DEPARTMENT OF INFORMATICS

TECHNISCHE UNIVERSITÄT MÜNCHEN

Bachelor's Thesis in Information Systems

Identification of Design Principles for Platform Engineering in the Public Sector

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Identifikation von Design Prinzipien für Platform Engineering im Öffentlichen Sektor

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I confirm that this bachelor's thesis in information systems is my own work and I have documented all sources and material used.

Munich, 15. September 2022 Vasilisa Poliarus

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Abstract

Government as a Platform (GaaP) is a promising concept that implies an open platform aiming to increase public value through collaboration of citizens and government. GaaP enables authorities to provide efficient and user-friendly public services for lower costs. However, the implementation of this concept is challenging and has not been thoroughly investigated. The literature does not provide a particular approach to designing a platform in the public sector. To fill this gap and supply governments with good practices, this thesis pursues the goal of developing general design patterns for platform engineering based on the practical experience of successful GaaP countries. After a literature review and examination of national reports and institutional websites, we focus on the analysis of interviews with Estonia, the UK, and Italy that have achieved significant progress in the implementation of the platform model. From these interviews, we identify design decisions made by the countries during platform engineering and, by filtering, sorting, and generalizing them, derive the underlying design patterns. We discuss the patterns regarding their suitability to serve as general GaaP principles that can guide the application of the platform approach in other countries. We conclude the thesis with a discussion of the limitations and implications of the results.

Kurzfassung

Government as a Platform (GaaP) ist ein vielversprechendes Konzept, das eine offene Plattform anstrebt, die darauf abzielt, durch die Zusammenarbeit von Bürgern und Behörden den öffentlichen Nutzen zu steigern. GaaP ermöglicht es den Behörden, effiziente und benutzerfreundliche öffentliche Dienstleistungen zu geringeren Kosten anzubieten. Die Umsetzung dieses Konzepts ist jedoch eine Herausforderung und wurde noch nicht gründlich untersucht. In der Literatur findet sich kein bestimmter Ansatz für die Gestaltung von Plattformen im öffentlichen Sektor. Um diese Lücke zu schließen und den Regierungen bewährte Verfahren an die Hand zu geben, verfolgt diese Arbeit das Ziel, auf der Grundlage der praktischen Erfahrungen erfolgreicher GaaP-Länder allgemeine Design-Muster für das Plattform-Engineering zu entwickeln. Nach einer Literaturrecherche und der Untersuchung nationaler Berichte und institutioneller Websites konzentrieren wir uns auf die Analyse von Interviews mit Estland, dem Vereinigten Königreich und Italien, die bei der Umsetzung des Plattformmodells erhebliche Fortschritte erzielt haben. Anhand dieser Interviews identifizieren wir die von den Ländern bei der Entwicklung von Plattformen getroffenen Design-Entscheidungen und leiten durch Filtern, Sortieren und Verallgemeinern die entsprechenden Design-Muster ab. Wir gehen davon aus, dass die aufgedeckten Muster als vorläufiger Leitfaden für die Anwendung des GaaP-Modells in anderen Ländern dienen können. Wir schließen die Arbeit mit einer Diskussion über die Grenzen und Implikationen der Ergebnisse ab.

Contents

1. Introduction

The role of digital platforms has thrived dramatically over the last decades and brought a lot of success into different fields of the private sector. Being defined as a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components [1], platforms are drastically altering business, the economy, and society in general [2]. Nowadays, many countries recognize the need for redesigning their public agencies using intelligence information technology and adopting a platform model within the government. In the public sector, platform engineering is discussed under the term "Government as a Platform" (or "GaaP"), which was coined by Tim O'Reilly in 2011 [3]. The concept of GaaP implies an open platform aiming to increase public value through collaboration of citizens and government [3]. This platform model enables the government to provide efficient and user-friendly public services for lower costs.

However, platform engineering in the public sector can be challenging [4], and in addition, there are no guidelines for it. Many authors research characteristics (Millard [5], Cordella & Paletti [6], Brown et al. [7]), principles (O'Reilly [3]), and components (Gawer [8], Bygstad & Hanseth [9], Baldwin & Woodard [1]) of GaaP, but there is no literature with a particular approach to how to design a platform in the public sector. Although Bygstad & Hanseth [9] develop a framework for platformization, i.e., the process of transforming a traditional IT silo structure into a platform-oriented digital infrastructure, this is only one of the steps towards implementation of the GaaP concept, and specific tools and methods applicable in practice are still lacking.

Over the last few years, some countries have managed to successfully adopt the GaaP concept. Estonia, the UK, and Italy are among those who achieved the most progress in platform engineering in the public sector [6, 7, 10, 11]. This thesis aims to identify design decisions of successful GaaP countries and use them as a basis for the development of design patterns for other countries. Consequently, the following research questions should be answered:

RQ1: What are the dimensions of design decisions in applying GaaP in practice?

RQ2: What are design decisions of countries that successfully apply GaaP?

RQ3: Which design patterns can be derived from these decisions?

To address these questions, we intend to analyze interviews with experts from countries which successfully have implemented GaaP (Estonia, Italy, the UK). We will develop a coding concept and apply it to the interviews in order to create a structured list of design decisions. Finally, we will refine the list of design decisions and transform them into general design patterns which can be applied for platform engineering in the public sector.

