of systems* difficulty. Moreover, it can support the integration of legacy systems. Legacy systems are defined as existing information systems that organizations are unwilling to replace or design after the introduction of a new technology (Mykkänen, 2007). These legacy systems are commonly used in healthcare organizations (Mykkänen, 2007) and thus could the use of CORBA improve the integration of such systems.
All in all, we recommend Creq to look into both CORBA and EAI to investigate whether these technologies are helpful for healthcare organizations in a practical context as well.

In addition, two healthcare organizations mentioned their wish to implement some sort of middleware and two organizations are in the process of using Identity and Access Management (IAM). These are both practical aspects that Creq should consider investigating.

Furthermore, *privacy regulations* are already declared as a difficulty by most of the healthcare organizations. However, the IT consultants expected this to increase with the introduction and application of privacy by design. This difficulty should therefore be focused on in the future, to prevent the privacy regulations from complicating the integration process even more.

The last integration aspect that should be concentrated on is the collaboration between healthcare organizations. All healthcare organizations mentioned the plan to expand this collaboration, but the difficulty of *a lot of standards and trust frameworks* and again *privacy regulations* are making it harder for the organizations to cooperate. Creq could explore the possibilities of easing that development.

5.6 Limitations

There exist various threats to the validity of this research.

First of all, this research was limited to three IT consultants at Creq and only four healthcare organizations. Moreover, Creq and the healthcare organizations are all specialized in the long-term elderly and home care in the Netherlands. As a result, the generalizability of the results to the healthcare sector as a whole is weakened, due to the small and homogeneous sample size.

Secondly, we cannot assure that all papers on integration were included in this research, as we used an informal search instead of a structured search. Therefore, the exact number of papers that mention the individual technologies could differ from the table in Appendix B. This can also be applied to the difficulties that were seen in the literature.

In addition, we did not follow a certain protocol during the interviews, as we wanted the interviewees to discuss what they believed to be important. However, this means that certain aspects of integration were not mentioned in some interviews, even though the interviewees might have known about them. Therefore, it can not be concluded that whenever a specific topic was not included in an interview, the interviewee was unaware of the topic altogether.

Another limitation with regards to the interview is the opposite of the one mentioned above. Namely, even though the intention was to be objective, in some cases we might have unknowingly directed the interviewees to certain topics as we knew that they were discussed before.

Furthermore, the focus of this research was on the difficulties that system integration causes. Even though integration also has potential with regards to the drivers that were named in Section 4.1, this was not the aim of this thesis and therefore not concentrated on. This might give a skewed view of system integration as a whole and should be taken into account.

Lastly, human factors should be taken into account in this research. For example, the interviews were held in Dutch and translated to English whenever a citation was used. Accordingly, translation bias may exist and have caused the citations to be different from the intention of the interviewees. In addition, the thematic analysis of the interviews could differ if it were done a second time, as the data could be interpreted differently.

6 Conclusions

Despite the existence of many studies, system integration is still one of the most critical issues that healthcare organizations face today. The literature review revealed that a lack of data exchange and interoperability prevents the optimal use of medical resources and the optimization of the application landscape of healthcare organizations. Moreover, the definition and interpretation of integration vary among disciplines and studies. Thus, this study aimed to clarify system integration in the practical environment of healthcare organizations in the Netherlands, to support the improvement of integration, using the following research question: "How can integration drivers, types, difficulties, and technologies regarding systems in healthcare organizations be classified?"

To answer this research question, seven interviews were conducted to gain a perspective from three IT consultants specialized in the healthcare sector and four representatives with IT positions within different healthcare organizations. Using thematic analysis, the two perspectives resulted in a classification of integration drivers, types, technologies, difficulties, and prospects. These perspectives will be concluded in the next sections. Finally, the main recommendations for Creq, the host organization of this thesis, will be presented.

Integration drivers
The IT consultants named various drivers for system integration, yet the healthcare organizations failed to do so. This could be explained by the difficulty that the bigger picture lacks, which prevents the organizations from identifying integration drivers.

