Institutions and Contact Tracing Applications

Comparing design processes in France, Germany and the Netherlands

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CoSEM MSc. Thesis

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by

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Preface

Before you lies the Master's Thesis "Institutions and Contact Tracing Applications: Comparing design processes in France, Germany and the Netherlands" which I finished at a time when it looks like contact tracing applications will be soon something of the past again and hopefully will be remembered as an artefact of the early 2020s with no reason to ever use these applications again.

This thesis is written to graduate from the Complex Systems Engineering and Management program at the TU Delft and covers some of the aspects of this program that I enjoyed the most: governance, law and IT systems. The research was also especially topical since it covered one aspect of the ongoing COVID-19 pandemic, but the writing of it was also affected by this same pandemic. This was for example because of limited options for thesis topics, my first topic included a lot of in-person interviews, which was not feasible with all the lockdowns, as well as the general challenges of working from home with the opportunity to go out and unwind after a long day of writing and researching.

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Additionally, I would like to Joris Leker who was willing to be an interviewee for this study. Both the French and German development teams had strict communication policies so no interviews were possible for these cases but the extensive input from mr. Leker helped me a lot in understanding not only the Dutch case better but also gave additional context on how these processes worked in general and in doing that helped me improve the quality of the entire thesis.

Finally, I would like to thank friends and family who supported me through writing this thesis, either through useful discussions about the content matter, or providing a distraction when I needed it.

Casper Kroes
Delft, March 2022

Executive summary

Research question and goal

After the start of the COVID-19 pandemic, many countries decided to develop digital contact tracing applications to assist in contact tracing. This aimed to warn people who were potentially infected as early as possible and stop them from spreading the virus further and bringing down the total amount of new infections. Even though there was some proof of the potential effectiveness of applications such as these, they had never been deployed at scale before the pandemic and there was no standardised and shared vision on how to best implement these applications, meaning that countries that wanted to include digital contact tracing as part of their COVID-19 strategies needed to design and develop an application themselves.

There is an extensive body of literature that shows that the institutional, regulatory and cultural environment in which a socio-technical system, such as a mobile contact tracing application, is developed, has a significant effect on the functioning of the system and also the design choices that are made in designing such a system. In this research paper, the design processes in three EU member states (Germany, France and the Netherlands) are analysed, together with their institutional environments, to answer the question:

"How have institutions influenced the technical design of COVID-19 Contact-Tracing applications in France, Germany and the Netherlands?"

In answering this question, an overview is given of the effect of the institutional environment on these cases, and the tangible effects it had on the technical application, as well as a comparison between the cases.

Methods

To analyse the cases, the Institutional Analysis and Development framework is used (Ostrom, 2007). This framework allows for each of the cases to be broken down into different institutional factors which can then be analysed per case and compared across cases. As input for the analyses publicly available documents are used, such as scientific reports and news articles, as well as an interview for the Dutch case.

Key findings

The three cases differed a lot on several different institutional factors. The primary differences were in the types of organisations tasked with developing the applications, the openness of the design processes, the perceived value of certain implementations and the implementations that resulted from these design processes.

When it comes to the composition of the coalitions tasked with developing the applications there is a large variation. In the French case, a large coalition with many academic, public and primarily private actors were charged with developing the application. In the German case, this task landed with two private companies, which organised a large open-source community around the project and in the Netherlands, the application was built in-house at the Ministry of Health, Welfare and Sports, also involving an open-source community. These different forms of organising in most cases reflected aspects of the governments that were responsible for developing the applications.

The openness of the process also varied widely over the cases. Even though each of the cases had open-source functionality integrated into the design process, how this was done differed a lot. In the French case, the source code was hosted publicly and available to the wider public, but the public needed special access to be able to propose changes to the code, which generally is seen as going against the idea of open-source. In the German case, the source code was hosted on a platform where everyone could propose changes, but communications with the responsible organisations were limited and only done over email. In the Dutch case, the code was open-source, and the developers were also publicly available through the platform Slack, where a forum was hosted where anyone could ask questions and be involved in the design and development process. Since research shows that stakeholder perceptions can make or break a socio-technical system, and trust can fluctuate a lot during large-scale disruptions, it would be expected that having an open process would increase trust and willingness to adopt an application, which also seems to be reflected in the case studies.

The perception of the value of centralised and decentralised implementations of mobile contact tracing varied also a lot between the cases. Both of these implementations have their own set of advantages and disadvantages. The centralised approach is characterised by central processing of data, little data being sent out to devices of users and less need to depend on big American companies such as Apple and Google. The decentralised approach is characterised by little centralised processing of data, but more data needs to be sent out to users and integrating the Google-Apple Exposure Notification framework was required for best results. Both in the German and French cases the original preference seemed to be for the centralised implementations due to considerations relating to ”digital sovereignty”, the desire not to be dependent on companies from outside the EU. Whereas France continued with that implementation, Germany eventually switched to the decentralised approach due to public pressure. The Netherlands never pushed for ”digital sovereignty” and due to accepting the demands from NGOs early on in the development and design process, the decentralised approach was the only option that complied with all formulated requirements.

Primarily because of the difference in perceptions mentioned above, the French implementation ended up being centralised, whereas the Dutch and German applications were decentralised, with the Dutch implementation using less data than the reference architecture due to the requirements formulated before the development process started.

Scientific contribution

This paper contributes to academic literature in three ways. First of all it contains a rigorous application of the Institutional Analysis and Development Framework, leading to an in-depth analysis of all the institutional elements that shaped the design of these contact tracing applications. Secondly, it shows the existence of a trade-off between trust versus how centralised a process can be, which is discussed further under ’policy recommendations’, and finally no significant influence was found of the type of organisation being tasked with developing the application (public, private or academic) on the architecture of the application itself. This last point is notable, because based on scientific literature one could expect that the type of organisation influence the design of the system.

Policy recommendations

Based on the research done in this thesis, the following policy advice is given:

The research shows that institutions had a significant effect on the functioning of contact tracing applications. When (continuing) developing a contact application it is therefore worthwhile to identify the institutional environment you operate in. One key factor in this is trust. Since trust tends to vary a lot during large scale disruptions such as the COVID-19 pandemic, it would be safest for governments to assume that trust will decline during the design process and because of that both the process and the application needs to be able to gain trust even in a low-trust environment. The exact method of achieving this will vary depending on the institutional environment but in both the Dutch and German cases it becomes clear that a more open process generally leads to less distrust towards the project. The same can also be said for stakeholder involvement in the process. By involving a plurality of stakeholders thoroughly early on in the process, they might feel less inclined to cause unrest in the media. In the French case, the strategic goals of ”digital sovereignty” have clearly been prioritised over an open process, this is also a valid course of action but centralising the decision-making process to achieve strategic goals in this case, comes with a cost to the amount of trust and it should therefore be a conscious trade-off between public trust and strategic goals.

List of Abbreviations

CWA Corona-Warn-App

DP3T Decentralized Privacy-Preserving Proximity Tracing

EU-DCC European Union Digital COVID Certificate

GAEN Google/Apple Exposure Notification Service

PEPP-PT Pan-European Privacy-Preserving Proximity Tracing

STS socio-technical system

TEK Temporary Exposure Key

Contents

1 Introduction

1.1. Problem context

At the start of the COVID-19 pandemic, starting March 2020, many governments decided to enact lockdowns in their countries to limit the extent of the first outbreak. The number of new infections was increasing rapidly and many governments decided that strong measures were necessary. By closing schools and shops in many countries, the spread of the disease was limited and the amount of new infections started going down again., but it was also clear that the SARS-COV-2 virus would be an ongoing problem for the foreseeable future. During these first weeks of the pandemic there were already speculations that after the first restrictive measures, longer-term solutions would need to be worked out to control the spread of the disease for the time that followed, as was for example described in the widely mentioned article dated March 19th, 2020 ”The Hammer and The Dance” (Pueyo, 2020). The (non-scientific) article describes that the ”r value”, which is the exponent in the exponential growth of new infections, should remain under 1 (meaning that overall infections are going down), and that measures to achieve this would include extensive testing, contact tracing and quarantining of (potentially) infected individuals. To facilitate contact tracing, many national governments around the world started developing mobile applications to support contact tracing efforts.

1.2. Contact tracing

Contact tracing, together with isolation, is one of the measures used to control the spread of diseases (Eames & Keeling, 2003). By contacting any persons that have been close to an infected person and requiring them to isolate, potentially infected contacts can be stopped from transmitting the disease further and breaking chains of infection. This brings down the overall amount of new infections within a community, slowing down the spread of the disease. In practice, this means that fewer healthcare resources are needed at once to treat infected patients. Contact tracing has historically been used effectively for managing outbreaks and reducing the spread of both sexually transmitted diseases (STDs) (Fitzgerald et al., 1998), as well as some potentially severe airborne infections such as SARS, smallpox, polio and measles (Riley et al., 2003), and therefore would also be suitable for managing outbreaks of COVID-19.

Up to the COVID-19 pandemic, contact tracing was primarily done using questionnaires and phone calls to people who were potentially at-risk, although some pilots were held with digital contact tracing using mobile applications during the Ebola outbreak in Guinea and Sierra Leone (Danquah et al., 2019; Sacks et al., 2015). The results of both these projects were promising but they could not be implemented on a large enough scale to replace the traditional methods of contact tracing. This means that at the start of the COVID-19 pandemic there were no IT systems and applications in place to support the Contact Tracing effort and most of the infrastructure would need to be developed from scratch.

1.3. Institutions and socio-technical systems

The design and development of contact-tracing applications is a complex process that is constrained and shaped by a number of external factors. The state of the technology is an obvious factor, but also the laws and rules that are used within the context of a specific country, as well as the culture, dictate which system designs are acceptable. On top of that, the selection of people who decide on the design and the interactions between them shape the system and its functions. Since different countries have different cultural and regulatory frameworks, one would expect them to also approach the design of such a contact tracing application differently. Different countries, after all, have different regulatory frameworks and different cultures that would produce different requirements for such an application in every country. Since it does not happen frequently that many different governments all design a system, that is so similar in intended functionality, as the contact-tracing applications are. This provides a unique opportunity to compare how the institutions in these countries affected the design process. This paper, therefore, covers a comparative case-study of the design and implementation of contact tracing applications in three different countries: France, Germany and the Netherlands. The question to be answered in this thesis is as the following:

> ”How have institutions affected the technical design of COVID-19 Contact-Tracing applications in France, Germany and the Netherlands?”

This selection of countries is chosen because their institutions have a lot in common due to the shared membership of the European Union. All three of these countries' governments are expected to comply with the GDPR and to respect democratic processes. Nevertheless these countries also differ on several fronts: the governmental systems differ a lot, with Germany being a federal republic, France having a presidential system with a large role for the president, and the Netherlands with its ”polder-model” in which legislative processes often include extensive stakeholder involvement and a strong focus on consensus. This selection of countries allows for identifying which differences influenced which results without the cases becoming completely incomparable due to institutional differences which are too large.

1.4. Societal relevance

Answering this question would give an in-depth overview of how institutions affect the technical design of a specific type of large-scale socio-technical IT systems. This would be relevant for society because it could lead to concrete recommendations that can inform governments that want to set up similar systems in the future about how their specific institutional set-ups will affect the resulting system. This insight could then be used to shape the institutional system in such a way that it yields optimal results. Additionally, this comparative case study could give an overview of which institutions would need to be considered when implementing an existing socio-technical system in a new institutional context.

1.5. Scientific relevance

The scientific relevance is realised by adding a rigorously applied analysis, using the Institutional Analysis and Development Framework (Ostrom, 2011), of real-life cases to the existing body of literature on institutions and socio-technical systems. Mobile contact tracing applications are a new IT development and have not been studied from an institutional analyses model before and therefore this would be a worthwhile addition. By evaluating the effects of institutions on these systems in multiple different environments, a frame of reference is generated that then consequently can be used to compare other systems against. Additionally, new insights can be generated on the application of institutional analysis within this field. Finally, the effects of institutions on the overall design process of mobile contact tracing applications, and socio-technical systems in general, can be evaluated and new potential relations between institutions and design choices and their consequences can be identified for future research.

1.6. Link to the COSEM programme

The TPM Graduation portal states that:

> ”The aim of CoSEM master thesis projects is to design solutions for large and complex contemporary socio-technical problems. This requires the consideration of technical, institutional, economic and social knowledge.”

This topic fits well within that mould since the aim is to evaluate the design processes of COVID-19 contact-tracing applications in three different institutional settings, which by itself should already show the many domains involved in this issue. The technology component is included by looking at how the institutional environment affected the final technical design using sufficient technical detail by evaluating specific technical functions, as well as the overall architecture. Since many of these applications were made in public/private partnerships both the public and private sector and the values originating from these sectors are represented.

2
Literature review

In this chapter existing literature on contact tracing systems and the effects of institutional arrangements on comparable systems will be reviewed, after which the main knowledge gaps are identified and the sub-questions are formulated. By reviewing the available literature on the effects of institutions on comparable systems, the issue of the development of contact tracing applications can be considered within the larger discipline of socio-technical design. The goal of this literature review is to give an overview of current knowledge on the effects of institutions on complex socio-technical systems such as contact-tracing applications and to identify a specific knowledge gap to focus on.

For this literature review, the PRISMA method (Page et al., 2021) is used. All the documentation of this method, including the methods of gathering literature and the search engines used, are included in Appendix A. This chapter contains a summary of the collected literature grouped among certain themes that resulted from the literature review.

2.1. Institutions and socio-technical systems

2.1.1. Introduction to the relationship between institutions and technical systems

This section focuses on the relationship between institutions and (socio-)technical systems. Where the term ”institution” in day-to-day use commonly refers to formal organisations, in this paper we follow the definition from the field of institutional economics, where institutions are more abstract and the term refers to any formal or informal rules and can cover a broad range of topics. These rules play a large role in shaping interactions, and can for instance dictate who has which formal role, who has access to information or power, which changes to systems or solutions to problems are acceptable, how the value of specific (changes to) systems are evaluated and many more aspects of decision making.

Both the institutional and technical components of a Socio-Technical System have an effect on how a system functions, and therefore both need to be considered when evaluating a system with strong technical and institutional components. This research will focus on the institutional components of contact tracing applications as a Socio-Technical System, and the influence that the institutional set-up has had on shaping the technical component.

Little research has been done on the effects of institutions on the technical design of COVID-19 contact tracing applications, or complex IT systems in general (as is shown by the limited results yielded by the keywords in Appendix A), but when generalising to effects of institutions on the usage of technology by governments in general, more is known. In this section, several themes are discussed that repeatedly appeared in the literature gathered.

The fact that institutions affect technical developments within a country is generally accepted, as is shown by the literature on Variety of Capitalism (Bonaccorsi, 2015; Casper et al., 1999). According to the Variety of Capitalism framework, capitalist societies differ on multiple dimensions and as a result of that, they fill certain niches in the global markets. Because of this they handle technical challenges in different ways and therefore different countries tend to specialise in the development of different types of technologies (Bonaccorsi, 2015). The primary dimensions that cause these differences are: relations between employers and employees, education and training, corporate governance and access to finance, relationships between firms, relations between employees. The same differences that affect the differences in the technology being researched and developed in countries, can equally well affect the implementation of these technologies.

2.1.2. Institutions and their influence on existing Socio-Technical Systems

This section discusses the effect of institutions on existing systems. The effect of institutions on technology is for example shown by Córdova et al. (2014). This paper compares the Office for Harmonisation in the Internal Market of the EU with the Internal Revenue System in Chile and shows how these bodies differ because of their institutional environment. The EU body relies a lot more on expert civil servants, whereas the Chilean body is mostly dependent on its director, which is a politically assigned position, leading to very different dynamics within the organisations. Nevertheless, some factors are also comparable, such as the increasing reliance on technology and domain experts as IT takes an increasingly important role in both organisations.

Organisations can also differ significantly between organisations within the same country, such as shown in Fleischmann et al. (2011). Here the values of employees of three labs where computational modelling is done were compared using surveys and interviews, and subsequently another set of surveys and interviews were used to identify whether this difference in values affected their modelling choices. The results show that whether a lab was a corporate, academic or government research lab affected how they set-up their models. This shows that organisational culture also can have a significant effect on how systems are implemented.

The success of waste management initiatives is largely dependent on institutions as is shown by Oh and Hettiarachchi (2020). This comparative case study using the Institutional Analyses and Design (IAD) Framework focuses on analysing the effect of the institutional environment on waste management in Brazil, Indonesia and Nigeria from a collective action perspective. The paper primarily is used to validate the framework within this sector, and it also provides some conclusions. One key finding is that the decentralised set-up of the systems considered was an advantage in the Brazilian case, but a disadvantage in the Indonesian and Nigerian cases, showing that individual institutions might have different effects based on the overall systems they are implemented in.