The thesis is structured as follows:

- **Chapter 2** provides theoretical background on relevant for this thesis concepts. It starts with distinguishing between three artifacts: design decisions, design patterns, and design principles, and proceeds with research on digital platform ecosystems and Government as a Platform.
- **Chapter 3** explains methodology of conducted research, describing how the data was collected and analyzed.
- **Chapter 4** presents dimensions of design decisions and developed coding schema for further data analysis.
- **Chapter 5** demonstrates identified design decisions and introduces an exemplary decision with a detailed description.
- **Chapter 6** provides description of derived design patterns as a final desired artifact.
- **Chapter 7** discusses possibility of converting derived design patterns into design principles and introduces limitations of the research.
- **Chapter 8** concludes the thesis with a summary of the main findings and suggestions for future work.

2. Theoretical Background

2.1. Design Decisions, Design Patterns, Design Principles

2.1.1. Design Decisions

Design decisions constitute the first artifact of this thesis. Hence, understanding of their concept and the structure of the decision-making process, which will be introduced in the following, is critical for further reading. Activities related to decision-making in the design process are complex, and the decisions taken have a crucial impact on the design solution and the design process [12]. In their paper, Zannier & Maurer [13] examine software design decisions in the context of software development and define them as "a selection of an option among zero or more known and unknown options concerning the Implementation, Structure, Interaction, and Usability of a software application". Hansen & Andreasen [12] provide more general description of design decision-making and consider it as selecting a design option from several alternatives, and answering the question "which design is the best one?".

Potts & Bruns [14] outline a generalized model for illustration design deliberation and describe its structure. Within the context of their paper, design deliberation is equivalent to deciding what artifacts to derive and why, i.e., to making a design decision. Figure 2.1 demonstrates the data model for design deliberation, adopted by Potts & Bruns. A decision on its own consists of three components: issue, alternative, and justification. Artifacts supplement the model of design deliberation and represent design documents which raise **issues**, i.e., problems to be solved, about the developing design. **Alternative** constitutes one of several options to address the issue and deduce the need to generate a new artifact, alter an existing one, or assert that no design changes are required. Lastly, **justification** clarifies the reasons for the choice or rejection of the corresponding alternative. The Table 2.1 summarizes design decision components.

Decision component	**Description**
Issue	Problem to be solved
Alternative	One of several options to address the issue
Justification	Reason for the choice or rejection of the corresponding alternative

Table 2.1.: Design decision components

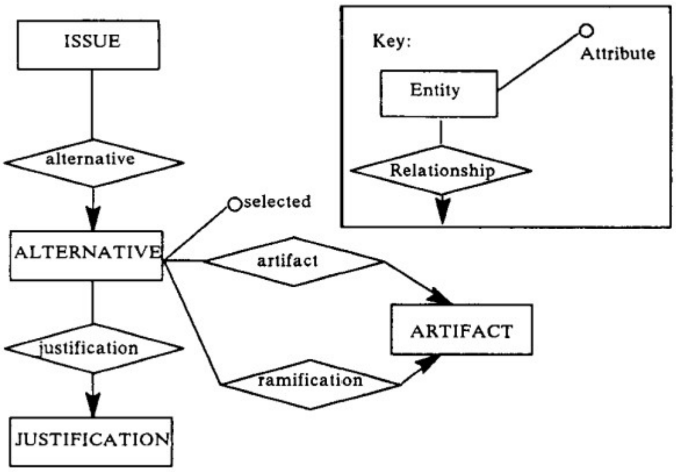


Figure 2.1.: Data model for design deliberation [14]

2.1.2. Design Patterns

The notion of design patterns was first introduced by an architect Alexander Christopher in his book "A Pattern Language: Towns, Buildings, Construction" [15], where he outlined more than a hundred architectural patterns for creating a building or town. Later, this concept was adopted for such fields as software engineering by Gamma et al. [16], software architectures by Buschmann et al. [17], and project management by DeMarco et al. [18] [19].

According to Taibi & Chek Ling Ngo [20], design patterns represent abstractions that arise from useful experiences of developers in solving problems recurring in a certain context. Patterns present operational knowledge gained from practice, i.e., they are neither invented nor developed, but observed [19]. Design patterns facilitate and accelerate the reuse of successful designs and architectures and make the proven techniques more accessible to developers of new systems [16]. The format of the pattern may vary depending on the research field. In this thesis, we use the schema proposed by Buschmann et al. [17], since they consider patterns in a software architecture context, which is mostly related to platform engineering. According to the authors, every pattern is constructed of three essential closely coupled components, described in the Table 2.2.

Pattern component	**Description**
Context	Situation giving rise to a problem
Problem	Problem arising repeatedly in that context
Solution	Proven resolution of the problem

Table 2.2.: Design pattern components

2.1.3. Design Principles

As stated by Markus et al. [21], patterns that can be regarded as coherent and self-contained design units, describing a solution to a specific problem, can be considered as elementary design principles [19]. Design principles are established to codify and formalize design knowledge in an accessible form and enable communication of innovative practices to promote design science and resolve future design issues [22, 23]. Due to the broad and interdisciplinary nature of design science, there are numerous definitions and compositions of design principles that vary by discipline and degree of specificity [22].