Integration types
The integration types were given by the IT consultants and one of the healthcare organizations. However, it can be concluded that integration can be categorized in various ways, given that our research gave yet another classification of integration types than the many already existing classifications.

From the interviews, it could also be derived that almost all healthcare organizations are still in the second integration type as defined in this research, namely *process optimization*. Only one of the organizations has already moved to the third integration type, which is *master data and control information*.

Integration technologies
This research found that two of the most mentioned technologies in the literature, CORBA and EAI, were not once mentioned in the interviews. This difference cannot be explained by the research taking place in the Netherlands. Therefore, this indicates a meaningful difference between literature and the practical context of healthcare organizations.

The results of the interviews and the literature, however, were similar with regards to APIs, as this was in both cases the most mentioned technology. The IT consultants expect the popularity of APIs to increase even more in the future, which is why APIs can be identified as the most important integration technology in the context of today's healthcare organizations.

Integration difficulties
During the interviews, thirteen integration difficulties were mentioned by either the IT consultants or healthcare organizations. The most mentioned difficulties were *diversity of systems*, *dependency on software suppliers*, and *privacy regulations*. Seven of these thirteen mentioned difficulties were also found in the literature. Therefore, it can be concluded that the literature has a good view of the practical difficulties that occur in healthcare organizations.

Integration prospects
From the integration prospects, it can be derived that all healthcare organizations wish to begin or expand their collaboration with other healthcare organizations. Interestingly, the Dutch government is trying to improve this process by implementing various programs, like PGOs and ZIBs. However, this is often having the opposite effect as the many regulations complicate the collaboration.

Another noteworthy result is the difference in the integration philosophy of the interviewed healthcare organizations, which could be explained by the impact that the current projects have on the believed importance of certain integration aspects.

Recommendations for Creq
Creq has multiple aspects to focus on with regard to system integration in healthcare organizations. First of all, they could consider the integration technologies API, CORBA, and EAI. Secondly, middleware technologies and IAM are on the agenda of healthcare organizations. Moreover, privacy regulations are becoming increasingly important with the introduction and application of privacy by design. Lastly, the collaboration between healthcare organizations could be concentrated on.

All in all, this research has identified and classified various aspects of integration in the practical context of healthcare organizations in the Netherlands. These aspects contribute to the clarification of system integration and are beneficial to the improvement of system integration.

6.1 Future work

To further clarify and improve system integration within healthcare organizations, additional research in the following areas would be beneficial.

First of all, future work could focus on a study with a larger and more diverse sample size to be able to quantify the results and generalize them to the healthcare sector as a whole. For example, hospitals are not included in this research but could be valuable to add as they are often larger than the healthcare organizations included in this research.

Moreover, the interviews were only conducted with IT consultants and representatives of healthcare organizations that held an IT position within their organization. Consequently, we did not interview healthcare staff themselves, who could have an alternative perspective on system integration. Further research could therefore be done on the attitude and knowledge of healthcare staff with regard to integration.

Additionally, the technologies that were most mentioned in the interviews and the literature could

be further investigated. This research merely stated whether a technology was mentioned or used within a healthcare organization, but it could be helpful to consider how or when these technologies are used, to further identify how the technologies contribute to system integration. Furthermore, the order of the difficulties with respect to their importance could be investigated.

Finally, the identified integration aspects in this research could be used to formulate a general integration approach for healthcare organizations in the Netherlands.

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Appendices

A Loose and tight integration

Table 1
Loose and tight type of integration

Loose integration	Reference
Focuses on exchanging…sharing data among partners	Kalakota and Robinson [13]
Low degree of processes dependency	Loinsky [18]
Low degree of integration	Brown [2]
The development of a homogeneous integrated cross-enterprise infrastructure is important	Helm [10]
Asynchronous communication	Puschmann and Alt [20]

Tight integration	Reference
Focuses on integrating cross-enterprise business processes and systems	Themistocleous et al. [28]
Highest degree of processes dependency	Kalakota and Robinson [13]
High degree of integration	Brown [2]
The development of a homogeneous integrated cross-enterprise infrastructure is important	Helm [10]
Synchronous communication	Puschmann and Alt [20]

Source: Themistocleous and Irani [27].