Sanches et al. (2021), in their paper on forest management in Brazil, identify the importance that the flow of information within a socio-technical system (STS) has. The case considers forestry management in a remote area of Brazil. Due to the remote area and its idiosyncratic culture communications tend to be insufficient to implement the government-mandated forest restoration acts. By ensuring that the right actors have the right information and the required knowledge to identify and guide local self-organisation, forest restoration can be done more efficiently and effectively.

Dong et al. (2009) show clearly how systems can fail if institutional environments are not taken into account. This case study of ecosystem management in Nepal shows how a lack of awareness of the social aspects of ecological management failed to foster cooperation between people which is crucial for achieving effective results in improving the quality of ecosystems in the Nepalese rangelands. These issues are primarily caused by a conflict between government ministries over land management and resource development, as well as a lack of communications between local organisations and the national government.

Institutions also play a major role in the electrification of rural areas (Lestari et al., 2018). This comparative case study of rural electrification in Indonesia shows that when developing independent electricity systems for remote areas in Indonesia, one should take into account the strong value that these communities assign to eventually being connected to the main grid. This means that local electrification projects should always be seen as temporary because they do not change this perception. Not taking into account how highly a connection to the main grid is valued will lead to wrong investment decisions. Additionally, the local and regional administrative bodies that are responsible for these projects require the adequate capacities to be present within their organisation to organise the operational and financial management of these systems, to ensure that they create the most value for the communities.

2.1.3. Effects of institutions in implementing new systems

Multiple cases from the literature search show the importance of institutions for the implementation of new socio-technical systems. For implementations of carbon capture and storage (CCS) (Kainiemi et al., 2013) in Finland, stakeholder perspectives seemed to be the most significant factor determining the success of CCS, and since CCS is unpopular with the general public in Finland this means that there are many obstacles to using this technology in Finland. Another factor playing a large role is EU legislation that limits the options for exporting CO2 for storage (close to the Russian border, on the Russian side there would be suitable geological storage site), which is an issue because Finland itself has no suitable locations for storing CO2. Finally, the Finnish government does not see CCS as a promising development that should be included in the national climate strategy. All these institutional factors severely limit the potential success of CCS implementations.

The importance of institutions in designing IT systems is also shown in a case study focusing on disaster management in the Caribbean (McNaughton & Rao, 2018). In this case, analysing knowledge sharing within the Caribbean Disaster Management community, the IAD Framework is used to identify potential improvements to the policies currently put in place by the administrating body. Only a preliminary analysis is made to identify potential blockades to the implementation of such IT systems such as a lack of standardisation in data usage but no concrete suggestions are made to resolve these issues. The paper concludes that more research needs to be done before definitive conclusions can be drawn.

Trust is a key factor in implementing new technical systems (Semaan et al., 2010), and this trust can fluctuate during large-scale disruptions (such as the original SARS epidemic). In this case study of trust during large-scale disruptions (Semaan et al., 2010), it is shown that trust between people and people and institutions can decline because of the disruptions. During these disruption, IT is often used to validate information, especially if people still trust the national authorities and institutions are being upheld. To be as effective as possible, IT developed for usage during large scale disruptions should be designed taking into account that public trust can fluctuate.

All these cases described illustrate and emphasise that the institutional environment in which systems are developed can lead to the success or failure of these systems.

2.1.4. Institutions and physical conditions

Since Socio-technical systems are often complex it can be difficult to specify where problems arise and which parts need attention. For example, it can be difficult to identify whether the focus of further developments should be on the material side of a system, or whether the primary focus should be on the people involved with that system. This is illustrated by Ran et al. (2020), which studies disaster management around the three gorges dam in China. This research concludes that current policy focuses too much on material conditions, whereas public education and disaster awareness among the populace might be a more effective way to mitigate the risks of disasters. Similar tensions can also arise between the different types of governance systems, as is illustrated by Kamal et al. (2021). In this paper on water management in Iran, it was shown that the Iranian government prefers to organise the governance of these water systems from a top-down perspective, but this would often lead to a lot of localised knowledge getting lost. It is therefore important to have a framework for our analysis that could evaluate the effects of different governance regimes.

2.1.5. Evaluation of institutions

When looking at the effect of institutions on socio-technical systems it is critical to evaluate the institutions as they are in place, rather than idealised versions of governance arrangements and laws. This is for instance illustrated by (Pahl-Wostl, 2017). This literature review on water governance describes the focus on idealised versions of governance models within the water sector and states that these do not represent reality well enough. The paper also emphasises the need for shared scientific frameworks, because results collected by applying the same framework can be compared more effectively.

One of these standardised frameworks is the Institutional Analysis and Development (IAD) framework (Ostrom, 2011), and the literature search yielded several papers where (an adapted version of) the IAD is applied to a socio-technical system. One of these papers is the one by Allarakhia and Walsh (2012), where the IAD is used for analysing nanotechnology developments by some nanotechnology consortia. Within their analysis, they show that different consortia use different governance models and some consortia are more open to new entrants than others. Although these factors are identified, the paper does not go into the consequences of these differences.

The IAD Framework is also used in a paper by Lammers and Heldeweg (2016). In this paper, an adjusted version of the framework is proposed which integrates Institutional Legal Theory into the framework with the aim of better analyse legal institutions and how they affect smart grids. The framework aims to then identify before planning and implementation of a system which (legal) barriers or opportunities might arise. This framework is then applied to a case study, and some barriers for implementing such a grid are identified. The primary obstacle proves to be the need for consensus of at least 70% for housing complexes before a housing complex can be connected to a smart grid.

2.1.6. Institutions and contact tracing applications

Several papers have already identified institutions that have affected contract tracing applications, although no papers so far have specifically focused on this connection and results related to institutions often come up when doing an analysis with a broader scope. Jacob and Lawarée (2021a), in their paper on the adoption of contact tracing applications by several European governments, identified several relations between institutions and the implementation of contact tracing applications. The paper describes how contact tracing applications have been implemented in France, Belgium and the UK. The first thing that stands out is the vast differences in processes that each of these governments went through in designing their application. The French application was developed by a national research institute and the process seems to have been quite linear from what is reported, whereas the first app developed in the National Health Service (NHS) in the UK ended up not functioning properly, requiring a complete redesign. The Belgian contact tracing application was developed internally by the Belgian government, which is remarkably different from the other cases discussed here and has been developed in close cooperation with other European countries. Apart from who were tasked with designing the applications, Jacob and Lawarée (2021a) also go into topics that frequently come up in policy issues regarding CT applications. These topics include the technologies used, how acceptable the national population finds contact tracing, interoperability and privacy. Additionally, in the Belgian case, political power and formal competencies played a large role. Although this paper supports the notion that institutions have had a significant effect on the design and implementation of these applications, it does not do an in-depth analysis of the specific institutions and their specific effects.

Kariuki et al. (2021) discuss contact tracing applications in South Africa. The paper discusses several implementations of contact tracing and then goes into privacy implications of contact tracing, concluding that it concerns invasive technology which comes with ethical risks. The paper ends with recommendations on procedures to limit the risks of privacy, primarily by regulating how data can be handled. That these regulations are necessary is also shown by Storm van Leeuwen et al. (2021), which shows that each of the current prevalent architectures results in risks that cannot be mitigated through purely technical means and therefore requires institutional arrangements.

2.2. Knowledge gap

The preceding literature review identifies that there is a clear relationship between institutions and the functioning and design of socio-technical systems, gives a list of relations identified in previous research, as well as a more in-depth context to the interaction between institutions and physical conditions within a system; it describes multiple applications of the IAD to evaluate this relationship and finally discusses previous work on institutions and contact tracing applications.

From this review, it becomes clear that most research is done at a relatively high level of abstraction, not linking specific (combinations of) institutions to specific features of the technical design of the system, even though the IAD framework would be suitable to analyse action situations at this level (Ostrom, 2009). Additionally, it has been identified that some research has been done on specific institutions and contact tracing applications, but this research does not use a strictly institutional lens (instead focusing more on process and outcomes) and does not go into the specific influence of specific institutions.

There is therefore a clear knowledge gap when it comes to the effect of institutions on the design choices made in designing contact tracing applications specifically, and large-scale IT systems in general. The best way to fill this knowledge gap would be through a comparative case study. By using the same framework systematically for multiple cases, a consistent method is used that allows for a thorough comparison of the cases. Additionally, a frame of reference is specified to which other CT applications could be compared.

2.3. Research Question

This leads to the following main research question:

”How have institutions influenced the technical design of COVID-19 Contact-Tracing applications in

France, Germany and the Netherlands?"

This yields a total of three cases. The geographical scope was chosen due to the availability of primary sources in Dutch, English, French or German from these countries, as well as to have a reasonable diversity in governmental systems and institutional environments, but not such large differences that comparison would be impossible. Additionally, the selection of countries has been partially informed by preliminary literature research where it became apparent that France originally implemented a more centralised system and subsequently changed their architecture (Jacob & Lawarée, 2021a) and that Germany considered multiple different architectures before deciding on a definitive one (Baumgartner et al., 2020). This selection means that the cases are both spread out over an area with different languages and cultural differences, and the cases also differ in the process with which they came to a final design for the applications. The Institutional Analysis and Development (Ostrom, 2011) framework will form the basis for answering the research question.

The following sub-questions will be answered to analyse each of the four cases:

1. Which technical decisions, framed as action situations, had a particular influence on the design of this contact-tracing application?
2. Which influence did institutions have on technical design choices were made in the design of the contact-tracing apps?
3. How did these design choices affect interoperability and privacy integration?

Answering the first two questions allows for identifying the institutions and using the Institutional Analysis and Development framework (Ostrom, 2011) to describe and explain why specific decisions were made. Answering the third question allows sudying the technical artifact as a result of the process that designed it.

After these questions are answered for each of the cases, a cross case comparison is done focusing on the following questions:

4. Which, if any, patterns of interactions are shared between the cases?
5. Which, if any, interactions within specific cases stand out in specific cases, and which factors caused this?

Answering these questions would allow for identifying any patterns that arise between the case studies, as well as any striking differences and could inform future decisions about how existing socio-technical systems can be implemented in new institutional environments.

3
Methodology

3.1. Approach

For this research, a case study approach is used, using the Institutional Analysis and Development framework to explain how institutions shaped decisions in designing contact tracing applications for COVID-19 in Germany, France and the Netherlands. Case studies can be valuable because they provide context-dependent knowledge (Flyvbjerg, 2006) of how institutions shape socio-technical systems. One disadvantage of case studies is that it can be difficult to generalise from them, but by investigating multiple cases any patterns and broader trends that become apparent across cases can be identified.

As also discussed in the literature review, the Institutional Analysis and Development framework (IAD) (Ostrom, 2011) is often used when evaluating socio-technical systems from an institutional perspective. This framework would also be useful for the case of Contact Tracing for COVID-19 applications, since it covers most of the main themes that were also discussed in the literature review. It allows for the integration of elements from variety of capitalism literature, has a strong focus on the role of institutions without ignoring the technical attributes of a system, evaluates rules as they are used and allows for a detailed analysis of different governance systems. Because of this, the IAD framework is used in analysing the cases for this study. Below the framework is introduced and afterwards, the methods for answering the research question is introduced.

3.2. The IAD framework

3.2.1. Introduction of the framework

For this case study, the Institutional Analysis and Development (IAD) framework (Ostrom, 2011) is used. The IAD framework is a framework, which is different from a theory or a model. As a framework, the IAD framework identifies the elements and general relationships among these elements that need to be considered to analyse an institutional system. The IAD framework attempts to identify all the relevant variables required to analyse all types of institutional arrangements. The interactions between these variables can differ significantly between the arrangements being analysed thereby leading to many different results, but the variables included in the framework should cover all aspects needed to explain these differing results.

The IAD Framework was developed within the field of institutional rational choice. It therefore assumes rational actors that either try to optimise certain outcomes for themselves according to pay-off rules or follow rules because it is expected of them. Interactions, such as formal decisions, happen within the boundaries of an ”action arena”. This action arena consists of all the actors involved in an interaction, and all the rules and incentives that regulate their behaviour. If the actors acted rationally, the combination of rules and other factors such as culture and the physical/material conditions should result in a narrative in which an actor performed a certain action as a result of the boundaries set by the institutional environment. If the combination of the elements within the framework, when applied to a specific action situation, would not lead to an explanation where an actor can be said to have aimed optimised a certain goal or set of goals, this means either information is missing, incomplete or false, or the framework is not applicable in this case. Since this framework is based on institutional

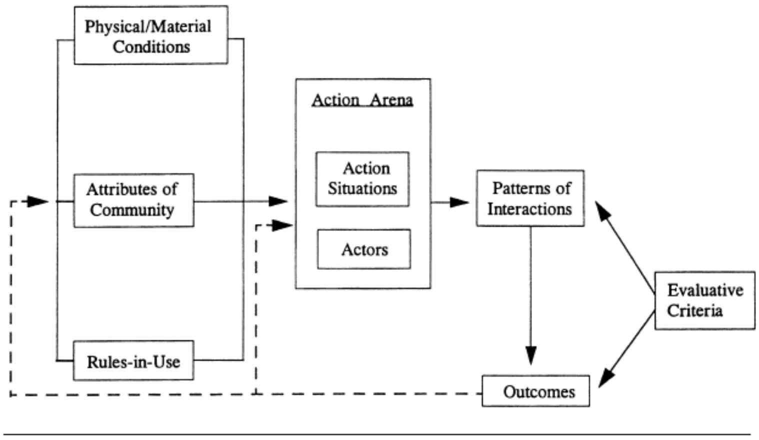

Figure 3.1: The IAD Framework (Ostrom, 2007)

rational choice, using this framework introduces the risk of rationalising irrational choices, but since most of the actors involved in these studies are large-scale organisations they can be expected to act in well-deliberated ways.

The IAD framework often is adapted to fit specific fields or cases by integrating elements from other fields (Allarakhia & Walsh, 2012; Lammers & Heldeweg, 2016), for this paper we use the framework as specified by Ostrom (2011) with as only change that we refer to ”biophysical conditions” as physical/material conditions as is also done in another paper by Ostrom (2007) because the systems discussed here do not have a strong biological component. A graphical representation of the framework is included in figure 3.1. For this framework, two concepts play a major role. The first one is the framework itself, and the second one is “Action Situations”.

3.2.2. The IAD Framework

The framework is depicted in figure 3.1. The framework aims to include all the required variables to analyse the results of the institutional arrangement. The elements are as follows:

- Physical/Material conditions refers to the technical properties of the socio-technical system. In the case of a contact tracing app this would be the app itself, but also the platform on which it runs and the infrastructure required for communications. For the contact tracing applications discussed in this paper, the physical/material conditions mostly affect the scope of solutions considered.
- Attributes of Community encompasses the specific characteristics, i.e. the culture, of the community within which a certain action situation occurs. This can have many different effects. It can, for example, shape the value assigned to certain alternatives, define the roles of
- Rules-in-Use refers to both the formal and informal rules that are used. These rules and their effects are further discussed in the section on ”action situations”.
- The Action Arena contains both actors and action situations. The actors are the specific people or organisations involved in an interaction. The action situation will be explained more in-depth later on.
- Because of the interactions between the actors, as guided by the other factors within the action situation and the drive to optimise certain results, certain patterns of interactions will manifest, resulting in certain outcomes. These outcomes can influence the physical/material conditions, the attributes of the community or the rules in use or the action arena itself (for example by introducing new actors). This causes a feedback loop and the patterns of interactions can change over time.
- For any intervention the patterns of interactions and the outcomes of these interactions are the most visible criteria for evaluating the institutions. These are therefore the most suitable variables to look at when considering the results of an institutional arrangement, and the outcomes can be used to infer the presence and effect of institutions, cultural factors or physical limitations.