Gregor et al. [23] describe design principles as prescriptive statements that generate "know-how" knowledge and explain the procedure for achieving a goal. The definition of Papadimitriou et al. [24] is more specific: "Design principles refer to agreed structural and behavioral rules on how a designer/an architect can best structure the various architectural components and describe the fundamental and time invariant laws underlying an engineered artefact <...>". Fu et al. [22] conducted a literature review of principles' representations and characteristics and put forward the following definition: principle is "a fundamental rule or law, derived inductively from extensive experience and/or empirical evidence, which provides design process guidance to increase the chance of reaching a successful solution".

In their article "The Anatomy of a Design Principle", Gregor et al. [23] present design principle structure based on four components: aim, context, mechanism, rationale, and on clarifying the role of all involved actors.

However, for this thesis, the standard way of defining the principles proposed by The Open Group Architecture Framework (TOGAF) [25] is more relevant. According to its template, each design principle should have four components, introduced in the Table 2.3.

Principle component	**Purpose**
Name	Clearly transmits the essence of the principle
Statement	Briefly and unambiguously communicates the basic rule
Rationale	Emphasizes the benefits of applying the principle
Implications	Describe requirements and consequences of adopting a principle

Table 2.3.: Design principle components

2.2. Digital Platform Ecosystems

2.2.1. Platform's Definition and Classification

The role of digital platforms has thrived dramatically over the last decades. In particular, platforms have gained a lot of attention in the private sector [26, 27]. Four of the world's biggest by market capitalization companies in 2022 - Amazon, Apple, Google, Microsoft - apply platform business model [2, 28]. In their book "Platform revolution", Parker et al. [2] emphasize that the concept of platform is drastically altering business, the economy, and society in general.

The history of platforms was initiated by the emerging of computing and put in more active use in the 1990s, when software developers started conceptualizing their offering rather as flexible platforms than as just narrow programs [29]. Nowadays, the term *platform* is applied in diverse academic fields, and its definition might vary slightly depending on the area of use. Baldwin & Woodard [1] describe platform as "a set of stable components that supports variety and evolvability in a system by constraining the linkages among the other components". The definition of Robertson & Ulrich [30, 1] is more broad: platform is "the collection of assets that are shared by a set of products", where assets may comprise components, processes, knowledge, and people. Parker et al. [2] see a platform as a business based on enabling the creation of value between external producers and consumers.

In the academic literature, there are a few different approaches to studying platforms. Gawer [8] provides two frameworks for that. The first framework divides platforms into **economical** and **engineering** perspectives. Economists consider platforms to be special kinds of markets that facilitate exchanges between different types of consumers who would otherwise not be able to transact with each other. *Network effects* constitute the basic mechanism of platform value creation in this perspective [31]: the more users join the platform, the more valuable the platform becomes for other agents [32]. These effects can further be divided into two categories: **direct network effects** (an increase in usage directly results in adding value to other users) and **indirect** or **cross-side network effects** (an increase in the use of one product or network gives rise to an increase in the value of the complementary product or network, which in turn can increase the value of the original) [27]. In contrast, from an engineering design perspective, product platforms are viewed as technological designs that help companies develop modular product innovations. One of the fundamental principles of platforms in this perspective is the systematic creation of economies of scope in innovation through the regular reuse of components for different products within a product family [8].

The second framework created by Gawer & Cusumano [32] classifies platforms into **internal** and **external** ones. Internal or company-specific platforms are a set of assets organized in a common structure from which a company can efficiently develop and produce derivative product streams. The main potential benefits of this type of platform are fixed cost savings and efficiency improved through reuse of common product parts. External or industry platforms are viewed as products, technologies, or services that serve as a basis on which a group of companies can develop complementary products, technologies, or services.

A slightly different framework for study platforms was provided by Baldwin & Woodard [1]. They describe three waves of research, accordingly concentrated on products, technological systems, and transactions. **Product platforms** create a new generation or family of products for a specific company, **technological platforms** are considered as valuable points of control in an industry, and **industrial platforms** mediate transactions between two or more groups of actors.

Since digital platforms, up to 2019, were mainly analyzed from single paradigms described above, Hein et al. [33] proposed a new paradigm by integrating the intra-organizational technical perspectives on digital platforms and the inter-organizational economic, business, and social perspectives on ecosystems. An ecosystem is defined by Jacobides et al. [34] as "a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled". In the new paradigm of Hein et al., it is critical that digital platforms enable and orchestrate this ecosystem of autonomous agents that contribute to the digital platform's value proposition [35]. Integrated these concepts, the following definition was derived: "**digital platform ecosystem** comprises a platform owner that implements governance mechanisms to facilitate value-creating mechanisms on a digital platform between the platform owner and an ecosystem of autonomous complementors and consumers" [33].

2.2.2. Platform's Infrastructure

Baldwin & Woodard [1] argue that, despite the versatility of the term *platform*, all of their representations have common roots in engineering design. The authors claim that the basic architecture behind all platforms is essentially the same and constitutes a modularization which partitiones the system into a set of **"core" components** with low diversity and high reusability and a set of complementary **"peripheral" components** with high diversity and low reusability. The third type of components includes **interfaces**, which reflect design rules enabling the core and the peripheral components to operate as one system. Both the core components and the interfaces are stable and long-lived elements of the system and hence form "the platform", while the peripheral components alter over time and can be considered as the complements of the platform.