Figure 2: Loose and tight integration (Themistocleous and Irani, 2002b).

B System integration technologies

References to the papers used in Table 13:
Ammenwerth et al. (2003); Bakker and Leguit (1999); Bellman et al. (2019); Budgen et al. (2007); Chapman and Kihn (2009); Chen (2005); Chenhui et al. (2008); Chu and Cesnik (2000); Contandriopoulos et al. (2004); Giachetti (2004); Grimson et al. (2000); Gulledge (2006); Hasselbring (2000); Khoumbati, Themistocleous, and Irani (2003); Khoumbati, Themistocleous, and Irani (2005); Khoumbati and Themistocleous (2006); Khoumbati, Themistocleous, and Irani (2006); Khoumbati, Shah, et al. (2007); Khoumbati and Themistocleous (2007); Kitsiou et al. (2006); Loos (2000); Lopez and Blobel (2009); Madni and Sievers (2014); Mathews and Pronovost (2011); Mykkänen, Porrasmaa, Rannanheimo, et al. (2003); Mykkänen, Porrasmaa, Korpela, et al. (2004); Mykkänen (2007); Pisching et al. (2018); Rajabalinejad et al. (2020); Robbins and Stylianou (1999); Rombout (2017); Sabooniha et al. (2012); Sanchez et al. (2020); Sharma et al. (2001); Shen et al. (2010); Sonune et al. (2017); Stefanou and Revanoglou (2006); Streekmann and Hasselbring (2008); Suri et al. (2017); Themistocleous and Irani (2001); Themistocleous and Irani (2002a); Themistocleous, Irani, and Love (2004); Toussaint et al. (2001); Volkoff et al. (2005); Wu and Trigo (2021); Xu et al. (2000); Yang et al. (2010); Zhigang and Huiping (2009).

System integration technology	**Number of papers it was mentioned in**
(REST) APIs	37
XML	26
CORBA	22
HL7	18
EAI	18
Web services	16
COM/DCOM	14
EDI	12
Data warehouse	12
Messaging	12
Adapters	11
Point problems	10
Application servers	9
Message broker	8
DHE	8
UN/EDIFACT	8
RPC	7
EJB	6
(Industrial) Internet of Things	6
MOM	5
SOAP	5
ODBC	4
JDBC	4
Internet technology	4
Screen wrappers	3
Federated Database System Technology	3
Mediators	3
Cloud computing	3
Data analytics	3
TPM	2
Java RMI	2
Service wrappers	2
DOT	1
Blockchain	1
System integration engine	1
ASN.1	1
ASTM	1

Table 13: System integration technologies in respect to the number of papers they are mentioned in.