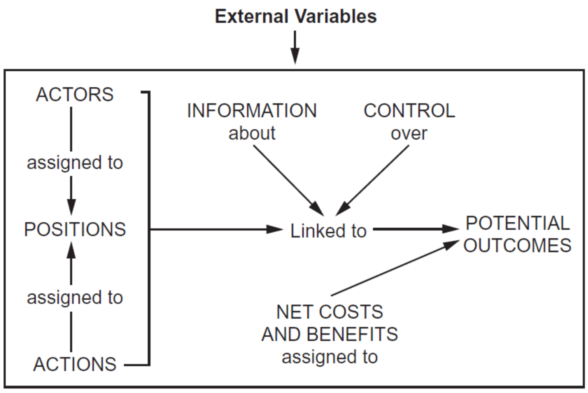

Figure 3.2: The internal structure of an action situation (Ostrom, 2011)

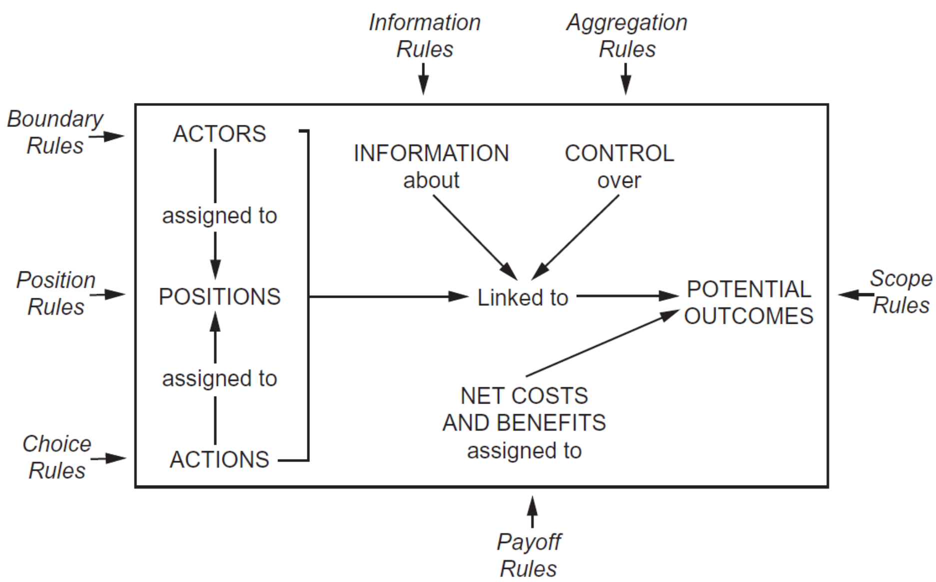

Figure 3.3: Action situations with rules as exogenous variables (Ostrom, 2011)

3.2.3. Action situations

Action situations have an internal structure that better describes them. This is best illustrated in figure 3.2. The action situations are shaped by actors and their actions, as well as the information and the control they have. Based on this information they decide which results would have which pay-offs for them and based on that they try to shape the situation so it results in their preferred outcome. Figure 3.3 shows how rules affect all these elements and how they affect perceived gains and losses.

The following are the different types of rules that can be relevant for an action situation (Ostrom, 2011):

- Boundary rules are rules that govern which actors are or are not involved in decision making. These rules can mandate the inclusion or exclusion of specific actors within decision making.

- Position rules govern the roles that actors can have within an interaction. These can for example be organisational roles (”president/chair”, ”boss”) or commercial roles (”client”, ”contractor”).

- Choice rules specify which actions from actors are deemed as acceptable. They regulate the range of possible actions and behaviours from actors.

- Information rules regulate the access to information that actors have. Since access to information often is a requirement for effective participation, limiting information to specific actors can mean they are less able to realise their preferred outcomes.

- Aggregation rules are less relevant for this case since they generally concern natural resources. Because of this they are also not discussed in the analyses of the cases.
- Payoff rules concern the value that each actor earns or loses from a specific potential outcome. In the cases studied in this paper, this is equated to perceived value.
- Scope rules concerns the scope of acceptable outcomes, for example which architectures or methods of implementations are acceptable. Whereas the choice rules focus on specific actions of actors, the scope rules focus on the outcome.

Action situations can describe both day-to-day decisions, as well as long-term policy decisions (Ostrom, 2011). The primary focus of this research is on the higher-level decisions.

3.3. Methods

To answer the research question, a mixture of desk research and interviews is used. To answer the first three questions for every case, literature research is done using Scopus and Google Scholar to find scientific articles on these cases, and where information is missing it is further contextualised with newspaper and other media articles, preferably by using standardised databases such as Nexis, although it is necessary to use more generic search engines such as Google to find enough results, especially for the non-Dutch cases. For each of the cases the following steps are taken:

1. Define key decisions, which are conceptualised as Action Situations in the application design process for each case.
2. For each case collect and analyse as many relevant sources as possible using both scientific literature, grey literature and media articles, and fill out the IAD Framework based on the gathered information.
3. Use the IAD Framework to explain and contextualise why specific design decisions were made and what effect these decisions had on the overall functioning of the application.

Defining the key decisions that will function as Action Situations introduces some challenges. First of all, it can be difficult to assess where one Action Situation starts, and another one stops, as described by Ostrom (2007), since interactions often happen on an ongoing basis and interactions that on first sight look like a single Action Arena might in fact be a combination of Action Arenas upon closer inspection. To resolve this issue there should be a clear outline of which Action Situations are analysed for this research, and it should be clearly delineated when one Action Situation ends and another one starts.

For this research, only Action Situations that had a major impact on the overall design or functioning of the application are covered. This includes the original design in each of the cases, as well as any complete revisions in architecture, or any significant additions in functionality. Per case, no more than two Action Situations are considered due to the time constraints for this research. If more potentially suitable action situations come up during the collection of literature, only the two with the most impact on the technical design are analysed.

For this analysis, decisions that were made during the same time frame are treated as a single Action Situation as much as reasonably possible. This means that as long as there is a significant overlap in actors, attributes of the community and rules-in-use between decisions in the same time frame they are treated as a single Action Situation. If the sets of actors are completely disjoint or if the rules-in-use differ significantly between decisions then these decisions cannot be treated as a singly Action Situation and will therefore be treated as separate Action Situations.

3.4. Interviews

Additionally to the desk research, the goal was to interview either someone in the public administration within the body involved with designing the application for each case or with someone in academia who is involved with research on the functioning of the application in a socio-technical context. Due to communication protocols within the respective organisations in France and Germany no interview could be organised for these cases so only an interview could be organised for the Dutch case. The interview is primarily used to validate findings from the literature research and therefore was held at the end of the analysis of a specific case. The interview is focused on reconstructing the different steps taken within the design process to validate the results from the analysis using the IAD framework. The transcript of this interview is included in Appendix B, and the findings from the interview is integrated throughout the chapters on the cases.

3.5. Cross-case comparison and discussion

For the cross-case comparison and discussion chapters, the literature gathered for the first phase is used together with additional literature on the influence of institutions on socio-technical systems and the elements of the IAD framework. Any patterns shared between the cases are identified and contextualised, as well as any patterns that are highly unique to any specific case. The results of the synthesis are also used for generating recommendations if any are warranted and to explore avenues for follow-up research.

4 Technological Background

This chapter gives an overview of the available technologies that can be used in contact tracing applications and serves as a general background for all of the cases since the technological options are all shared between the cases. The first section covers the available technologies and the consequences of using specific technologies. The second section will go more deeply into ”centralised” and ”de-centralised” contact tracing applications, and what the choice for either architecture means for the overall functioning of the application and its security risks. Finally, three important technical projects are introduced that operated at either a European or global scale, which influenced the applications in each of the cases. These are the Google/Apple Exposure Notification framework, and European research collaborations PEPP-PT and DP3T.

4.1. Available technologies

The current state of technology allows for a range of options for technologies that can be used in mobile contact tracing applications. Some of these options are presented in figure 4.1. In this section, these technologies will be introduced, as well as a brief introduction on how the choice of specific technologies affects the overall system.

Contact tracing applications require a method of identifying the devices of nearby users of the application. Two methods for doing this have been considered. First of all, GPS can be used. GPS, the Global Positioning System uses a network of satellites to identify a device's location. If you know the location of two users you can calculate the distance between them and based on that identify the people that need to be notified if one of them tests positive. Even though privacy-preserving measures do exist that ensure that location data cannot be traced back to specific people, the required constant collection of location data is seen as a privacy risk (Krishnan et al., 2020). The usage of satellites also makes indoor use difficult (Jacob & Lawarée, 2021a). The main alternative to using GPS data is Bluetooth. Bluetooth uses radio waves to contact nearby devices (Bisdikian, 2001). Because this does not require users to share their physical location this is seen as a method that is better at protecting the privacy of users (Jacob & Lawarée, 2021a), since only the distance to a user is measured, and not the physical location of any person. The bluetooth-based implementation of contact tracing apps uses Bluetooth Low Energy (BLE) to scan for the Temporary Exposure Keys (TEKs) of nearby devices. These Temporary Exposure Key (TEK)s are changed frequently so that a single key cannot easily be traced back to a single device by scanning for a specific key.

Data storage and exposure notification can be centralised, partially centralised or decentralised. This covers both where data is stored and how the exposure risk is computed. A more in-depth description will be given in the following section, since this is one of the most contentious issues in the European debate on how to implement applications for digital contact tracing.

Data collection can be minimal, but additional information can also be encoded for research purposes. Doing this could provide additional information about at-risk groups or how the virus is spreading, but it also comes with additional privacy risks. This additional data can for example be data about where many infected people live (see Appendix B.1) or more detailed information about when someone was infected.

Specifications	Potential options
Proximity measurement mechanisms	• Bluetooth • Local GPS
Data storage	• Centralized storage (data is automatically stored on a central server) • Partially centralized (only data from infected individuals is transferred to a central server) • Decentralized (data is stored solely on smartphones)
Data collected	• Information exclusively related to interactions (e.g. location, duration, date, numerical key) • Ability to encode demographic and medical data (age, gender, diseases, medications, etc.)
Notification mode	• Binary notification (information on whether or not the user has been exposed to an infected individual) • Graduated notification (information regarding the potential level of risk to which the user is exposed based on his/her interactions)
Method of installation	• Manual installation (the user takes care of installing the application) • Default installation (installation is automatically carried out by the manufacturer)
AI module	• Integration of an AI module to measure the level of risk to which a user may have been exposed • Exclusion of an AI module to measure the level of risk to which a user may have been exposed
Relationship with regards to manual tracing	• Application is used in conjunction with manual tracing • Alternative to manual tracing

Figure 4.1: Technology options from Jacob and Lawarée (2021b)

Notifications can be either binary, where users receive a notification if they have been at risk, such as in the Dutch CoronaMelder app (CoronaMelder.nl, 2021), or they can notify in degrees, such as the German Corona-Warn-App (coronawarn.app, 2021b) that will give you a notification when you were seriously at risk, but it can also inform you about lower-risk interactions if you open the application. More detailed notifications do require the processing of additional data though, which would mean increased privacy risks.

Installation could both be done by users or government-mandated. Within the European cases studied in this thesis mandated installation was never discussed. AI modules were also not considered. The cause of this is likely that it goes too much against the European vision on privacy. Within the European Union there is a lot of attention to privacy issues, as is shown by its extensive data protection regulation: the General Data Protection Regulation (GDPR).

And finally, there is the relationship to manual tracing. In the European cases discussed here the applications are always used in conjunction with manual tracing, meaning that every country also had a call centre to assist with contact tracing after somebody received a positive test, and not as a replacement for manual contact tracing..

4.2. Centralised or decentralised

One of the key decisions in designing the contact-tracing model is whether a centralised or decentralised architecture should be used. ”Centralised” and ”decentralised” might have a different meaning here than they would have in other contexts within the field of Computer Science. In the context of COVID-19 contact-tracing apps, ”centralised” or ”decentralised” refers to the locus of analysis of the data, i.e. the place where the notifications are generated.

In a decentralised model information from contacts is stored locally and a publicly stored list of keys associated with a positive test is compared against the contact IDs stored by the application to decide if there was any risk of exposure to the disease (Baumgartner et al., 2020). In this model, users send out a unique TEK via Bluetooth that changes at set time intervals. The mobile devices of users of the

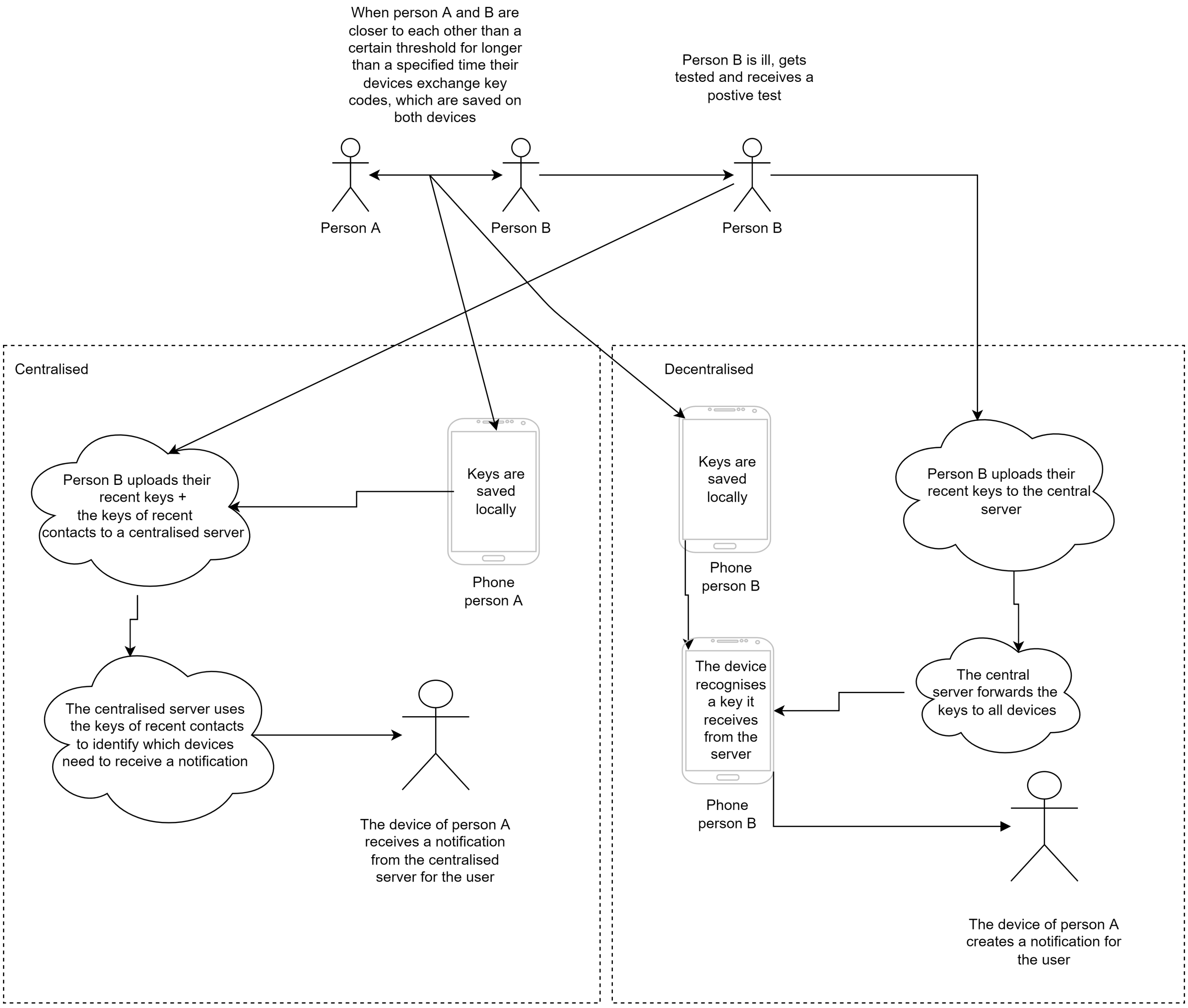

Figure 4.2: Graphical depiction of centralised vs decentralised applications

application store any keys they have received for longer than a set time interval and of which the other device was closer than a certain pre-determined distance. If someone tests positive for COVID-19, all the TEKs they generated over a predetermined amount of days (for example 14 days) get uploaded to a database, and then sent to all the devices that use the application. If a phone receives an ID from the database of a device they were close to for a prolonged period of time, a notification is generated and sent to the user. This means that the centralised database has no method of knowing who was notified, which is seen as having a positive influence on privacy. The disadvantage is that all TEKs of infected people are available publicly, and even though it would be very difficult to trace these TEKs back to individuals, it would not be technically impossible.

In a centralised architecture, a central system does the matching and notification of contacts. Whenever someone receives a positive test, they upload both their own TEKs and any TEKs they have recently received. The system checks then checks the TEKs of their recent contacts and informs them they have been exposed to someone who was infected. The advantage of this is that no specific TEKs need to be sent out, just the notification of exposure. Nevertheless, this systems requires high trust in the owner of the central system since people could be de-anonymised if the system was not set up correctly, and the central server is processing more data than is done in a decentralised set-up (Vaudenay, 2020). The difference between centralised and decentralised architecture is further illustrated in figure 4.2.

	France	Germany	Netherlands
Proximity measurement	Bluetooth	Bluetooth	Bluetooth
Data collected	Exclusively interactions	Exclusively interactions	Exclusively interactions
Notification mode	Binary	Degrees	Binary
Method of instalation	Manual	Manual	Manual
AI module	None	None	None
Relationship to manual tracing	Used in conjunction	Used in conjunction	Used in conjuction
Architecture type	Centralised	Decentralised	Decentralised
Reference Architecture	PEPP-PT	DP3T	DP3T
GAEN integration	No	Yes	Yes

Table 4.1: Overview of technologies used

4.2.1. GAEN

The Google/Apple Exposure Notification Service (GAEN) is a development framework developed by Google and Apple to aid in the development of decentralised contact tracing applications. As the interview in Annex B.1 shows, Google and Apple needed to be involved to get the right access to Bluetooth which is required for these applications to function, since normally developers do not have the required low-level access to the Bluetooth modules. The GAEN framework offers most of the technical functionality for digital decentralised contact tracing (Google, 2020). This includes the generation of random IDs/Temporary Exposure Keys (TEKs), as well as the matching between stored keys and the keys associated with known infections. The framework was announced on April 10th 2020 (Apple, 2020), and launched in May of 2020. The framework was only offered to a single government per country (Appendix B.1), meaning that no separate applications for federal states or provinces could be developed.