In their paper, Bygstad & Hanseth [9], exploring how platform thinking can improve the understanding and management of large digital infrastructures, derive the model of *platform-oriented infrastructure*, which is not a clean-cut platform architecture, but rather a hybrid form. Bygstad & Hanseth describe platform-oriented infrastructure, using the architectural principle of Baldwin & Woodard [1] and splitting the platform ecosystem into a stable **core** and a dynamic **periphery of user services**. Beyond that, they add such an element as **boundary resources** to the platform ecosystem. Ghazavneh & Henfridsson [36] emphasize the significance of using platform boundary resources, since they allow various user services to exchange data with the core. Boundary resources are defined as tools and regulations that serve as an interface between the IT silo systems and the user services. There are two drivers of boundary resources design: resourcing and securing. Resourcing is the process of expanding the scope and diversity of a platform, while securing denotes the process of strengthening control over a platform. [9]

Considering the platform architecture proposed by Baldwin & Woodard [1], Kuhn et al. [4] adopted the platform-oriented infrastructure model of Bygstad & Hanseth [9] and created the following scheme:

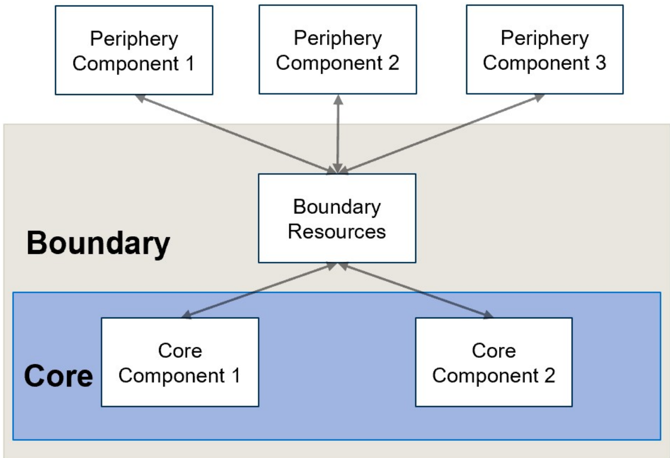


Figure 2.2.: Platform-oriented infrastructure (own depiction based on [4])

The benefits of such platform-oriented infrastructure include economies of scale, economies of scope, and economies of substitution, resulting from reusing modular components instead of building the system from scratch [33, 37]. The profit also comes from reutilization of the existing base of knowledge, as well as savings in testing and production costs [38]. Furthermore, platform-oriented infrastructure offers secure and sophisticated services built on standards and enables system flexibility and faster innovation [9].

2.2.3. Platformization - a Transformation Process

Large organizations currently typically run a multitude of applications, each integrated with a number of other applications within the same organization and, intensifying, with external ones. This increases the complexity of the system and causes the IT silo problem. The IT silo problem is characterized by many poorly integrated systems, with little flexibility for change, and slow innovation. Organizations can address this issue through platformization. Törmer & Henningsson [39] describe platformization as "the socio-technical process of transforming a large-scale Information Systems towards a platform architecture". This architecture is based on a core of stable functionality, a periphery of highly variable components, and interactions between components via standardized interfaces [40]. In their paper, Bygstad & Hanseth [9] develop the framework for such a transformation process (Figure 2.3). The steps of platformization are characterized as follows:

1. Break up silo structure and establish boundary resources as connection between user services and the core;
2. Stabilize core elements (data and basic functionality);
3. Redesign user services in the periphery of the core.

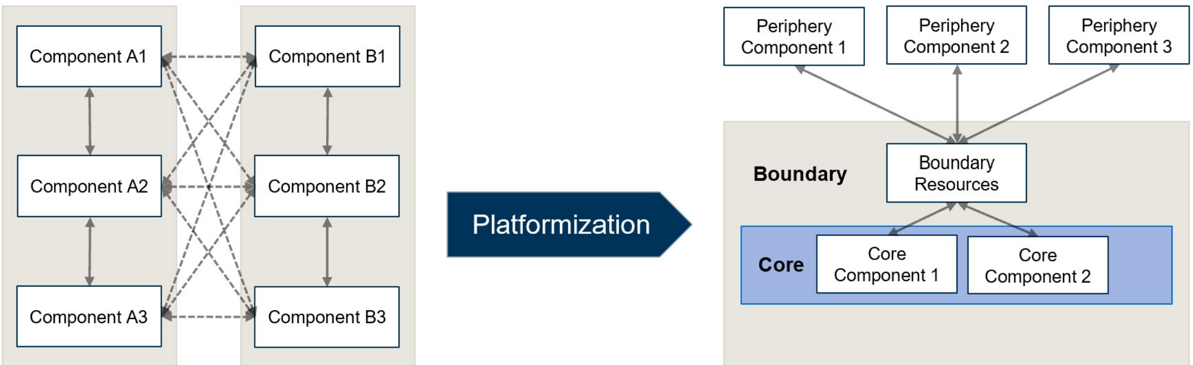


Figure 2.3.: Platformization process (own depiction based on [4])

2.3. Government as a Platform

2.3.1. Definition and Principles of Government as a Platform

Over the last few years, such trends as financial issues, widespread low trust in government, limits of representative democracy, and rapid growth of civil society have accelerated the transformation of governments. Induced by these trends and inspired by the enormous success which the platform model has brought to companies in the private sector [28], many countries recognized the need for redesigning their public agencies using intelligence information technology and adopting a platform model within the government [26]. In the public sector, platform engineering is discussed under the term "Government as a Platform" (or "GaaP"), which was coined by Tim O'Reilly in 2011 [4, 3]. The concept of GaaP implies an open platform aiming to increase public value through collaboration of citizens and government [3].