C System integration approaches

Approach	Applicability	Supported Technologies	References
Integration Processes Layer	Integration of Business Processes	Workflow tools	Hasselbring (2000)
Enterprise Application Integration Layer	Integration of autonomous ERP	EAI solutions, Message services, XML	Hasselbring (2000)
Middleware Integration Layer	Integration of componentized information systems	DCOM, CORBA Transaction Monitors Database Gateways	Hasselbring (2000)
Messaging Integration Approach	Integration of loose coupling of systems	Message services XML	Grimson *et. al.* (2000)
Enterprise Application Integration Approach	Integration of specific ERP systems	Wrapping Techniques XML, Message services	Grimson *et. al.* (2000)
Data Warehouse Integration Approach	Data integration	Data Warehouse	Grimson *et. al.* (2000)
Distributed Component Based Approach	Integration of business processes	DCOM, CORBA	Grimson *et. al.* (2000)
Integration Implementation Model which includes Transport, Transaction, Translation, Transformation, Time and Process layer	Integration of intra and inter-organisational applications	EAI Tools	Duke *et. al,* (1999)
Transport layer	Data integration Application integration	Middleware products EAI solutions	Klasell and Dudgeon (1998)
Translating and Formatting layer	Data integration Application Integration (e.g. ERP-to-ERP)	EAI Adapters, objects, message services Message Brokers, XML	Klasell and Dudgeon (1998)
Process Automation layer	Application integration E-business integration	EAI products	Klasell and Dudgeon (1998)
Data-level EAI	Data integration	XML	Linthicum (1999a)
Application-interface level	Package AI (e.g. ERP-to-ERP)	APIs CORBA, COM	Linthicum (1999a)
Method-level EAI	Business Process integration	EAI adapters, CORBA, COM, MOM, Message brokers	Linthicum (1999a)
User-interface level EAI	Custom Packages (e.g. legacy) Integration	Screen Wrapping	Linthicum (1999a)
Messages and Transportation Layer		Message oriented Middleware Products	Edwards and Newing (2000)
Integration Service Layer		Message Brokers	Edwards and Newing (2000)
Business Logic	Process automation integration	Workflow tools EAI solutions	Edwards and Newing (2000)
Data-level integration	Front-end integration	Middleware products	Ring and Ward-Dutton (1999)
Object level integration	Synchronisation of data between applications and databases	CORBA, COM, Middleware	Ring and Ward-Dutton (1999)
Internal process level integration	Semantic integration	EAI adapters, Middleware	Ring and Ward-Dutton (1999)
Cross-enterprise application integration	E-business integration Package to package integration	EAI adapters, XML	Ring and Ward-Dutton (1999)
Data Integration Model	Database Integration	Database Middleware	Ruh *et al.* (2000)
Presentation Integration Model	Legacy Integration	Screen Wrappers	Ruh *et al.* (2000)
Functional Integration Model	E-business integration Package to package integration Business Processes integration	APIs, EAI adapters	Ruh *et al.* (2000)

Table A1.6: Integration Approaches

Figure 3: Integration approaches by Themistocleous and Irani (2002b).

D Classification of integration

The table below is created by Themistocleous, Irani, and Love (2004) and shows a classification of integration technologies.

Table 4
Evaluation of integration technologies

Category of integration technologies	Integration technologies	Evaluation criteria												
		Applications elements			Integration layers			Classifications of system types						
		Data	Objects	Process	Transportation	Translation	Process automation	Custom-to-custom	Custom-to-packaged	Custom-to-e-business	Packaged-to-packaged	Packaged-to-e-business	E-business-to-e-business	Custom-to-packaged-to-e-business
Database oriented middleware	ODBC	●	×	×	×	◩	×	◒	◒	◒	●	●	●	●
	JDBC	●	×	×	×	◩	×	○	◒	◒	◒	◒	●	◒
Message oriented technologies	RPC	◩	×	×	●	×	×	○	○	○	×	×	×	○
	MOM	◩	○	×	●	×	×	◒	◒	◒	○	○	×	○
	Message broker	◩	○	◩	●	●	●	●	●	●	●	●	●	●
	XML	◩	◩	×	●	●	×	○	○	●	●	●	●	●
Transaction based technologies	TPM	◩	×	×	◩	○	×	◒	○	○	○	○	○	○
	Application serves	◩	◩	×	◩	×	×	×	◒	◒	◒	●	●	◒
Distributed object technologies	CORBA	◩	●	–	◩	◩	–	◒	◒	◒	●	●	●	◒
	DCOM/ COM	◩	●	–	◩	–	–	○	◒	◒	●	●	●	◒
	EJB	◩	●	–	◩	–	–	○	○	◒	◒	●	◒	
Interface oriented technologies	Screen wrapper	◩	◩	×	×	◩	×	●	●	●	○	○	○	●
	APIs	◩	◩	–	–	◩	–	–	◒	×	●	●	●	●
	Adapters	◩	◩	×	×	◩	×	–	◒	◒	●	●	●	●

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Figure 4: Classification by Themistocleous and Irani (2002b).

The following tables are constructed by Sabooniha et al. (2012) and present a classification of integration technologies according to certain integration requirements.