4.2.2. PEPP-PT

Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT) was a European collaboration on developing standards and technology for a contract tracing application (PEPP-PT, 2020). PEPP-PT originally worked on both a centralised and decentralised architecture (PEPP-PT, 2020). Nevertheless the centralised reference architecture seems to have been prioritised at some point over a decentralised version (PEPP-PT, 2022), causing unrest within the community, leading eventually to the collaboration being disbanded (Boell.de, 2020; DP3T, 2022; heise online, 2020b; Veale, 2020).

Regrettably, a lot of information about PEPP-PT is not available anymore since the website of PEPP-PT has since been taken down and a lot of organisations publicly distanced themselves from the project.

4.2.3. DP3T

Decentralized Privacy-Preserving Proximity Tracing (DP3T) was a research collaboration between a number of of universities and research institutes (EDFL, KU Leuven, TU Delft, UCL, CISPA Helmholtz Center for Information Security, University of Oxford, University of Torino, Aix Marseille Univ, University of Salerno, IMDEA Software, University of Port and Stanford University) that focused on developing a reference architecture for decentralised contact tracing applications. (DP3T, 2022) It was allegedly set up in reaction to the work done by PEPP-PT after unhappiness with the privacy risks associated with a centralised architecture (Veale, 2020) which was being proposed by several organisations within the PEPP-PT collaboration. Several of the organisations working on DP3T had previously worked on PEPP-PT but had resigned (DP3T, 2022).

The reference architecture specifies many features such as the data required, user journeys, recommendations for operational security, how to calculate exposure scores and interoperability, and as such works as a blueprint to serve as a basis for the national COVID-19 contact tracing applications.

4.2.4. Overview cases

Table 4.1 gives an overview of the final design choices made for each of the applications discussed in this paper. For all three of the cases, the choices for using Bluetooth, exclusively collecting interactions, manual installation and not using AI modules were made very early on in the process, with the choices primarily being motivated by privacy considerations and requirements that flow from the European Union General Data Protection Regulation (GDPR) such as data minimisation, which means that organisations operating within the EU need to be conscious about the amount of data they process and aim to use as little data as possible. Much more contentious were the decisions for the architecture type, the reference architecture and the (potential) integration of GAEN, as well as the notification mode.

5 Case Study: France

5.1. Decisions

The Covid-19 contact-tracing application in France was originally called StopCovid but was later renamed to TousAntiCovid. The French project stands out because of its centralised architecture (INRIA, 2021a) as well as its low adoption rates (Balagué, 2020; researchprofessionalnews.com, 2020; Venturebeat.com, 2020; Willsher, 2020). These low adoption rates are said to also have been the deciding factor on the rebrand of the application from StopCovid to TousAntiCovid in October 2020.

At the start of the development process, the choice for a centralised architecture was written about extensively both by researchers (Balagué, 2020; Senn & Loosli, 2021; Weiß et al., 2021), as well as many media outlets. Subsequently, the choice for rebranding the application and adding additional functionalities to it was also widely covered in news media since it followed a critical report from the Ministry of health (des Solidarités et de la Santé, 2021). In this chapter, both decisions will be analysed using the IAD framework, and afterwards the effects on the technical design of the system will be discussed. In the analysis, only elements that have a direct influence on the design of the applications will be considered.

5.2. IAD Analysis original design

5.2.1. Rules-in use

Boundary, position and control rules This category concerns rules that determine who is involved in decision-making, and which official roles they fulfil in the process. The French Ministry of Health and Solidarity delegated the development of StopCovid to INRIA (INRIA, 2020b). INRIA is a French research institute and together with a collaboration of French companies (Capgemini, Dassault Systèmes, INSERM, Lunabee, Orange, Withings), the French Cybersecurity agency ANSSI and public health organisation Santé Publique France they started work on developing StopCovid. For the purpose of this case, when referring to INRIA it should be seen as referring to this entire coalition.

Having the development delegated to solely French companies fits in the French policy of ”Digital Sovereignty” (ANSSI, 2016; Grzegorzewska, 2021). The French government has held the position that Europe, and by extension France, has gotten too dependent on the United States and China for critical IT services. By encouraging the development of these services by European companies this dependence can be avoided. Another reason for this selection of French companies can be the preference to use French as a working language, which is illustrated by the documentation for the application which is largely in French (INRIA, 2021b). The code for the application is open-source and available online (INRIA, 2021b), but whereas open-source software via GitHub or similar platforms allows anyone to contribute to the code of a project, the chosen solution by INRIA only allows people to contribute who are invited by an INRIA member (INRIA, 2022), meaning that independent developers could not contribute to the project via the portal itself and would either need to get a specific invitation or find some other method of proposing changes to INRIA. Another aspect that stands out when compared with the German case, is the limited amount of documentation that INRIA provides to give an overview of the entire project. No general architecture documents for the entire system are included, apart from a single file that describes which project folders refer to which functionality, and the limited documentation on rules for collaboration and naming conventions are only provided in French.

Apart from the organisations delegated with the responsibility of developing the application, there are also actors outside of INRIA who can influence decision-making processes. These can, for example, be actors that can pressure the French government, such as privacy-focused NGOs (Chadwick, 2020; du Net, 2020; RFI.fr, 2020) and the French Data Protection Agency CNIL (CNIL, 2021). Additionally, the French parliament has the final say over the application (France24, 2020).

Information rules Throughout the process, INRIA has been very public both in their deliberations regarding the design of the application, as well as making the code behind the application publicly readable. The documentation was originally published on GitHub, but was later on moved to INRIAs own GitLab implementation where the source code of the application was also added (INRIA, 2021a, 2021b). The first documents were published on April 18th of 2020. This openness enabled anyone with the required technical knowledge to be well informed about how the application works, meaning that on this dimension no additional boundaries were erected to stop people from taking part in the public discussions about this application.

Despite this apparent openness, the public had no access to propose changes to the code itself via the GitLab platform, which is normally standard in open source development. To actually take part in proposing changes people need an account on the GitLab platform, which can only be created by INRIA. This is therefore a limitation on the openness of the project.

Choice and scope rules When it comes to rules limiting which functionalities the application could have, the primary limitations come from privacy regulations such as the European Union General Data Protection Regulation (GDPR). Bradford et al. (2020) describes that even though contact-tracing applications fall within the scope of the GDPR. Both centralised and decentralised systems as described in the literature review could be allowed under the GDPR and would have to comply with it. Where the limiting role of the GDPR primarily comes into play is in the details of the implementation of these applications, especially where it comes to the storage and transmission of data. Within France, data protection agency CNIL is designated to ensure that citizens' data is well protected.

When looking at the output of the design and development process of the application in France, it seems like the policy of "digital sovereignty" also played a large role in setting the scope for what solutions would be acceptable, since involvement from Apple and Google seems to have been actively avoided. Nevertheless, no sources were found that expressly confirm this.

Payoff rules Within this context, we assume that the perceived value of outcomes is primarily shaped by the perceived utility of the overall StopCovid system, where the utility of different implementations varies greatly across actors. The ROBust and privacy-presERving proximity Tracing protocol (ROBERT), developed by INRIA is a centralised contact-tracing protocol. Within the documentation of the ROBERT protocol (INRIA, 2021a), INRIA argues that centralised systems are better at preserving the privacy of its users since no IDs of infected users are sent out to its users.

Other French actors argued that the centralised architecture provided a too big risk of de-anonymisation (Balagué, 2020; Techcrunch.com, 2020b; techdirt.com, 2020), with some even framing the centralised architecture as "Spying on users". This means that any decisions made by actors can be expected to be done according to their perceived value of specific implementations.

5.2.2. Attributes of the community

Within the scope of this case, there are several cultural factors that can be expected to have a significant influence on the design choices within this system. The first factor that is mentioned frequently in media articles is the general focus on privacy of the French institutions (ANSSI, 2016; Grzegorzewska, 2021; Venturebeat.com, 2020), together with a distrust of IT systems that is also reflected in academic literature (Vance et al., 2008). This cultural factor could explain why privacy worries played a big role in the debate surrounding these applications. This seems less likely though if you take into consideration that, compared to other EU countries, French citizens are less aware of privacy and privacy regulations (for Fundamental Rights, 2020).

Another thing that stands out is both the centralised nature of the French government, as well as the individualistic culture within the country (Yan et al., 2020). This centralisation means that the French national government has a lot of decision-making power, and needs to consult fewer other governmental bodies than a federal state such as Germany would.

5.2.3. Physical/material conditions

When it comes to physical and material materials, the section on technology from the literature review provides all the necessary context for this case. Primarily the discussion on a centralised or decentralised architecture, shaped the discourses around StopCovid, as well as which privacy-protecting technologies should be implemented.

INTRIA was not the only actor providing arguments on a technical level. When it comes to the technological implementation, privacy watchdog CNIL described that, even though there were adequate safeguards, there still was a risk of de-anonymisation of people. Additionally, they warned that the 3DES protocol should not be used, in line with an official baseline published by cyber security agency ANSSI (CNIL, 2020). The original ROBERT protocol did include the usage of 3DES.

5.2.4. Actors

The most influential parties that were directly responsible for the original design were INRIA, as the organisation tasked with developing the application (INRIA, 2020b), the Ministry of Health and Solidarity, as the organisation that requested the application and the French parliament as the legislative body responsible for the application. CNIL was indirectly influencing the process by writing opinions and sending them to parliament (CNIL, 2020). Additionally, privacy-focussed NGOs tried to influence the decision-making process (du Net, 2020) and should therefore also be considered.

At the start of the development of the ROBERT-protocol, INRIA joined PEPP-PT, one of the European initiatives to develop a contact-tracing protocol (INRIA, 2020a; Techcrunch.com, 2020b) together with other scientific organisations, some of which were the Fraunhofer Gesellschaft from Germany and the EPFL and ETHZ from Switzerland, but this collaboration was dissolved after some organisations left the collaboration after arguing that PEPP-PT was not transparent enough.

5.2.5. Action Situation

No scientific or media sources are available that describe how decision-making processes were done internally within INRIA or the Ministry of Health and Solidarity. What is therefore described in this chapter, is based on the relations between the factors in the IAD framework under the assumption that actors acted rationally to optimise their perceived value of the system, in line with the official control over the system that the institutional framework gives them.

From the available information, decision-making on the StopCovid app seems to have been centralised within the coalition led by INRIA, the Ministry of Health and Solidarity, the French Parliament and CNIL. Whereas NGOs have tried to influence their decision-making any effect of this is not clear from the resulting system. Within the action arena, the primary goal of the INRIA coalition seems to have been to implement an application based on a decentralised protocol in as little time as feasible. The focus on a decentralised protocol becomes clear from the repository with the documentation of ROBERT (INRIA, 2021a). The focus on a short timeline is decribed by Jacob and Lawarée (2021a). The agenda of the Ministry of Health and Solidarity seemed to have overlapped with that of INRIA since they never published any articles or opinions going against INRIA. That said, this Ministry was also the official client for the application so any disagreements between these parties could be discussed bilaterally.

The role of the parliament seemed to have been to ensure proper privacy protection in the application (Chadwick, 2020), for example by demanding that any changes proposed by CNIL would be enforced (France24, 2020).

5.2.6. Patterns of interactions

The overall decision-making process seems to have been very centralised if you look at the resulting outcomes, with most design decisions being made by INRIA and the French authorities and no evidence being visible of significant influence from actors outside the government. Even though the project is open-source, almost all of the changes to the code made on GitLab are made by users from INRIA and other parties from they collaborated with (INRIA, 2021b), meaning that no other parties effectively exerted control over the system. The French parliament seems to have focused primarily on enforcing the demands of privacy watchdog CNIL.

5.2.7. Outcomes

Privacy

When it comes to privacy, the architecture has the typical advantages and disadvantages that are related to centralised architectures. The advantage of this system is that no keys of infected people are sent out. The disadvantage is that a lot of data is processed centrally which provides risks of de-anonymisation and serious breaches of privacy if sufficient security measures are not in place.

The fact that no keys of infected people are sent out is good for privacy since it means it is not traceable whether a specific person has been infected with COVID-19 or not, since a user only receives the notification and no further details about what triggered the notification. This means that there is no technical method by which a user can trace back who caused a notification. In a decentralised system, this would be possible if the right mitigating measures are not taken.

The disadvantage is that to realise this, all contacts perceived by the application are sent to a central server for processing. ROBERT uses anonymisation to ensure that any received information about contacts cannot be traced back to specific people, but faulty implementations of this anonymisation could lead to people being de-anonymised, which could theoretically lead to them and all their contacts being exposed. To mitigate this risk the code must do what is expected of it, and the code running on the centralised server(s) should be the same code as everyone expects it to be. To verify this independent audits have to be done to verify that no malicious activity is taking place on these servers, as is also recommended by CNIL (Clerc et al., 2020).

Overall a clear trade-off seems to have been made here where trust in institutions seems to have been higher than the trust in technology itself, since a centralised server operated and audited is seen as more preferable to an algorithm that protects and anonymises keys being sent out to users.

Interoperability

As a result of the PEPP-PT collaboration falling apart, the French application ended up being very different to the GAEN based applications that most other European countries ended up using. Because of this, interoperability is not only hard to realise, but it would also undo the advantages of both centralised and decentralised systems since any method to make centralised and decentralised applications would require both sending out the contact keys from the centralised system to the individual applications in the decentralised system and the decentralised applications would need to upload all their contact keys to the centralised system, undoing the advantages of either system. This is also the reason why the European Commission lists TousAntiCovid as ”not potentially interoperable” (Commission, 2022). This is also unlikely to change since it would require a complete redesign and redevelopment, with all the associated costs.

5.3. Effects on the technical design

The base design of the application was done by INRIA, and therefore to discuss the effects of institutions on the technical design, any changes proposed on demand of other actors will be discussed, as well as the institutions that allowed these actors to influence the design process. When it comes to specific technical demands, these seem to have originated from three different sources: CNIL, the parliament and NGOs.

The CNIL wrote a deliberation before the original release of the StopCovid app (CNIL, 2020). This document mostly reflects on procedural requirements, such as the need for a Data Protection Impact Assessments, as well as general statements of things that should be considered, such as the risk of de-anonymisation and false alerts. The specific technical proposals that CNIL does all refer to security. Concretely, CNIL advised the following:

1. Usage of hardware security models and trusted third parties for encryption
2. Not using 3DES as an encryption standard, as was originally intended, but using stronger encryption methods instead.

The lack of overall architecture documentation makes it difficult to identify how far these measures have been implemented. What can be identified is that in the most recent version of the ROBERT specification (INRIA, 2021a), no mention is made of 3DES and the stronger AES is used, and trusted third parties are mentioned as a method for auditing the central servers. Based on the factors identified in the IAD framework we can therefore reasonably state that CNIL's official position as privacy watchdog, as well as the information they had access to since the project was open-source, has enabled them to effectively enforce these changes.

Apart from emphasising the demands from CNIL, some members of parliament also had their own demands. Based on reporting on the debates in the French parliament, the following could be identified (Chadwick, 2020):

1. No geo-location used in the application
2. Independence from Google and Apple
3. No unnecessary collection of data

Geolocation, or the usage of GPS data, was never considered for ROBERT, and therefore this demand was not relevant. Independence from Google and Apple was achieved in the sense that the app does not make use of GAEN, which also fits with the focus on digital sovereignty identified under attributes of the community. Nevertheless, the applications are still hosted in Google's Google Play Store and Apple's App Store and runs on the operating systems developed by these companies. This means that independence is only partly achieved.

From the NGOs, the wish for a decentralised system seems to have been the most prevalent one (Techcrunch.com, 2020b; techdirt.com, 2020). This demand was not fulfilled and is illustrative of the limited influence that NGOs had on the design process of this application.

5.4. IAD analysis Rebrand

When it comes to the rebrand to TousAntiCovid, most of the institutional environment had not meaningfully changed since the original application. For the analysis for this second decision only aspects that were notably different from the original design will be covered. By October 2020, it had become clear that the StopCovid application lagged behind in adoption rates (Balagué, 2020; Techcrunch.com, 2020a; Venturebeat.com, 2020; Willsher, 2020). The application had only been installed 2.4 million times, and 700,000 people had reportedly uninstalled it already (Venturebeat.com, 2020).

5.4.1. Rules-in use

Payoff rules It is difficult to make a definitive statement about the perceived value of certain decisions within the context of the re-branding and inclusion of additional features into the application. It is clear that there was a link between the rebrand and an expectation that it would increase the uptake of the application (Venturebeat.com, 2020), but it is not clear whether this perception only existed within the French government or was also shared by INRIA. The French president, Emanuel Macron, himself came out saying that the StopCovid had been a failure (Stangler, 2020) and announcing the TousAntiCovid app with additional functionality, from which it could be conjectured that this decision was primarily pushed by the French government. The INRIA website itself has no published statements on the rebrand.