In his book, O'Reilly [3] suggests considering the government as a bazaar instead of using the vending machine analogy, described by Donald Kettle [41]. In a vending machine government, citizens "insert the coin in the slot and wait for the product to arrive" [41]: they pay taxes and expect services. In case of not obtaining a desired result, all their collective action comes to collective complaint - shaking the vending machine. The entire menu of available services is determined in advance in such a model. Only a few providers have an opportunity to add their services to the vending machine, so the choices are limited, and the prices are high. On the contrary, a bazaar implies active participation of all parts, since it is a place where the community itself exchanges goods and services. In this situation, the government acts as a manager of a marketplace.

Literature does not provide a uniform definition of GaaP [26, 4]. This concept can be considered, among others, as a way to provide better public services, a means to break down a silo structure, and an open platform to build upon [42]. Even though scholars describe GaaP in different ways, they all mention active participation of citizens and the private sector and facilitation of public value creation as an integral part of this concept [26]. The main characteristics of GaaP include modularity, co-creation, and openness. According to Cordella & Paletti [6], modularity of the platform organization, i.e., the independence of each platform component from the rest of the subsystem, allows the government to combine its elements into an infinite number of configurations. Hence, it offers citizens more opportunities to personalize the consumption of public services and meet their specific needs. Co-creation implies the participation, engagement, and empowering of citizens and other legitimate actors in policy development and service creation [5]. This active participation leads to a better response to the needs of society and thus increases support for and trust in government [43, 7]. Platform openness plays the key role in enabling large numbers of different agents to use the platform and contribute to its development [44]. Millard [5] describes the concept of open government in detail, arguing that it makes the public sector much more efficient and effective through harnessing and coordinating unrealized assets and resources. In their papers, many researchers also refer to the principles introduced by O'Reilly [3] and note their importance for implementation of GaaP. O'Reilly bases his theory on seven lessons learned from successful private platforms: *open standards*, *simplicity*, *design for participation*, *learning from your "hackers"*, *data mining*, *lowering barriers for experimentation*, and *leading by example*. According to the author, in order to build a working GaaP environment, it is crucial to lower barriers for entrepreneurs to enter a market, design a simple participatory system with minimal services and clear rules for actors' collaboration, and gather creative ideas not only from the platform's inventors but also from its hackers. In addition, the government should use open data to allow innovative private sector participants to improve their products and services, teach employees the importance of failed experiments, and start all processes by showing what can be done.

Although these principles are essential for the adoption of the GaaP model, communicating them to public sector IT infrastructure stakeholders is challenging [4], and it is overall unclear what makes the infrastructure ready for GaaP [45]. As a potential solution to this problem, Kuhn et al. [45] present a tool for public sector infrastructure analysis that supports the application of GaaP in practice and bases on four dimensions: **platform elements**, **platform roles**, **platform openness**, and **platform management**. However, these are not the only GaaP dimensions in the literature. For instance, Brown et al. [7] consider the GaaP model as **technical architecture**, **market dynamic**, and **organizational form**, whereas Seo & Meyong [26] mark the following dimensions for GaaP building: **infrastructure**, **structure**, **value**, and **outcomes**.

2.3.2. Government as a Platform and Public Value

One of the main characteristics of a platform is that active participation and collaboration of its agents bring benefits to all of them [27]. Similarly, the GaaP concept is valuable for all participating sites. The benefits associated with GaaP in the literature can be divided into benefits for citizens and benefits for the public sector [4]. Most of the benefits of GaaP for society center on user-friendliness [45, 26, 6]. For instance, the integrating capability of technical platforms simplifies the bundling of services and thus increases the convenience of users by offering interactive public services such as one-stop service [4, 46]. GaaP can also help citizens improve productivity, decision-making, and well-being [26]. Generally, many researchers associate platforms with user-centric approaches [26] and innovations [3], which can lead to more user-friendly services [4]. The value of GaaP for the public sector comes in the form of increased efficiency. Growing number of interactions within a platform leads to a more extensive number of complementary products and services [26, 47] and to expansion of the economies of scope and economies of scale, which enables authorities to reduce the costs [27]. Collaboration of different parties also improves the effectiveness of public agents by encouraging partnership and cooperation across levels of government and between the government and private institutions [5].

In the GaaP model, however, the government acts more as a convener and an enabler than as the initial driver of civil society action [3]. It does not have a monopoly on public value creation, but in most cases, it plays the prime role in ensuring that this value is created [5]. In other words, the role of the government as the sole producer of services has changed to the role of coordinator and facilitator of the co-production of the services. This is because, to produce and deliver public value, it is not enough to satisfy one specific need, but it is also necessary to orchestrate the way in which the configuration of production affects other needs and values over time, and to adapt when these needs change. Without effective orchestration, GaaP risks having a negative impact on the creation of social value. [6]

To sustain GaaP and make it successful, it is necessary to construct an appropriate governance system and mechanisms for public value delivery. In his paper, examining the potential for open governance systems to "do more with more", Millard [5] proposes a conceptual framework for open governance systems, depicted in Figure 2.4.