Table1: Compression of some current integration solutions in the context of Non-Functional integration requirements.

Non- Functional Integration Requirements										
		Flexibility	Real-time	Reliability	Reusability	Performance	Complexity	Maintainability	Maturity	Portability
Message- OI	HL7	×	✓	✓	×	×	✓	∞	×	∞
	DICOM	×	✓	✓	×	×	×	∞	✓	∞
Middleware-OI	CORBA med	✓	✓	✓	✓	×	✓	✓	×	∞
	HANSA	✓	✓	✓	✓	×	×	✓	×	✓
	SYNEX	✓	✓	✓	✓	×	×	∞	×	∞
Application- OI	IHE	✓	✓	✓	×	×	∞	✓	∞	✓
Coordinated-OI	CCOW	✓	✓	✓	∞	×	×	×	×	✓

∞ : Unknown

Table2: Compression integration solutions based on Functional Integration Requirements.

Functional Integration Requirements			
		Scalability	Heterogeneity
Message- OI	HL7	×	×
	DICOM	×	×
Middleware-OI	CORBA med	×	✓
	HANSA	✓	✓
	SYNEX	✓	✓
Application- OI	IHE	✓	∞
Coordinated-OI	CCOW	×	×

Figure 5: Classification by Sabooniha et al. (2012).

E Explanation of integration technologies

	Explanation (from the interviews)
Common	
API	See Section 2.2.1
Service bus	A service bus (or platform) is used between two systems to transform the data that flows between them.
Power BI	Power BI is a tool created by Microsoft that uses and combines data from various sources to create new insights. This is usually done with bulk data.
Power apps	Power apps are the same as Power BI, except that they can communicate back to the source. They are mainly used to edit the received data and send it back.
HL7	See Section 2.2.4
XML	See Section 2.2.2
Point solution	A point solution is a term used for a connection that is only a relation between two systems. There are no alternative uses for this point solution other than that relation. A point solution is more a type of solution, as it could very well be an API or make use of XML or HL7.
'Fire and forget'	'Fire and forget' is a term for systems that send data to another system and then proceed to 'forget' what they sent. In other words, the data that is transported is not stored afterward.
Service automation	Service automation is automating a service task that used to be done manually.
Uncommon	
ERP	See Section 2.4.1
Blockchain	Blockchain is a type of database that stores transactions in a safe way.
Service wrappers	Service wrappers are containers in which you can do tasks.
RPA	RPA stands for Robotic Process Automation and can be seen as automating tasks in an application without creating a different interface.

Table 14: Explanation of the integration technologies (source: interviews).

F Explanation of integration difficulties

Difficulty	Explanation (from the interviews)
Diversity of systems	The systems used by healthcare organizations all differ from each other.
Dependency on software suppliers	Healthcare organizations are dependent on their software suppliers regarding connections they want or need.
Privacy regulations	Nowadays, privacy regulations are becoming more extensive and complex, which has consequences for the systems and standards healthcare organizations use.
A lot of standards and trust frameworks	Especially because the Dutch government is subsidizing various programs, there are currently many standards and trust frameworks to which healthcare organizations want or need to adhere.
Change aversion	Healthcare organizations often have change aversion, which might prevent the organizations from implementing the right solutions to integration.
Healthcare is lagging in technology adoption (immature IT department)	Healthcare as a sector is lagging in technology adoption with respect to other industries. This can also be seen within an organization, where an immature IT department might impact the way that they integrate their systems.
Bigger picture lacks	Healthcare organizations sometimes lack the bigger picture, which is needed to optimally integrate systems.
Validation	Validation is very complex to organize, as many components have to cooperate at the exact same moment.
Unknown ownership	Often when a connection is created, it is unknown who or what the owner is of that connection, which leads to other difficulties when a connection needs to be optimized.
Policies are hard to establish	The policies on which the connections are based are very difficult to establish, as it is human work that usually cannot be optimized or replaced.
Lack of resources	Healthcare organizations usually lack the time and money to integrate their systems optimally.

Table 15: Explanation of the integration difficulties (source: interviews).