Choice and scope rules The legal framework in which the app was designed did not change significantly between the first design and the rebrand. The goal and therefore scope of this decision was different though since at this stage the focus was more on creating an app that was attractive for people to use, rather than creating an initial working application. The existing infrastructure is therefore a limiting factor on the scope and choice rules since it would not be reasonable to change parts of the system that functionally worked as intended. The potential scope was therefore smaller than for the original design.

5.4.2. Attributes of the community

The primary change in the attributes of the community is that by the time of the redesign, it had become clear that relatively few people had been willing to download the application, as shown both by the low amount of downloads (Venturebeat.com, 2020), as well as the overall primarily negative reviews of the application (Garousi et al., 2021). When we consider the statements from the French government (Stangler, 2020), this is also put forward as the primary reason why the rebrand was necessary.

5.4.3. Physical/material conditions

The main difference in the physical/material conditions is that by this point in time the infrastructure for the StopCovid app had already been set up and was operating, meaning that for any design changes the current infrastructure needed to be taken into consideration. This means that large changes to the overall system were unlikely since a lot of sunk investments were already made.

5.4.4. Actors

Fewer actors participated in this decision, with no CNIL opinions being published regarding the rebrand and no significant debate in the French media. It seems that the only actors involved were the French government, the French Parliament COVID-19 committee and INRIA.

5.4.5. Action Situation

When considering the formal control over the application and the decision made, we can infer that the French government and parliament COVID-19 committee seemed to have been in agreement over the need for a relaunch of the application to get more people to use the application, and the decision seems to have been made according to hierarchical lines. This is also supported by the statement by the French parliament COVID-19 Liaison Commitee (des Solidarités et de la Santé, 2021) that suggests a ”A relaunch of the promotion of the StopCovid application”. Subsequently, the government made the decision to rebrand the app and add some functionalities with local statistics on Covid-19, and INRIA implemented this. Since INRIA published no statements about the change of name they were not publicly involved in the debate on this issue making it seem like they at a minimum did not object to the proposed change.

5.4.6. Patterns of interactions

What we can observe from the patterns of interactions is that the decision to rebrand the application was announced by the French president and implemented without much public debate.

5.4.7. Outcomes

The changes implemented were a redesign of the User Interface of the application, a change of name and logo, and local COVID-19 statistics and news (healthcareitnews.com, 2020). When it comes to the ROBERT protocol and the contact-tracing functionalities, not design changes were made, making this a largely cosmetic change and not a functional one, and therefore it does not affect interoperability or privacy.

5.5. Effects on the technical design

The technical design was changed by adding the ”information centre” feature (healthcareitnews.com, 2020), which gave users access to local COVID-19 news and statistics. After the rebrand user statistics did start increasing, although this primarily happened after the health pass was also included in the application, which was obligatory to visit public venues like restaurants, hotels or theaters.

6
Case Study: Germany

6.1. Decisions

The German Covid-19 contact tracing application is the Corona-Warn-App (CWA). The German contact tracing solution is a decentralised application based on the GAEN (Dix, 2020). When compared to the other cases covered, the German application stands out due to its high interoperability with other countries (coronawarn.app, 2021a), as well as relatively high adoption rates (Munzert et al., 2021; Zeitung, 2021).

The CWA does more than just contact-tracing and also has integrated functionalities for storing the European Union Digital COVID Certificate (EU-DCC) (coronawarn.app, 2022), local COVID-19 statistics and check-in functionality for events. As of January 2022, CWA has had two major releases, the 1.x version originally only included the contact tracing functionality, and later had the EU-DCC integrated into it. The 2.0 release primarily added the functionality for event registration, which users can use to verify that they have the right documentation (for example tests, vaccination or proof of recent recovery) to attend an event. Since this functionality is outside of the scope of this thesis, only the original release will be included for further analysis.

6.2. IAD Analysis original design

6.2.1. Rules-in use

Boundary, position and control rules The German federal government tasked mobile service provider Telekom and enterprise software developer SAP (SAP, 2020; Telekom, 2020). The development happened in close collaboration with the Federal Office for Information Security and the Federal Commissioner for Data Protection and Freedom of Information. The application was developed as an open-source project on GitHub (sap), and more than 7000 developers contributed to the project before the official launch. Because of this set-up, Telekom and SAP were not only in the lead for developing the application but also responsible for orchestrating the contributions of others.

Before the app could be implemented, the German parliament needed to give approval, and just like in the French case NGOs and other organisations had the opportunity to pressure parliament.

Information rules The German CWA was developed fully open-source on GitHub, with any GitHub user being able to propose changes to the code base. The German GitHub repository (S. a. Telekom, 2022) contains not only the code for the system, including the application and the servers but also extensive documentation on the overall architecture of the application as well as whitepapers on specific algorithms. All this information is provided in English, so developers from outside of Germany can also contribute. The repository was made public on May 12th 2020, well before the original release date of June 16th 2020, giving any interested parties a month to review the code before the official launch. Contact with the developers from SAP and Deutsche Telekom was organised over e-mail (corona-warn-app, 2022). This means that the contents of these communications are not publicly available. The openness of this process was in line with demands from German NGOs. (spiegel.de, 2020a).

Choice and scope rules When it comes to choice and scope rules, the limits on what can legally be done with regards to data processing are mostly limited by the GDPR, just as with the French case (Bradford et al., 2020). When it comes to scope, the limits are primarily set by the task as set out by the German government, i.e. the result should be a contact-tracing application that takes privacy issues into consideration.

Payoff rules Data protection is one of the cornerstones of CWA (SAP), and all involved actors seem to have prioritised measures that would improve data protection as they perceive it (bundesregiering.de, 2020). Within the German case, a decentralised system was perceived by all involved parties as being better at preserving privacy, as is illustrated by the backlash that the centralised architecture from PEPP-PT got, which was partly aimed at the lack of transparency of the project (fr.de, 2020), but a lot of criticism was also levelled against the centralised architecture (spiegel.de, 2020b) of which the centralised server was seen as too risky since it would become too easy to re-identify anonymised data. This led to a perception of privacy protection which was very different from the perception within the French case.

6.2.2. Attributes of the community

Germany is a country that is well known for its car manufacturing and engineering of machinery, but also as a country that has struggled to make the step to more high-tech developments (Casper et al., 1999). Hermawan (2019) shows that trust in technology is higher than in France. Pre-COVID vaccination rates in Germany have also been comparatively high, which could be an indicator of high public trust in public health authorities.

Germans are on average very aware of their privacy rights (for Fundamental Rights, 2020), which could result in an extra focus on privacy issues in the public debate, since many German citizens will have opinions on this issue.

6.2.3. Physical/material conditions

In chapter 4 a comprehensive overview of the technological boundaries and choices is given. For this case, it is notable that German organisations originally participated in both the centralised Pan-European Privacy-Preserving Proximity Tracing (PEPP-PT) as well as the decentralised Decentralized Privacy-Preserving Proximity Tracing (DP3T) projects, but most organisations left PEPP-PT by the end of April 2020, choosing for a decentralised architecture definitive quite early on in the project.

6.2.4. Actors

SAP and Telekom were tasked with the development of the application by the Robert Koch Institute (Greef, 2021) and took the lead in designing and developing the application. Originally the German app would be based on the PEPP-PT reference architecture, but this was changed to DP3T after the centralised architecture sparked controversy. In this process, they were aided by an open-source community submitting issues and proposing changes to the GitHub repository, and in total over 7000 programmers helped in implementing the application according to Telekom's estimations (Telekom, 2020). Additionally, the application was made in collaboration with the DP3T project and based on their reference architecture.

Apart from the developers, the German government also played a role in this process, with the Ministry of Health being the organisation that contracted SAP and Telekom to develop the application and the German parliament (Bundestag) providing the legal basis for data processing. Additionally, the Federal Office for Information Security (BSI) and the Federal Commissioner for Data Protection and Freedom of Information (BfDI) were involved in designing the application (Simon & Rieder, 2021).

Lastly, NGOs were also interested in following the development of this application and they demanded an open process, also referring to the lack of transparency in the PEPP-PT project (spiegel.de, 2020a),

6.2.5. Action Situation

As can be seen in the GitHub repository, the original design was proposed by employees at SAP, and even though the open-source community participated actively in fixing typos and making sure the documentation was complete, there seems to have been no discussion about the architecture of the application itself, and no functional changes were proposed to the architecture during the first design phase. From this, it seems fair to conclude that the design itself was done completely by SAP and Telekom with the approval of the RKI. The open-source community was very active though in the development and implementation of the application where also functional changes were proposed.

6.2.6. Patterns of interactions

We can see that most major design decisions were made by SAP and Telekom with involvement from the RKI and the DP3T project. These design decisions were then implemented by SAP and Telekom together with the open-source community to result in a decentralised application.

6.2.7. Outcomes

The resulting application is a decentralised application based on the reference architecture developed by DP3T and integrating GAEN.

Privacy

When it comes to privacy considerations, the risks and advantages of this system are the inverse of those of the French centralised system. As a decentralised system, only keys of infected people are sent to the central system and then forwarded to all devices, where all the smartphones individually identify whether they recognise any of those keys from previous contacts. This means that the central servers have no knowledge about who met with who or which people were marked as contacts of infected people. The disadvantage is that users could know which specific key triggered an alert, and even though mitigating measures are in place to reduce the risk of identification, it would still be possible to identify a specific infected person if you track them all day and save all the Bluetooth keys sent out by their device. If you then receive their keys from the central server as newly infected people, you can figure out who was infected. Nevertheless neither the German data protection agency (BfDI) (BfDI, 2020), nor the German cyber security agency (BSI) (BSI, 2021) noted any issues with the tracking algorithm. The BfDI only remarked about the planned built-in functionality to call a hotline with questions. This function would sent too much user data to the hotline, which would go against the principles on which the application was built. In discussion with the RKI, they avoided the implementation of this functionality (BfDI, 2020).

Interoperability

When it comes to interoperability, this application works with many other European applications (Commission, 2022). Since most European applications use the full DP3T reference architecture or the GAEN framework that is at its core. Since these applications can easily operate with other applications that use the GAEN framework that aids in generating and storing keys, the CWA operates together with many other contact tracing applications.

6.3. Effects on the technical design

The application was developed with a large open-source community resulting in many people evaluating the applications development which would ideally lead to better security and better functionality. Unlike the other cases discussed in this paper, the CWA also returns different risk levels, based on how long and how close someone has been to an infected person. The core of this design was put forward by the RKI, DP3T and SAP/Telekom but also supported by the open-source community. When it comes to the choice of technology there was little controversy regarding the technical design of the application, apart from some worries by the German data protection agency about the metadata that would be sent when the application was used to call the hotline with questions. The process of the design of the CWA, therefore, seems to be best characterised by a high trust in technology, the organisations tasked with developing the application, as well as the institutions responsible for privacy protection.

7

Case Study: Netherlands

7.1. Decisions

Compared to the other applications studied in this paper, the Netherlands had the slowest development process, with the official date of the release of the application being September 1st 2020. The process started with an appathon where private companies could propose and demonstrate their applications as a way for the Ministry of Health, Welfare and Sports ('Volksgezondheid, Welzijn en Sport'; from now on 'VWS') to be informed about all the solutions available on the market. Since the appathon yielded disappointing results (see also the interview in Appendix B.1) and the security of the proposed applications was deemed insufficient (KPMG, 2020), the Dutch Ministry of VWS decided to have the application developed in-house by several experts from both inside and outside of the government with experience in IT design Utrecht, 2020; valsplat.nl, 2021, the so-called "building team". After the original design, no major functional changes were made to the application apart from some algorithm fine-tuning, bug fixes and security updates and minor graphical changes. For this reason, this case study will focus only on the original design.

7.2. IAD Analysis original design

7.2.1. Rules-in use

Boundary, position and control rules Originally the Ministry of VWS decided to organise a competition ('appathon') where companies could submit their proposed applications that could help in combating COVID-19 (van Algemene Zaken, 2020a). The appathon originally got 176 proposals for contact tracing applications, of which 63 qualified for consideration. After reviews by different expert groups on different fields related to both contact tracing as well as application security and privacy specialists, 6 apps were left for consideration, none of which ended up meeting the demands of the application (see also Appendix B.1), as is also illustrated by the report of the security tests done on all of these applications (KPMG, 2020).

The next steps taken by the ministry suggest a change of direction based on the results of the appathon. The ministry decided to have the application developed in-house by a 'building team' (van Algemene Zaken, 2020b) of internal and external experts (deingenieur.nl, 2020; Utrecht, 2020; werkenvoornederland.nl, 2020). This building team was tasked to develop the application under the responsibility of the ministry of VWS. Around the building team, an open-source community was organised (Ministerie van Volksgezondheid, 2022), which coordinated through Slack, an online forum application, which was publicly accessible (codefor.nl, 2022). This open-source community was involved early on in discussing potential architectures as well as in building the application.

Control was formally centralised within the building team and the ministry of VWS, which is accountable to the Dutch parliament and senate. Compared to France the Dutch executive bodies have less power and approval from parliament is required for more things. There is also a formal role for the Dutch Data Protection Authority ('Authoriteit Persoonsgegevens'). A less formalised form of control is in the hands of the open-source community which can propose changes to the code, although they need to be accepted by someone from the building team.

A group of Dutch privacy-/digital rights-based NGOs grouped together to form the coalition ”safely against corona” (”Veilig Tegen Corona”) (Corona, 2020). They submitted a list of 10 demands for the application that it should adhere to. Although these organisations have no formal power they did reach out to the press to try to get their voices heard and influence the representative bodies. From the interview (Appendix B.1) we can see that this manifest had a significant influence on a number of developers of the application, some of whom made it even a condition that the manifest needed to be integrated, for them to be willing to join the project. This manifest was fully integrated into the requirements for the application.

Information rules The Dutch process for designing the application was very open. Not only was the source code published on GitHub (Github.com, 2022), but also a lot of conversations between volunteers were publicly accessible via slack (codefor.nl, 2022). This means that not only the technical details themselves are public, but also part of the conversation surrounding it within the CodeFor.nl community, meaning that most of the information about the development process was public. The Dutch process was even more open than the German one because for the German application a lot of communications went via e-mail, meaning that the contents of these communications were not publicly visible. Additionally, the Dutch government frequently updated parliament in public documents about the developments of the application (van Algemene Zaken, 2020c; van Volksgezondheid Welzijn en Sport, 2020a, 2020b). This meant that anyone could be informed about the ongoing development of the application, and contribute to discussions with the developers. From the interview, we can conclude that this was done on purpose to aid in realising more trust in the application.

Choice and scope rules The following decisions towards the scope were formally made: Within the first set of design documents on GitHub, we can see that some decisions were already made in advance (minvws, 2021): The app would work using Bluetooth and would use a decentralised design. Additionally, a number of design principles were outlined, which included a requirement that the application would be temporary, reliable, interoperable with neighbouring countries, accessible to as many people as possible, including people who do not speak Dutch or have any disabilities and many others. The application should also comply with principles from the General Data Protection Regulation (GDPR) such as privacy by design and data minimisation. It should also comply with all relevant security baselines that the Dutch government uses.

Additionally, before the GitHub repositories were launched, the coalition ”veilig tegen corona” also submitted 10 demands, which were adopted by the building team and also integrated into the applications’ requirements on GitHub (minvws, 2021). The most notable of these demands were:

- The application needs to be provably reliable and developed by experts
- Data cannot be traced back to individuals.
- As little data as possible should be used
- No data should be stored centrally.

From these demands of the coalition, it is clear that they would also prefer a decentralised system and they even noted that ”they would actively resist a system that does not align with their demands”. The formal power of these NGOs is limited but the interview shows that this manifest had significant influence on both the building team, as well as key stakeholders hire up in the ministry of VWS and as a result of that they were very effective in reducing the scope of acceptable solutions for this application.

Payoff rules When looking at the design principles as outlined on GitHub (minvws, 2021), it is clear that the building team saw the most value in a decentralised application that aligned with the demands of ’veilig tegen corona’, guidelines that were set out in the ”common toolbox” of the European Commission (European_commission_ehealth_2022), as well as the Baselines used by the Dutch government and recommendations by the Dutch cybersecurity agency. It seems like there was relatively little disagreement on a technical level between all involved parties, with the building team willingly taking over the demands of ”veilig tegen corona”.

The most controversy was surrounding the usage of the Google-Apple Exposure Notification framework. The Dutch Data Protection Agency (Persoonsgegevens, 2020) wanted that the Dutch government would make an agreement with Google and Apple about the data protection of Dutch citizens, and also demanded a solid legal basis for the processing of data. Interesting here is that the first issue, regarding Apple and Google, was never formally resolved, retracted or followed up on by the privacy authority. It is therefore not clear whether any agreement has been reached with these parties and whether it was satisfying for the agency. The Data Protection Agency does note that they are positive about the design of the application itself. The lack of controversy about the architecture itself shows that there was consensus about which architecture to use early on in the process.