The idea behind **open assets** is to convert "waste", i.e., unused assets, into "resources" through sharing and use them for the collaborative creation, innovation, and production of new products, services and other assets. **Open services** are driven by such trends as *mass customization* and *design thinking*. Mass customization means that every service, product,

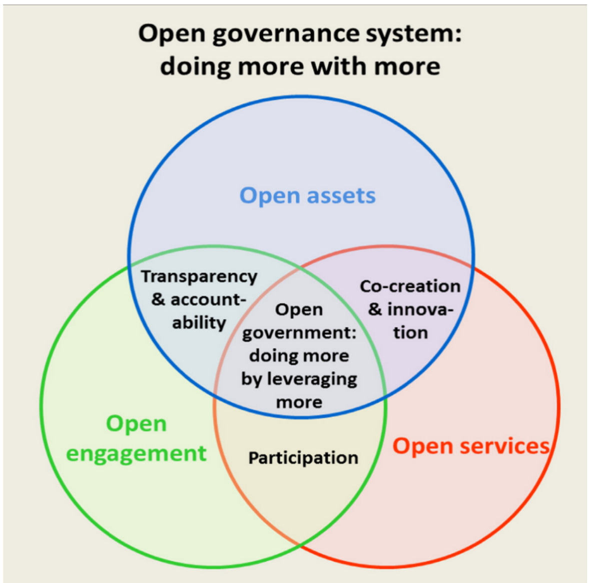


Figure 2.4.: The open governance system [5]

facility, etc., is tailored precisely to a very specific customer need, while design thinking aims to understand the "full architecture of a problem" and improve the quality and impact of e-services. Finally, **open engagement** implies inviting all legitimate actors to participate in government activities as long as this participation is itself open and enhances social value.

Millard [5] also describes the four pillars of GaaP, which further efficient creation of public value:

1. **Facilitate and orchestrate:** ensure that public value is created by the most appropriate means in terms of what works best in a given context and for given needs.
2. **Provide tools:** afford structured guidance within which service co-creation can take place. "Guided" support reduces the burden on citizens of participating in this way, while maximising the return for both public administrations and citizens.
3. **Manage assets:** identify, broker, match, and orchestrate assets that can be shared and transformed into social value impacts, instead of being wasted, if unused.
4. **Ensure public value:** take responsibility for overall quality standards and mechanisms of resource sharing and legal frameworks, even when these are legally delegated to other actors.

3. Methodology

3.1. General Approach

The problem to tackle is the lack of a particular approach to designing a platform in the public sector. Since the main questions behind this concern are "how" and "what", we try to address the problem by conducting multiple case study [48]. First, we carry out literature research on platforms, the GaaP concept, design decisions, and design patterns and generate an appropriate coding schema for analysis of interview data. Next, we carefully examine interviews of countries that successfully implemented the GaaP model and apply the developed coding schema on the data to identify design decisions taken by respondent countries. Afterwards, we refine, generalize, and group these decisions. Finally, we convert the refined decisions into design patterns based on their frequency of occurrence in interviews. In conclusion, we discuss whether the derived design patterns can be extended to other countries for successful platform engineering in the public sector.

3.2. Multiple Case Study Approach

Case study is an empirical investigation that examines a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident [48]. According to Eisenhardt [49], by building theory from case studies, replication logic should be followed, i.e., each case should be a separate experiment and stand independently as a unit of analysis. Eisenhardt [50] also noted that building theory from case studies is "one of the best (if not the best) of the bridges from rich qualitative evidence to mainstream deductive research". We have chosen this research method because its close interaction with actual evidence allows for development of a novel, testable and empirically valid theory [49]. Furthermore, a multiple-case study was preferred to a single-case study, since the propositions of the former are more deeply rooted in diverse empirical evidence and, hence, result in a more accurate, robust, and generalizable theory [50].

In his paper, Yin [48] emphasizes the relevance of developing a research design as a plan for collecting, analyzing, and interpreting observations. The design of our multiple case study is based on five components proposed by Yin:

1. **Study's questions.**

   To address the problem of the thesis, the following questions are posed:

   RQ1: What are the dimensions of design decisions in applying GaaP in practice?

   RQ2: What are design decisions of countries that successfully apply GaaP?

   RQ3: Which design patterns can be derived from these decisions?

2. **Propositions.**

   Government as a Platform is a relatively new model, and there is no literature with a particular design approach for it yet. Therefore, the topic of the thesis is the subject of "exploration", and no propositions regarding the research questions can be derived in the beginning. However, we suppose that the countries that successfully implemented GaaP in practice made mostly similar design decisions, which consequently, can be generalized and applied in other countries.

3. **Unit(s) of analysis.**

   The concept of GaaP can be applied on a national as well as on a regional or municipal level. The national level is more crucial for us though, because it is the national government that manages fundamental IT infrastructure, coordinates citizens' data, and issues regulations and privacy policies. We, hence, have decided to analyze steps undertaken by different countries on a national level to successfully implement the GaaP model.

   Three European countries were selected as cases for the research: Estonia, the United Kingdom, and Italy.

   Estonia was chosen as one of the countries that made the greatest progress in realizing the GaaP vision. Although Estonia is small and sparsely populated compared to other European countries, its model was used as a leading example for bigger countries, such as Germany [51] and Ukraine [52].

   The UK started implementation of the GaaP model much earlier than other countries, and this allowed it to develop a lot of successful digital public services. By 2002, an international e-economy benchmarking report recognized the UK as being in "... the vanguard of developing common IT architectures" [7, 53]. Even though the country encounters many barriers and still has things to improve, it appears in the top ten leading countries in terms of digital Government, according to the UN E-Government Development Index (EGDI) [54].

   Italy has significantly boosted the development of digital governmental platforms over the last few years [6] and it has relatively quickly increased the usage rate of digital public services among citizens. Moreover, Italy disposes of a considerable amount of documentation and information about the adoption of the GaaP concept.

4. **Logic linking the data to the propositions.**

   The current state of the art does not provide detailed guidance on the fourth and the fifth components of research design, but these steps are necessary for understanding of how to proceed after data collection [48]. In our case, we link the data to our assumption through comparison of design decisions of different countries and finding similarities among them.

5. **Criteria for interpreting the findings.**

   As a criterion for estimating the candidacy of the identified design decision to become a design pattern, we use *the rule of two*, which was adapted from *the rule of three* established by Coplien [55]. As claimed by Coplien, the documented pattern must refer to at least three known uses in practice to ensure the re-usability of the offered solution [19, 55]. Since for now, not so many countries have implemented the GaaP model and only three of them are examined in this thesis, we narrow the requirement to "at least two uses". In the context of our research, this means that design decisions made by at least two of three analyzed countries are considered as valid design patterns.

3.3. Case Descriptions

Table 3.1 provides a brief description of the selected cases, including the rationale for the selection presented in the previous subchapter. The countries differ greatly in population size, but they have all made significant progress in government platform engineering. In terms of implemented infrastructure, all three countries have established a solid foundation for the operation of GaaP [6, 7, 10]. In Estonia, the main infrastructures include the interoperability system X-Road, which enables secure data exchange between information systems; e-ID, which is a mandatory national card providing digital access to e-services; and the information portal eesti.ee, which brings together the public e-services of different authorities. The UK GaaP model is found on the GOV.UK Verify, GOV.UK Pay, GOV.UK Notify, and GOV.UK. GOV.UK Verify serves as an alternative to the ID card identity assurance system for citizens' authentication in government digital services; GOV.UK Pay is a tool that allows authorities to accept online payments; GOV.UK Notify is a government messaging platform enabling communication between agencies and users; GOV.UK represents information website for accessing public services. Italy has built a similar infrastructure: it has launched the public identity system SPID, electronic identity card CIE, the payment platform for government services PagoPA, the national register of the resident population ANPR, and the IO App, which provides access to digital public services, similar to eesti.ee and GOV.UK.

3.4. Data Collection

Case studies can combine a variety of data sources, including interviews, archives, surveys, and observations [49]. We start by reading **scientific papers**, using *backward & forward searching*, to become familiar with the key concepts of this thesis and determine lacking information in the literature. In the backward searching, a few core papers are examined on their cited works to study the origins of a concept and identify experts who specialize in a research topic. In the forward searching, works that cite the original papers are analyzed to expand the knowledge on the topic under study and detect new insights and developments in that field. The following papers served as a starting point for the literature review: Baldwin & Woodard [1], Gawer [8], and Bygstad & Hanseth [9] for analyzing the concept of platform;

	Estonia	UK	Italy
Population (million)	1.331	67.22	59.55
Main infrastructures	X-Road, e-ID, eesti.ee	GOV.UK Verify, GOV.UK Pay, GOV.UK, GOV.UK Notify	SPID, CIE, PagoPA, ANPR, IO App
Reason for selection	One of the most successful countries in the implementation of GaaP. Is in the top five leading countries in terms of digital Government.	One of the first implementors of GaaP. Is in the top ten leading countries in terms of digital Government.	Achieved significant progress in GaaP implementation over the last years. Disposes great amount of documentation on adopting the GaaP concept.
Number of interviews	6	5	8

Table 3.1.: Cases summary

O'Reilly [3], Seo & Myeong [26], and Millard [5] for examining Government as a Platform model; Potts & Bruns [14], Buschmann [17], and Gregor [23] for researching design decision, design pattern, and design principle concepts accordingly. After scientific paper analysis, we examine **national reports** and **institutional websites** to dive deeper into each case and investigate the current state of each country in the implementation of GaaP. Finally, the most essential and solid source of data in our research are the **interviews** with the key participants of strategy development in each case study. The interviews were conducted in order to fill literature gaps, obtain more detailed information about governmental strategy, and find out the main steps of successful platform engineering in the public sector. This research method was chosen as the main one, because, compared to other methods, it is more powerful in eliciting narrative data that allows for a more in-depth exploration of people's views [56, 57]. Interviews are also well suited for our study, since they are most appropriate where little is known about the research phenomenon or where detailed insights are needed from individual participants, which is exactly our case [58].