7.2.2. Attributes of the community

The Netherlands has a long tradition of involving a lot of different parties in negotiations, the so-called ”poldermodel”. This originated because of labour negotiations in the second half of the 19th century (Vos et al., 2002) but has since extended to many other facets of public policy-making such as the recent climate agreement (Meer et al., 2019). Evidence that this also played a role within the process of designing the application can be found for instance in the different expertise groups involved in judging the appathon (zaken_gelopen_2020).

The Netherlands has privatised a lot over the last decades and moved a lot of responsibilities from the government to market parties who would then be contracted by the government (Stellinga, 2012). It would therefore not have been surprising if the Dutch government would have taken the same approach as France and Germany and would have tasked a private company with the development of the application. Nevertheless, this could also be influenced by recent negative experiences with outsourcing certain healthcare tasks to private companies. That these experiences could lead to other considerations when outsourcing tasks is also suggested in grey literature (treep_zelf_2022).

And finally, the Netherlands has a relatively high trust in its governmental institutions, especially when compared to France and Germany (Dekker, 2012). This would be expected to lead to less resistance to the development of the application and a higher uptake.

7.2.3. Physical/material conditions

For the Netherlands, no other factors were at play than what is described in chapter 4.

7.2.4. Actors

The actors involved were:

- The ministry of VWS
- The building team
- The open-source community
- The Dutch public health authorities (advising role)
- The Dutch Data Protection Agency
- The NGO coalition ”safely against corona”
- Google and Apple

The first three were involved as the parties responsible for creating the application. The health authorities were involved since the applications were meant to automate part of the contact tracing activities and therefore simplify their work. The Data Protection Agency is tasked by law to safeguard the privacy of Dutch citizens. The NGO coalition ”safely against corona” operated as a pressure group that pressured the building team to make specific design choices. Google and Apple made the GAEN framework available and helped out with implementing it (interview Appendix B.1).

7.2.5. Action Situation

When considering the number of actors involved and the extensive influence of actors that did not hold formal power, the ’poldermodel’ is clearly visible in this case. This is illustrated for example in the many expert teams being involved in grading the applications in the appathon, or the inclusion of all the requirements in the manifest ’safely against corona’ into the requirements for the application. Due to the time pressure the steps normally taken by the Dutch government in ensuring stakeholder interaction was sped up, turning it into what Joris Leker (user experience expert) in the interview on this case (Append B.1) described as ”an extremely efficient version of the poldermodel”.

When looking at the action situation itself we can see that the building team, as the primarily responsible party for the development of the application, complied with both the scoping requirements coming from the Dutch government, as well as those brought forward by ”safely against corona”. Their perception was that a decentralised application based on DP3T and GAEN would be the most valuable. The only actor in the action situation that contested that perception of value was the Dutch Data Protection Agency that wanted additional agreements to be made with Apple and Google. In the end, this did not lead to any changes to the technical design though.

7.2.6. Patterns of interactions

The result is that the application was implemented as designed by the building team, with most discussions and controversies being about other topics than the technical design itself.

7.2.7. Outcomes

Privacy

The privacy results of the Dutch application are largely the same as the German application since both integrate GAEN and are based on the DP3T reference architecture. This means that no contacts are centrally uploaded or processed, and the decision to notify someone is made locally on their device. This means that all centrally processed data is anonymised, but notifications can more easily be traced back to specific people, especially if you are able to track a specific person for an extensive period of time.

The key deviation from GAEN is that the application uses less data than the framework could provide. By reducing the data regarding the specific time of exposure processed, it is more difficult to link notifications to specific contacts (minvws, 2021). Additionally, the original application had no ”grading system” like the German CWA that gave more details about the amount of risk a person had of getting infected in a certain period of time. This all seems to be an implementation of the demand of the coalition ”Safely against corona” to minimise the amount of data used.

Interoperability

Since this application is based on GAEN and the DP3T reference architecture, it could be interoperable with any other applications with a similar design, and operates with many other European contact tracing applications (Commission, 2022).

7.3. Effects on the technical design

When looking at the overall effects of specific actors, we can state that the building team had the most influence on the design of the infrastructure. Their design, made under the responsibility of the ministry of VWS preceded a lot of open-source collaboration and was mostly implemented as design.

The coalition ”veilig tegen corona” also had a significant influence on the definitive design. A lot of their demands were just reiterating obligations that the building team already had under the GDPR, but their demands regarding data minimisation clearly had a lot of influence on the definitive design, using even less data than GAEN provided.

The Data Protection Agency was clearly very involved in the process but had few remarks related to the technical design itself.

8 Cross-case comparison

In this chapter the cases will be compared, focusing both on which patterns were shared between cases and which patterns were markedly different. Three areas will be focused on: the design process, the role of attributes of the community vs institutions in general, and the role of perceived value and pay-off rules specifically. For each of the categories a general analysis is given and then certain sub-themes will be analysed.

8.1. Actors, position rules and control rules

When it comes to the initial design process, France took a more centralised approach with relatively little open-source participation. The Netherlands and Germany took a more open approach with large, involved open-source communities. In Germany this was led by two large industrial companies. In this section, we will look at the different cases from the perspective of which actors were involved, and which positions and control they had. First, the composition of the organisations tasked with the development and design of the applications are compared. Then the different ways that these organisations ensured having the right access to the right specialisms will be discussed. Finally, the role of the media and data protection agencies is explored.

8.1.1. Responsible organisations

The French case stands out because of the size of the coalition. Even though all three cases were open-source, the French case was the only one where the access for proposing changes was limited by using a privately hosted online repository, only people who have been granted INRIA accounts can add issues or make 'pull requests', concrete proposals for changes in the code. There was therefore very little involvement from volunteer developers. The decision to have only French companies involved in the development of the application is a typical example of the French policy of "digital sovereignty", in which they do not want to be dependet on American companies.

The German operational responsibility was assigned two too large companies, with a large open-source community. When compared to the French case the process was more open since the German Corona-Warn-App was built on the public platform Github.com instead of a private alternative. This means that anyone could raise issues or contribute to the code. The designation of two large industrial companies for the design of the application is not surprising, especially since Germany is well known for its industry. What is surprising is the complex relationship between the developers and the federal government, where SAP and Telekom seem to have been originally given the mandate to chose an architecture (heise online, 2020a), but after that having a decentral architecture being demanded by the federal government (heise online, 2020b).

The Dutch process was the most open of the three, with not only the code being publicly available and hosted on an open platform, but also most of the conversations about the code being open on Slack. This meant that anyone could pitch in and join the conversation, even outside of the limited options of raising issues and proposing changes on Github.The decision to develop the application in-house at the Ministry of VWS is partially surprising since normally you would expect that the development would be outsourced (either to the market or to a body within the government that specialises in IT development,

	France	Germany	Netherlands
Actors and control	Centralised, few involved countries	More involved actors, open-source community actively involved	Decentralised, extensive stakeholder involvement, very involved open-source community
Responsible organisations	Coalition of academic organisations and private companies	Two companies (Telekom and SAP) in the lead with an open-source community surrounding them.	Developed in-house at the Ministry by the building team with help from an open-source community
Integration of different disciplines	Represented by different specialisations of companies taking part in the coalition.	Present in Telekom and SAP or sourced from the open-source community	Different expertises taken into account when forming the building team.
Public involvement	No visible effect on final design	Switch from PEPP-PT to DP3T due to public pressure	Extensive stakeholder and NGO involvement in setting the requirements for the application
Data protection agency involvement	External advisor to the project	Integratedto in the development process	External advisor to the project
Culture	Focus on "digital sovereignty" made a centralised architecture more attractive	High trust in institutions and authorities made adoption easier.	Cultural standards for stakeholder involvement heavily shaped the design process.
Institutions	Shaped the process according to the centralised presidential system of France	Informed the decision to delegate the development to SAP and Telekom	Shaped the steps in stakeholder involvement and the overall development process
Perceived value	Focus on "digital sovereignty" as key requirement for development of the app	Switch from "digital sovereignty" to "less data collection" throughout the process	Focus on collecting and processing as little data as possible

Table 8.1: Overview of main differences between the cases

as also illustrated by the interview in Appendix B.1). The Netherlands seems to have never been actively pushing for ”digital sovereignty”, and it is therefore not surprising that no effort seems to have been taken to be independent of Apple and Google and was willing to work with them from the start.

8.1.2. Representation of different disciplines

Developing a large scale application requires many different disciplines, both many different technical specialities are required, but also people experienced with the legal aspects of applications like this and people who can communicate about the app and promote it (see also Appendix B.1). In each of these cases, different methods were used to ensure that all required knowledge was available.

The French case primarily focused on having the necessary disciplines involved within the different organisations involved. To ensure that all the necessary disciplines within IT were represented within the coalition, a large number of companies and agencies took part in the development effort, under the leadership of national research institute INRIA and the french Ministry for public health. By excluding developers and smaller companies from contributing, the development process became a very centralised effort in which only big players could participate.

The large size of the French coalition, when compared to the German and Dutch cases, would therefore partially be caused by the limited amount of open-source community surrounding this project. Having fewer people from outside the project to rely on, the coalition would have needed more knowledge within the organisation to develop the application and launch it.

The reason why Germany, unlike France, only needed two large organisations for developing this application will, in part, be caused by the leveraging of an open-source community. By having 7000 independent developers to rely on, the need for ensuring every single specialisation is reduced. Nevertheless, SAP and Telekom will also have had most required specialisations available to them when looking at how large these organisations are.

In the Netherlands a combination of both approaches was taken, where all the necessary disciplines were represented by involving individuals with the right skill set in the building team (see Appendix B.1), but there was also an open-source community that could be leveraged if any expertise was missing.

8.1.3. Public involvement

The cases vary largely in to which degree the media and NGOs (Non-governmental organisations) were involved and had an influence on the process.

In the French case, it is clear that the NGOs, although active in the media (du Net, 2020) had no significant effect on the application itself. INRIA and the French Ministry of solidarity and health stood by their decision to make a centralised contact tracing application.

The German case showed more effective involvement from the media and NGOs in reinforcing the worries about the centralised architecture that PEPP-PT was pushing (Boell.de, 2020; heise online, 2020a). This seems to have been effective because in the end the German government (heise online, 2020b) decided that the German Corona-Warn-App should be decentralised. This decision was likely primarily taken due to public pressure.

In the Netherlands, NGO input was already incorporated from the very start after the manifest ”veilig tegen corona” was submitted, which means that no changes needed to be made after starting building the application. This will have helped avoiding any controversy or the need to drastically change directions like in Germany, with all the costs associated with it.

8.1.4. Involvement data protection agencies

In all three cases, the national data protection agencies were closely involved in the process. This happened either directly, with the development of the applications such as was the case in Germany or France, or in the debate surrounding it as was the case in the Netherlands. Through both these methods of collaborating in the process, data protection considerations had a clear ambassador throughout the development of each of these three applications. This shows the value of these institutions, although one can wonder whether they would have been equally involved if these projects got less media attention.

8.2. Attributes of the community vs institutions

Another difference between the cases was the influence of attributes of the community (culture) and institutions. Below the influence of both these factors are discussed per case.

8.2.1. Culture

The case can be made that cultural factors are very influential in the French case, especially the distrust in technology playing a role in the architecture design. This distrust likely affected the system two-fold. First of all, it might be one of the factors that drives France’s push for ’digital sovereignty’, where this distrust shapes the attitudes in France towards American tech companies, therefore also reducing trust in GAEN. Additionally, this might also result in distrust towards decentralised systems themselves since they rely heavily on technology for their privacy-protecting features. This might have added incentives to go for a centralised architecture that leans more on trust in (French) organisations.

In Germany, the high trust in institutions and health authorities will have made implementation of the app easier and explains the comparatively high initial adoption rates. Nevertheless, this did not manage to lessen the initial controversy surrounding PEPP-PT, which might be related to the relatively high privacy awareness in Germany.

The Dutch process was primarily shaped by the ”poldermodel” which has both cultural aspects, as well as specific institutions. When it comes to the cultural aspects of the polder model the lack of hierarchy and the direct lines of communication were cultural factors that partially explain why so many stakeholders were involved early on, and why the input from ”veilig tegen corona” was as big as it was.

8.2.2. Institutions

Institutions in the French case primarily had an influence on shaping the process itself, where the generally centralised French governmental system is reflected in how the responsibilities were delegated, with INRIA and the coalition working under the responsibility of the Ministry of public health and primarily following their lead.

When it comes to the process of design and delegation in Germany, of the development most can probably be attributed due to the institutions that Germany has, as a country with a lot of good functioning ”classical industry”, with high trust in the private companies that made these applications.

When it comes to the institutional aspects of the ”poldermodel”, the standard processes regarding stakeholder involvement, although at a quicker pace than normal, will have contributed to shaping the requirements for the application by making sure that as many actors as possible could give their opinions on the app early on in the process.

8.3. Perceived value and pay-off rules

The last key difference is in the perceived value. The reason why France choose ROBERT and Germany and the Netherlands for DP3T was primarily because of the differences in pay-off rules attached to these options in the different cases.

In France, the doctrine of ”digital sovereignty” seems to have been a primary influence on the preference for ROBERT since it was the alternative that would be less dependend on US companies. Since the INRIA coalition was also held the position that not sending exposure keys to all applications was better for privacy, the centralised architecture became a natural choice.

Germany first seemed to value the PEPP-PT project higher since it aligned with the goals of ”digital sovereignty”, but after public outcry over perceived privacy issues it became clear that many stakeholders in Germany perceived the decentralised approach of PEPP-PT as more valuable.

Within the Netherlands, the choice for a decentralised architecture was the only option that would comply with all of the demands from ”safely against corona”, and therefore it seems like the PEPP-PT architecture was never seriously considered at all.

9 Discussion

In this chapter, the results will be contextualised using the literature from the literature review. This chapter focuses on evaluating the applicability of methods used and situates it within the body of literature found in the literature review. First, the applicability of the IAD framework to the case will be discussed. Afterwards, the findings from the analysis will be compared to the literature from the literature study.

9.1. Reflection on the usage of the IAD Framework

The IAD sufficed to analyse the cases in this paper. The different elements in the framework provided enough detail to construct a complete analysis of why specific decisions were made, under the assumptions that the framework is based on (rational actors following institutions). This underlines that the framework is as comprehensive as it is supposed to be and can be used as intended, with no elements clearly missing. Different parts of the framework played large roles in the different cases, although in each case boundary and position rules, as well as pay-off rules played the largest roles since most decisions were made by the people assigned with developing the application based on the system that they perceived as having the most value. The role of information varied between the cases. Whereas the openness of the project in the Dutch case seems to have no influence on increased debate about the technical design, in Germany this openness led to more debate and might have played a role in the shift from PEPP-PT to DP3T.

Control and position rules tend to be similarly organised across the bodies tasked with developing the applications as they are within governments that tasked them with developing them. In France, the development process was centralised around INRIA, much like the centralised role the French national government plays in French public administration. In Germany, which is a federal state with many tasks decentralised to the federal states, the process is also more decentralised with a large open-source community. In the Netherlands, the ”poldermodel” system is clearly visible in the process with extensive stakeholder involvement from the very start and an extremely open process. It might be worthwhile to research whether this is generalisable to any projects started by any governments, or whether this was unique for just these three cases for developing these applications.

Nevertheless, the IAD framework has some inherent limitations. By assuming that the factors in the IAD framework are related and actors behave rationally within the bounds of the framework, any irrational choices were made they could be rationalised through the process analysis. Additionally, by focusing on organisations and the role of these organisations the role of specific actors could be underestimated, meaning that there could be specific individuals who had a profound impact on the design processes that becomes less clear when aggregating to the level of organisations. Lastly the application of the framework leads to focusing on specific elements leading to a simplification of the overall action situation, which aids in making an analysis but could also lead to insufficient emphasis being put on factors that are not included in the framework.

9.2. Relation to other research

9.2.1. Institutions and their influence on existing Socio-Technical Systems

Fleischmann et al. (2011) noted differences in the modelling of data between public, academic and private organisations caused by differences in values between these organisations. Their research used surveys, interviews and focus groups to identify which values employees at these labs found most important and how it did affect their modelling choices. They concluded that the different types of labs resulted in different value structures in their employees, which also affected modelling choices.

It would be interesting to consider whether a similar pattern could be visible in one of our cases. If we consider that the French case was primarily a private-academic collaboration, the German case was primarily developed from the private sector and the Dutch application in the public sector you would expect clear influences from that if you look at the conclusions of Fleischmann et al. (2011). If we look at the analysis of the cases no such influences can be identified; no specific choice seems to have been made primarily because of the type of body charged with designing and developing the application. This could be because the influence of this was too small when compared to differences with a large impact (such as the different cultures), or because no such effect was present in this case.

Oh and Hettiarachchi (2020) showed how similar technical systems can have widely different effects if placed in different institutional environments when comparing waste management systems in Brazil, Indonesia and Nigeria. In this study, this effect is less visible. The applications of Germany and the Netherlands are functionally similar and yield similar results, but the institutional environments of the Netherlands and Germany are also not too dissimilar so that was to be expected. The French application is functionally too different from the other two to make a comparison that does justice to the original paper.

9.2.2. Effects of institutions in implementing new systems

From Kainiemi et al. (2013) it was already clear that managing stakeholder perceptions can make or break a socio-technical system and this finding is further reinforced by the findings from our analysis. We see that by incorporating stakeholder input relatively early on, the Dutch developers managed to avoid the same levels of controversy that Germany and especially France dealt with. It does not seem to be fair to attribute the poor adoption rates in France purely and only based on stakeholder involvement since the attributes of the community also did not help in that case, but it potentially could have helped if stakeholder involvement was more integrated in the process in France. This shows that the importance of stakeholder management in socio-technical systems extends wider than just the carbon capture and storage that Kainiemi et al. (2013) discusses and is at least also relevant to contact-tracing applications and maybe other types of socio-technical systems too.

Semaan et al. (2010) showed that trust can fluctuate during pandemics and therefore IT interventions need to be developed while taking fluctuating trust into account. In the Dutch case, it shows from the interview (Appendix B.1) that there was a clear emphasis on the need to be open and one of the reasons for this is likely this need for trust. If the process is open then the public can potentially verify for themselves whether an application can be trusted or not. In the German case, it starts off quite closed and openness is only realised after there was unrest in the media, so fluctuating trust was not taken into account in the process. Part of the unrest could have potentially been avoided here if fluctuating trust was taken into account from the very start. In the French case, it seems like trust was never considered as a factor in developing the application. From this we could conclude that when developing IT systems during crises, it would be best to assume a low-trust environment since the actual levels of trust might differ throughout the process. From the conclusions that can be drawn from this research, this is also the most actionable and it should be taken into account when developing IT systems for usage during disruptive events in the future.

9.2.3. Institutions and contact tracing applications

Kariuki et al. (2021) and Storm van Leeuwen et al. (2021), in their work on the privacy implications of specific design choices of contact tracing applications, concluded that both of the prevailing architectures of contact tracing applications had inherent flaws that would require additional regulation and institutional measures to properly protect the privacy of end users. If we put our results within this context we can identify that in the three cases studied, specific non-technical measures that have been taken to deal with these issues. In the French case, the national Data Protection Agency pushed for frequent audits of the central server and the organisation running it. In the Netherlands, the Data Protection Agency called for additional agreements with Google and Apple to regulate how they can use the data relating to contact tracing. This shows that in both these cases issues that had no technical solutions were identified and solutions were proposed throughout the process.

9.3. Summary of findings

The primary scientific contribution from this paper is threefold. First of all this paper concerns a rigorous application of the Institutional Analysis Design Framework to contact tracing applications. Since studies that feature an application of the IAD Framework to an IT system are rare, as shown by the limited results yielded by the literature search, there is inherent value to this. The Institutional Analysis and Design Framework allows for a clear subdivision in all the institutional elements that affect a system and to identify their roles independently, giving the opportunity to identify which elements played a role in the design of these systems. Since the institutional environment can have a significant effect on the functioning of socio-technical systems, being aware of these environments can support making design decisions that yield the best results for any specific situation. The cases studied in this paper could support national governments in the (further) development of applications that are similar to the contact tracing applications studied. A second key finding is the interactions between trust and how centralised a process can be. In France, the decision to put the strategic goal of Digital Sovereignty above other values such as stakeholder involvement is clearly reflected in which actors had an influence on the design processes. This centralisation of decision-making authority in the process led to the centralised architecture that the French government preferred, but also resulted in more public controversy. In the Dutch and German cases, a lot more stakeholder involvement was included in the process, leading to less public controversy surrounding the application. Most stakeholders in the German and Dutch cases preferred a decentralised architecture resulting in a decentralised system as a result of these design processes. The final interesting result is that even though previous research would suggest that the type of organisation involved in designing a contact tracing application, be it private, public or academic, could very well have an influence on the resulting system itself, no such effect was seen. This effect would be caused by different values being held by the employees of private, public or academic organisations. The Dutch and German systems, one designed by the government itself and one by private organisations, are very similar, so no effect is visible here. The French system on the other hand is very different, but it was mostly developed by private organisations. Naturally, the sample size of this research is too small to make any definitive claims but it does mean that this effect is not universally present.

10 Conclusions

10.1. Research question

This chapter will first go over the research questions and how they were answered and then some avenues for future research will be proposed.

The main research question for this paper was as follows:

”How have institutions influenced the technical design of COVID-19 Contact-Tracing applications in France, Germany and the Netherlands?”

This question has been answered through a thorough analysis using the Institutional Analysis and Design framework (Ostrom, 2007). This main research question was split up into three sub-questions. A summary of the answers to these questions will be included below. For the full analysis please refer to the respective chapters on these cases.

1. Which technical decisions, framed as action situations, had a particular influence on the design of this contact-tracing application?
2. Which influence did institutions have on technical design choices were made in the design of the contact-tracing apps?
3. How did these design choices affect interoperability and privacy integration?

In the French case, it was identified that both the original technical design, as well as the rebrand had a significant impact on the overall technical design. The original design was primarily influenced by the policy of ”digital sovereignty”. Because of this, architectures that did not lean too heavily on American tech giants were prefered. Additionally, the organisations tasked with developing the application perceived a decentralised architecture to have a higher value as part of the pay-off rules. This, together with all the other factors outlined in chapter 5 explains the choice for the decentralised architecture based on the ROBERT protocol.

This choice for a decentralised architecture is the reason why the French application is not interoperable with any other applications since France is the only EU country that implemented this specific decentralised architecture. When it comes to privacy results, the decentralised architecture requires data about all contacts a user has, to be uploaded to a central server. From the central server, notifications are sent to the devices of any users that were at risk.

For the German case, the original design was discussed. Originally Germany also considered using the centralised architecture developed by PEPP-PT, also from considerations regarding ”digital sovereignty”but after public pressure other actors who perceived the value of a decentralised system as higher managed to pressure the government in demanding a switch to a decentralised architecture. From an institutional perspective both the pay-off rules from different actors, as well as formal rules about positions and control played a large role in this case.

When it comes to interoperability, the decentralised architecture based on the Google/Apple exposure notification framework and the DP3T reference architecture was widely used within Europe and therefore this application is interoperable with many other applications. Looking at the privacy features of this architecture it is clear that less data is sent to a central server, meaning that less trust is required in the parties running the server. The downside is that the Bluetooth keys of anyone who proves to be infected need to be sent out to everyone's devices, which means that hypothetically they could be traced back to specific people. Different mitigations are in place though to avoid this.

When looking at the Dutch case, a large group of stakeholders was involved in the design process from the very start and a coalition of NGOs submitted a manifest that in essence demanded a decentralised architecture. This manifest was fully integrated into the design requirements for the Dutch contact tracing application, with the resulting app being a decentralised application based on GAEN and DP3T. The existing institutions that lead to the high amount of stakeholder involvement in Dutch decision making had a clear influence on the process, which was the most open of the three and the resulting architecture.

When it comes to interoperability the Dutch application has the same advantages as the German application since it was also based on DP3T and GAEN. The only difference to DP3T is that the Dutch application uses less data than it potentially could. Because it uses DP3T and GAEN it is compatible with many other European contact tracing applications. The privacy considerations are also the same as with the German application, with the main difference that the Dutch app uses less data so de-anonymisation is even more difficult.

Apart from the questions per case, there were also two sub-questions to the main research question meant to compare the cases.

4. Which, if any, patterns of interactions are shared between the cases?
5. Which, if any, interactions within specific cases stand out in specific cases and which factors caused this?

When we look at the cross-case comparison a few things stand out. First of all, all three projects needed to integrate different IT disciplines. This was done in different ways in each case. The French case realised this by having a large consortium of organisations develop the app. The Dutch and German applications used open source communities to leverage many different expertises.

Another pattern shared between the cases, was the high amount of involvement from Data Protection Agencies shared between all the cases. These agencies are required because of EU law and because of this all three EU member states discussed in this paper had such an agency. In all three cases, these agencies provided input on the applications, either closely involved with the project such as in Germany, or by submitting opinion pieces such as was the case in the Netherlands and France. In all three cases the roles of these agencies were clearly visible.

Large differences were mostly related to the centralised versus decentralised architecture debate. In France, the centralised architecture was seen as the most valuable from the start and the organisations tasked with developing the application did not change their mind on this during the process, despite public criticism. In Germany, the centralised architecture was seriously considered early on in the process, but after public criticism the chosen reference architecture was changed to a decentralised one. The Dutch process started off with a broad inventory of available technologies. During this process NGOs started pushing for a decentralised architecture, which eventually was the architecture that was adopted.

In the end, we can conclude that Germany and The Netherlands valued stakeholder involvement the most and therefore ended up choosing decentralised architectures since it was prefered by most of the involved stakeholders. France on the other hand preferred strategic independence from Apple and Google and therefore preferred realising these goals over implementing the most popular solution.

10.2. Academic contribution

When looking at the contributions made to the existing body of literature, three types of contributions are made: extra evidence was found supporting findings from previous research, evidence was found that did not support existing findings, meaning that the effects found earlier are not present in every case and an overall contribution was made to the wider field of IAD research.

When it comes to findings that reinforce existing research, the most interesting results relate to stakeholder perceptions and trust. From all three cases, it becomes clear that managing stakeholder perceptions is key, which aligns well with the results from Kainiemi et al. (2013) in a case study of

Carbon Capture and Storage in Finland. This shows that importance of stakeholder management in another type of socio-technical system. Regarding trust, it was found that considering the fluctuations of trust that come with large disruptions, such as found by Semaan et al. (2010), in the design process could potentially reduce the amount of controversy related to a contact tracing application. The lesson that we can draw from this is that when developing IT systems during crises, it might be best to assume a low-trust environment since the actual levels of trust might differ throughout the process.

When it comes to previous findings from literature for which no evidence was found, one finding stands out. First of all, it is interesting that it seems to have had little or no influence whether an app was developed by a private or public organisation since the Dutch and German applications are very similar functionally. From the research by Fleischmann et al. (2011), one would suspect that the different types of organisations would have different internal cultures which would have a visible effect on the design processes or the result but no major influence that can be attributed to this can be found. This could mean that the differences in public and private bodies described in the study only exist in specific subsets of private and public organisations and not on the ones discussed in this paper.

When it comes to the general contribution to research using the IAD framework, this study contains a full analysis of three cases which can in the future be used to compare other similar cases against, hopefully adding to the further development of the framework and institutional analysis and development in general.

10.3. Limitations

This study is limited in a couple of different ways. First of all,there are the limitations that come with the application of the IAD framework in this paper. First of all,the framework assumes rational behaviour and therefore irrational behaviour could be rationalised. Additionally, by aggregating actors to the level of organisations, the role of individuals might be underestimated.

A second limitation is the limited scope for the collection of sources and the limited timeframe for the study. Both the German and Dutch cases have endless amounts of issues, pull requests with comments and conversations on public platforms that could add an endless amount of detail to the analysis but it would not be feasible to go through all these sources. A similar limitation is caused by the limited inclusion of French-language sources due to lack of fluency with the language.

The final limitation is the lack of German and French interviews included in the study. It does align with the findings related openness of the process that it would be harder to find interviewees for these cases but a study that can include interviews about these two cases would aid in validating the results of this study. For the German case an official response was received that they have the policy to not hold interviews about the process due to a lack of manpower as well as 'data protection reasons'. For the French case potential interviewees indicated there being a policy in place that did not allow them to accept interviewees, and the official contact e-mail did not respond to follow-up emails after a request for an interview.

10.4. Policy Recommendations

From the synthesis, we can conclude that trust is absolutely critical in developing applications such as these to be used during emergencies and times with fluctuating levels of trust. To best mitigate the effects from varying levels of trust, it would be safest for governments to assume that trust will decline during the design process and because of that both the process and the application need to be able to gain trust even in a low-trust environment. The exact method of achieving this will vary depending on the institutional environment but in both the Dutch and German cases it becomes clear that a more open process generally leads to less distrust towards the project. In the French case, the choice for digital sovereignty seems to have made existing issues regarding trust worse, which suggests that there is a trade-off between ensuring trust and how centralised a design process can be. This centralisation affected a lot of different individual institutions. It affected the access to information that the public had, limited the amount of actors that could be involved in the design process and limited the control of actors who had no formal role in the process. Either the option for an open process or steering towards a certain outcome for strategic reasons can be valid courses of action but decision-makers should be conscious of the consequences of both these alternatives.

10.5. Recommendations for future research

The following proposals would be worthwhile avenues for future research. First of all,the lack of comparable cases makes it difficult to compare the cases studied in this paper to other cases. Part of this is also caused by the many modifications that are frequently made to the IAD framework. These modifications could be interesting if used with clear intention but having more research using a basic unmodified version of the IAD framework would allow for more opportunities to compare cases, using the unmodified version therefore makes it more usable for future research. This is also the same recommendation as (Pahl-Wostl, 2017) makes. A similar recommendation is made for the method of analysis. By populating all fields in the IAD framework, including the rules inside the action situation, cases can be compared on a more detailed level than what many currently published studies provide. The last recommendation relates to the limitations mentioned. Not all potential sources of data could be used for this study and it could therefore be worthwhile to make a further analysis of each of the individual cases using more sources in the native language of these respective countries. This could generate more detailed results which could be used for further comparison. The contents of this research could be used to compare to other cases using other types of systems or set in other countries. For example by comparing the results from this research to cases in other countries in the European or outside of it, or by looking at a different type of IT system (tax form submission systems for example) that is implemented in each of the three countries discussed in this paper to see if the interactions between institutions and system are similar or differ, and why. This would add further to the literature on the interactions between institutions and (IT) systems and therefore could help improving more types of systems and generalising results. Finally, more research into designing IT systems for disaster management could be useful. By studying other types of systems used in disaster management and how institutions are used to support trust in these systems, more detailed methods could be found to realise the required trust that Kainiemi et al. (2013) and Semaan et al. (2010) identify.

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A

Literature review documentation

This appendix covers all the items from the PRISM 2020 checklist, following the checklist from top to bottom. The checklist itself is included at the end of this chapter.

A.1. Eligibility criteria

All literature was included that:

1. Was available via the TU Delft library, or publicly available
2. could be found via SCOPUS
3. covered both a socio technical systems design and the effect of institutions on STSs

A.2. Information Sources

Only SCOPUS was used as a database for the literature review.

A.3. Search strategy

The strategy for the collection of literature was aimed at finding literature that focused on the interaction between institutions and socio-technical systems, and that was as similar as possible to mobile contact-tracing applications (i.e. with an aim to scope down to IT systems and then to mobile applications). The goal was to find around 20 papers that were as relevant as possible for this case.

Three searches were done to find relevant papers. The first search took intuitions and technology design by governments as a starting point, and then scoped down on information technology and socio-technical systems to make the query more specific. The second search took the Institutional Analysis and Design Framework as a starting point and then scoped down on the usage of technology by governments. The third and final search focused on getting all relevant literature specific to contact tracing applications. Specific keywords are included later.

A.4. Selection process

All of the papers were initially screened basis on the abstract available in SCOPUS, and if they appeared relevant they were further screened on availability, and finally screened on the entire contents. This means a single reviewer screened all articles. No automation was used.

A.5. Data collection process

All data was collected by a single reviewer. No effort was taken to obtain or confirm data from study investigators, and no automation was used.

A.6. Data items

No quantitative data was searched, and no hypotheses about specific effects of specific institutions on STSs were formulated in advance.

A.7. Study risk of bias assesment

Only peer-reviewed papers were included to reduce the risk of including biased papers, and where applicable any statements about funding sources and competing interests were considered before including the study.

A.8. Reporting bias assesment

For the keywords used an assesment was made of the bias this could include in the overall literature review. This assesment is included below in the section ”Risk of Bias in studies”.

A.9. Certainty assesment

In all the papers the wording of any conclusions was considered to judge the certainty of the conclusions any of these studies reached.

A.10. Flow chart

A.10.1. Search 1

To find literature, first a cursory search for the right keywords was done. The first search yielded to many results to be practical. Because of the many uses of the word ”institutions”, adding this word in the filter by itself did not provide more relevant results since papers often talk about ”health care institutions” as a means to describe hospitals, pharmacies etc. which is different from the meaning used in institutional economics. By instead including government and design as a keywords the resulting papers were more relevant to the topic of this thesis.

A.10.2. Search 2

To make sure all relevant literature on the interactions between institutions and STSs is included, a second search was done taking the IAD framework as a basis. This was done because it is known that the IAD framework focuses on the relations between institutions and STSs (Ostrom, 2011), and therefore including this would likely result a higher amount of more relevant papers. The two groups of resulting papers were further processed as shown in the flowchart.

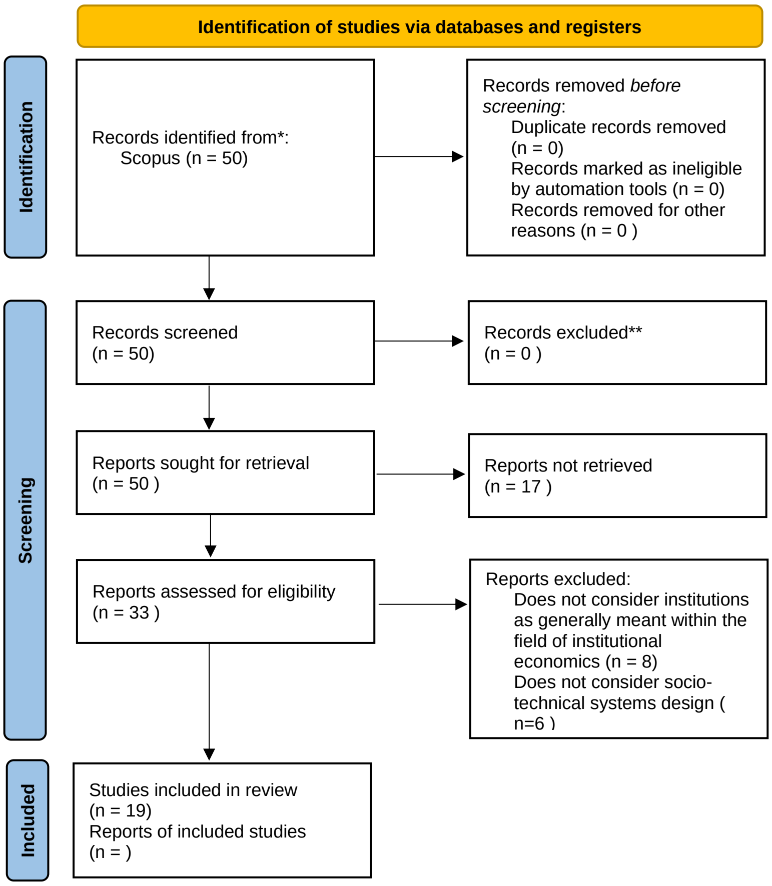
Of the second search the last set of keywords had the most relevant keywords.

A.10.3. Search 3

To ensure all relevant literature on contact tracing applications was included a third search was done with the keywords from table A.3. The last search query yielded the most relevant papers so that one was used. In combination with the other queries this yielded 50 results in total.

Flowchart

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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TITLE-ABS-KEY ({Contact tracing} AND application)	621
TITLE-ABS-KEY ({Contact tracing} AND application AND institutions)	14
TITLE-ABS-KEY ({contact tracing} AND application AND design AND government)	23

Table A.1: Search terms first search

TITLE-ABS-KEY(IAD AND Framework)	251
TITLE-ABS-KEY ((({institutional analysis and development}) OR (iad AND insitutions)) AND framework)	288
TITLE-ABS-KEY ((({institutional analysis and development}) OR iad) AND framework AND mobile AND application)	1
TITLE-ABS-KEY ((({institutional analysis and development}) OR iad) AND framework AND health)	21
TITLE-ABS-KEY (({institutional analysis} AND development) OR (iad AND institutions) AND framework AND health)	15
TITLE-ABS-KEY (({institutional analysis} AND development) OR (iad AND institutions) AND framework AND {information technology})	2
TITLE-ABS-KEY (({institutional analysis} AND development) OR (iad AND institutions AND framework AND health AND policy)	7
TITLE-ABS-KEY (({institutional analysis} AND development) OR (iad AND institutions) AND framework AND {technical systems}	6
TITLE-ABS-KEY (({institutional analysis} AND development) OR (iad AND institutions) AND framework AND systems)	212
TITLE-ABS-KEY ((({institutional analysis} AND development) OR (iad AND institutions) AND framework AND systems AND design))	48
TITLE-ABS-KEY(({institutional analysis} AND development) OR (iad AND institutions)) AND framework AND technology AND (government OR governance))	23

Table A.2: Search terms second search

TITLE-ABS-KEY ({Contact tracing} AND application)	621
TITLE-ABS-KEY ({Contact tracing} AND application AND institutions)	14
TITLE-ABS-KEY ({contact tracing} AND application AND government AND (design OR adoption))	44
TITLE-ABS-KEY ({contact tracing} AND application AND government AND (design OR adoption) AND implementation)	4

Table A.3: Search terms third search

A.11. Risk and reporting bias assessment included studies

The primary risks of bias for this literature review stem from the search terms used. By specifically searching for the IAD framework, alternative methods for analysing the impact of institutions on STSs might not have come up in the results.

Additionally the search terms assume that there is an effect of institutions on socio-technical systems design, so any research on the contrary position might not have show up in the results

A.12. Registration and protocol

The review was not registered, there is no review protocol prepared.

A.13. Support and competing interests

Even though staff of the TU Delft contributed to the DP3T project, none of the staff members involved with this were in any capacity involved with this research. No external funding was used for this project.

A.14. Availability of code or other materials

No automatisation was used and therefore no code is available. All the papers found are included in the bibliography and are available to those with the required subscriptions.

A.15. Checklist

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Chapter 2.1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	N.A.
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Chapter 2.1
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Chapter 2.1
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Chapter A.1
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Chapter A.2
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Chapter A.3
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Chapter A.4
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Chapter A.5
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	No quantative data included
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Chapter A.6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Chapter A.7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	No quantative data included
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	No quantative data included
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	Appendix A.8
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	A.9

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	A.10
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	A.10
Study characteristics	17	Cite each included study and present its characteristics.	Chapter 2
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	A.11
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N.A.
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Chapter 2
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Chapter 2
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N.A.
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N.A.
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	A . 10
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	A .9
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Chapter 2
	23b	Discuss any limitations of the evidence included in the review.	Chapter 2
	23c	Discuss any limitations of the review processes used.	Chapter 2
	23d	Discuss implications of the results for practice, policy, and future research.	Chapter 2
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	A.11
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	A.11
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	A.11
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	A.12
Competing interests	26	Declare any competing interests of review authors.	A.12
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	A.13

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71

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B

Interview Transcripts

B.1. Interview: Joris Leker, user experience expert Coronamelder

Wie ben je en hoe was je betrokken bij het ontwikkelen van de coronamelder?

Ik ben Joris Leker. Ik ben specialist gebruikersgericht ontwerpen van digitale toepassingen. Ik heb in het dagelijks leven samen met mijn compagnon een eigen bedrijf met gebruiksonderzoekers en ontwerpers. Dat is een man of 40 inmiddels en ik ben dus veel betrokken bij allerlei projecten rond digitale transformaties. Dat is mijn rol in het dagelijks leven.

Bij coronamelder heb ik een vergelijkbare rol, zorgen voor een zo gebruiksvriendelijk als mogelijke app die door een zo breed mogelijke doelgroep goed gebruikt kon worden en begrepen werd. Ik ben betrokken geraakt na de appathon, toe het ministerie besloten had Coronamelder zelf te gaan ontwikkelen. De CIO van het ministerie VWS heeft toen een groep specialisten gezocht en hun de opdracht gegeven en daar ben ik via-via bij terechtgekomen in het eerste groepje van 9 externe adviseurs. Mijn rol/functie was niet breder omschreven dan “adoptie”, en die rol heb ik eigenlijk tot aan lancering gehad. Er lag vanuit de appathon de doelstelling om een app te maken die niemand zou uitsluiten en ik heb me vanuit die rol vooral bemoeit met de inhoudelijke kant van de app. Er waren ook anderen die zich bezig hielden met communicatie en campagne er om heen.

Dus je bent pas na de appathon aangehaakt. In hoeverre was je op de hoogte van het proces rond de appathon?

Ik ben niet voor niets door VWS gevonden. Vanaf het eerste moment dat Hugo de Jonge aankondigte dat we iets met apps gingen doen dacht ik “dat kan toch helemaal niet?”. “Ik weet genoeg van digitale technologie om te weten dat dit nergens op slaat”. Ik ben me toen wel gelijk gaan inlezen met de insteek “zou het dan toch kunnen?”, “hoe dan?” en ik vond het wel interessant en heb me vervolgens ingelezen op nabijheidsmeting met behulp van Bluetooth en die ontwikkeling gevolgd. Toen heb ik ook direct gedacht dat het alleen zou kunnen als Apple en Google ook meedoen, anders krijg je nooit de vereiste adoptie. Toen de eerste ideeën rond de appathon publiek werden ben ik direct met wat collega’s wat gebruikersonderzoek gaan opzetten om tijdens de appathon met ons respondentenpanel, we hebben een panel met mensen die vaak meedoen aan onze onderzoeken, en we hebben toen op de vrijdag dat de invulling van de appathon bekend werd een onderzoeksopzet bedacht en tijdens e appathon alle pitches op basis van een aantal onderzoeksvragen bij ons panel uitgezet met de vraag om een reactie. Op basis daarvan hebben we gedurend het weekend van de appathon een advies voor het ministerie geschreven en met de aanwezige teams gespard en contact gelegd met andere mensen die op een vergelijkbare manier bij de appathon betrokken waren en een netwerk van mensen opgebouwd waardoor we uiteindelijk ook in dat team terecht zijn gekomen.

De appathon was redelijk uniek voor het Nederlandse process. Weet je ook waarom er voor een appathon gekozen was gekozen? Waar kwam het idee vandaan?

Het idee kwam bij minVWS vandaan, ik weet niet wie het bedacht heeft maar vanaf het eerste begin was het al duidelijk dat dit behoorlijk invasieve technologie is, je gaat permanent als overheid bij iemand in zijn broekzak zitten als overheid, dus als we dit gaan doen moet het zo open en transparent mogelijk gedaan worden.

Je zegt: het is redelijk uniek, maar er worden normaalgesproken ook marktconsultaties gedaan. Maar om die zo publiek uit te zenden is redelijk uniek, maar voor zover ik weet is dit allemaal gedaan om het zo transparant mogelijk te doen, met de insteek "laten we het zo maar proberen". Ook die appathon was een experiment volgens mij.

Vervolgens is er voor gekozen om het in-house te ontwikkelen en niet bij een private partij. In de documenten kan je lezen dat het ministerie niet tevreden was met de resultaten van de appathon. Waarom is die keuze om het in-house te ontwikkelen gemaakt?

Dat weet ik niet zeker. Zover ik heb begrepen was de kwaliteit van de inzendingen dusdanig ver van het vereiste niveau dat het niet logisch was om met die partijen verder te gaan. Het aspect van snelheid was ook belangrijk. De logische stap na een marktconsultatie is normaal een aanbesteding en dat is een langlopend proces. Ik heb dus ook het idee dat de perceptie bij het ministerie dus ook was dat ze het sneller konden doen als ze het in-huis ontwikkelen, maar dat is mijn waarneming achteraf.

Er wordt dus een bouwteam ingericht. Hoe zag dit er uit? Waren dit vooral ambtenaren, mensen van buiten? 50/50?

Op 4 mei was de eerste interne meeting van het bouwteam. Wat er toen zat was DICTU (Dienst ICT Uitvoering), uitvoeringsorganisatie ICT van de belastingdienst, NOVUM (innovatielab Sociale Verzekerings Bank). Op 6 mei zaten de eerste 9 externe experts, ik ook dus, er voor het eerst bij. Toen waren we met ongeveer 40 man in totaal, vanuit alle disciplines inclusief juridisch en beleid tot bouwers en ontwerpers. In de beginfase was de verhouding voornamelijk ambtenarij en overheid intern, gedurende het proces kantelde dit naar meer extern. Alle externe experts zaten daar op persoonlijke titel, dus niet namens een bedrijf.

Is er ooit een centraal model overwogen?

Nee, nee dat is het niet geweest. Tijdens de appathon zijn er inschrijvers geweest die een meer centraal model hadden, maar daar is toen vanuit de privacy en security community, en ook vanuit CodeFor.nl en mensen die meekeken vanuit de overheid zwaar afgefakkeld. Vanuit Waag en BitsOfFreedom is toen ook dat manifest "veilig tegen corona" opgesteld en na de appathon is door VWS ook gezegd dat de tien punten van "veilig tegen corona" volledig overgenomen zouden worden.

Ik kan ook voor al die 9 externen die toen zijn aangehaakt zeggen dat we anders niet meegeholpen hadden in het bouwteam. We hebben op 5 mei samen gezeten met 8 van de 9 experts samen gezeten en toen afgesproken dat we alleen zouden meehelpen als de app binnen de kaders van "veilig tegen corona" ontwikkeld zou worden.

Vanaf het moment dat besloten was dat het ministerie van VWS het zelf zou gaan ontwikkelen was het al duidelijk dat deze punten meegenomen zouden worden, en daarin was geen ruimte voor een centrale architectuur. Arjen Lubach had in het weekend voor de appathon, of twee weken daarvoor, ook een item gemaakt over de corona-app. Als je ziet wat daar allemaal aan ethische twijfels wordt opgevoerd dan weet ik dat dit het manifest aardig gevoerd heeft en ook de publieke opinie, dus ook VWS.

Oh, ik wist niet dat het manifest zo veel invloed had gehad, ik dacht dat het meeste sowieso al verplicht was vanuit de AVG

Het is het manifest [dat invloed had], maar de CIO van het ministerie van VWS zit ook vrij sterk op de strenge interpretatie van de AVG, zeker in het medische domein, dus "sla niet meer op dan je absoluut nodig hebt" en "we gaan geen centrale registers opzetten" etc.

We kiezen dus voor een decentrale app gebaseerd op de referentiearchitectuur van DP3T. Hoe zag de samenwerking met DP3T er uit?

Een deel van de eerste groep externen was ook betrokken bij het feedback geven DP3T en PEPP-PT inzake issues zoals het op de achtergrond draaien van dit soort technologie op Android en überhaupt de slechte toegang tot Bluetooth op iOS. Het was al vrij snel duidelijk dat zonder Apple of Google je een soort van gemankeerde oplossing zou hebben in die fase.

Nu was het ten tijden van de appathon nog niet duidelijk of Google en Apple iets zouden doen. De toegang tot het framework was er nog niet toen we begonnen met bouwen, maar de contacten lagen er al wel.

Hoe was het contact met Google en Apple?

Het contact was tweezijdig, met de Nederlandse vertegenwoordiging van Apple en Google. Het was al vrij snel duidelijk dat de technologie alleen maar beschikbaar zou worden gesteld aan een overheid per land. Er was rechtstreeks contact met de techneuten daar en de vertegenwoordigers.

Zijn er nog andere grote afwijkingen?

Nee, volgens mij niet. We hebben bewust voor het aller-minimaalste gegaan en daar vrij streng in geweest. We hadden bijvoorbeeld via locatiegegevens naar de postcode kunnen vragen maar dat hebben we bewust niet gedaan om alle schijn weg te nemen. Al blijft dat in de publieke perceptie lastig: “Hoe weet je anders dat twee mensen dicht bij elkaar zijn?”. Het is ingewikkeld.

Als ik kijk naar het proces, en zeker naar het begin, dan zie ik daar duidelijk het Nederlandse poldermodel in. Veel stakeholders betrokken vanaf het begin, ook bij de appathon. Denk je dat dit een terecht constatering is?

Ja, al vind ik het niet typisch poldermodel. In mijn hoofd is poldermodel: we maken wat, we bedenken wat, we gooien het over de schutting en gaan er dan eindeloos over overleggen. Als dit poldermodel is, dan is het wel een extreem efficiënte variant er van is, maar het hele idee van “iedereen doet mee en we slaan niemand over”, dat zit er wel sterk in.

Ik denk eerlijk gezegd dat daardoor het hele eisenkader vrij snel behoorlijk duidelijk was, en dat heeft wel geholpen. Al kan je nooit iedereen alles geven. De lat ligt door het uitgebreide eisenkader wel vrij hoog.

Het lijkt apart te zijn dat het in-huis ontwikkeld is, en dat een app van een vergelijkbare schaal in een andere situatie niet door de overheid ontwikkeld zou zijn. Ben je het hier mee eens?

Wat vooral uniek is, ik bedoel de overheid doet vrij veel eigen ontwikkeling, Logius ook, maar dit wordt doorgaans door uitvoeringsinstanties gedaan en niet door de ministeries. De ministeries maken vooral beleid, geen gereedschap dus dat was redelijk uniek. Dat de overheid zelf aan softwareontwikkeling doet is niet heel erg bijzonder, hoewel het wel vaak ingekocht wordt. Ik weet niet of dat inkopen ook altijd zo’n goed idee is.

Er zijn, behalve een technische finetuning van het algoritme, geen grote veranderingen meer geweest aan de app, toch?

Dat is inderdaad de grootste verandering onder de motorkap. Er zijn nog wel wat kleine functionaliteiten toegevoegd zoals pauzeren en het aansluiten op de Europese gateway. Verder geen grote doorontwikkelingen.