The interview data was collected and kindly provided by students of Polytechnic University of Milan. 19 interviews - 6 with Estonia, 5 with the UK, and 8 with Italy - are semi-structured and have a duration of about 58 minutes each on average. The following topics were discussed during the interviews:

- **Government as a Platform definition and main constitutive elements**: implemented platforms, interoperability standards, cybersecurity, and public-private relationship;

- **Government as a Platform strategy and governance**: historical context, evolution of the main digital projects, and recommended governance for digital transformation;
- **Government as a Platform public values and possible negative aspects**: social inclusion, privacy protection, and challenges that could arise during project definition and implementation. [59]

The table below provides a detailed overview of interview data:

Country	Interview ID	Organization	Role	Duration (min.)
Italy	01-IT	Digital Transformation Team	Technical Project Manager	63
	02-IT	Department of Public Administration	Director General	101
	03-IT	Digital Transformation Ministry	Former Minister	71
	04-IT	AgID	Project manager, Officer	57
	05-IT	Digital Transformation Team	CTO	43
	06-IT	Private	Expert in support of PA digitalization projects	56
	07-IT	Digital Transformation Team, Council of Minister	Government Commissioner, Head of Digital Transition	103
	08-IT	Advisory Group on Advanced Technology	Chairman	120
Estonia	09-EE	E-Governance Academy	Expert for legal aspects	60
	10-EE	Cybernetica	Development Manager, Legal	55
	11-EE	Cyber4Dev	Expert	43
	12-EE	E-Estonia	Digital Adviser	48
	13-EE	E-Governance Academy	Senior Consultant	70
	14-EE	Government	Former Prime Minister	24

UK	15-UK	Cabinet Office	General Director, International Government Service and Digital Envoy	26
	16-UK	Government Digital Service	Product Manager	51
	17-UK	Government Digital Service	Executive Director	27
	18-UK	Government Digital Service	Director at Cabinet Office	48
	19-UK	Public Digital	Partner	44

Table 3.2.: Interview data

3.5. Data Analysis

The analysis of the collected data and its quantitative results are presented in Figure 3.1. To address the first research question, we carried out two-sided literature research. One focus part contained platform and GaaP topics, and another - design decisions. After gathering important information about different components of RQ1, we defined dimensions of design decisions in implementing GaaP in practice, and based on them, developed a coding schema for in-depth interview study. Next, in order to reveal concrete design decisions, we applied the coding concept to 19 interviews with three countries: Estonia, the UK, and Italy. At this step, 219 relevant quotes were noted down and thoroughly investigated. 32 quotes without clear explanation and connection to other quotes were discarded, whereas the other 187 quotes were linked together, clustered under the key idea, and converted to 44 design decisions. Finally, identified design decisions were filtered by the previously described *rule of two*, and the remaining 15 decisions were grouped by the issue they address, generalized, and transformed into design patterns. As a result of the data analysis, we derived 7 design patterns for successful platform engineering in the public sector.

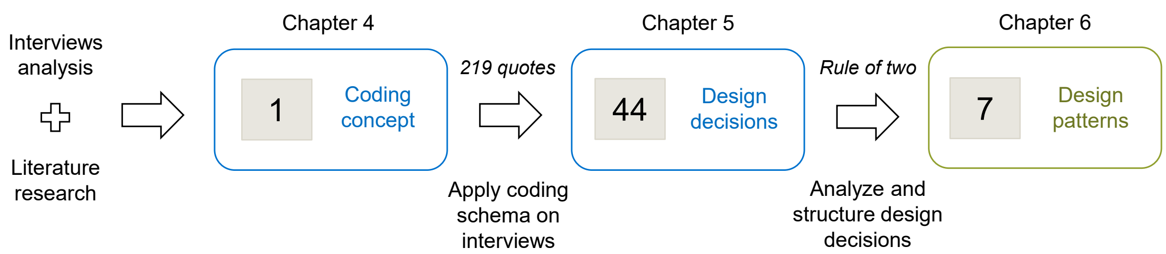


Figure 3.1.: Data analysis schema

4. Dimensions

4.1. Content Dimensions

Comprehensive analysis of the literature on the topics of Government as a Platform and the platform concept itself has shown that the implementation of the GaaP model can be considered from different perspectives. For example, O'Reilly [3] focuses on the basic principles of GaaP, such as openness and participation, Bygstad & Hanseth [9] examine how the platform can be constructed from an architectural perspective, Millard [5] and Cordella & Paletti [6] describe governance mechanisms for guaranteeing the proper functioning of GaaP and enhancing public value. Kuhn et al. [45], Brown et al. [7], and Seo & Meyong [26] do not examine the GaaP model from a single perspective, but directly divide the implementation and analysis of GaaP into several dimensions, mentioned in Chapter 2. Taking into account the results of the literature review, we decided that the dimensions proposed by Kuhn et al. [45] are the most appropriate for the classification of design decisions in applying GaaP in practice, as they embrace all crucial parts of platform engineering on which scientific papers focus the most. Therefore, we introduced four content dimensions, describing design decisions in terms of their scope within the GaaP model: platform architecture, platform roles, platform openness, and platform management. These dimensions form the basis for platform engineering in the public sector.

Platform architecture dimension aims to identify the elements of the infrastructure, the structure of their connection and interaction, and their mapping to the platform parts, i.e., the platform core, the platform boundary resources, and the platform ecosystem. This dimension is relevant, since the platform elements, i.e., software components such as digital identity and interoperability system i.a. constitute the main part of the platform. Bygstad & Hanseth [9] in their paper emphasized that the platformization process starts with the proper architecture. **Platform roles** dimension concerns the organizational aspect of GaaP. It intends to determine stakeholders of the infrastructure and map them to the platform roles. The typical roles in the digital platform ecosystem are platform owner, complementor, and user [33]. Understanding their responsibilities is crucial for proper platform functioning. **Platform openness** dimension is based on the relevance of openness for platform success as it determines how well platforms can leverage their external users' resources to match their internal capabilities [37, 60]. It aims to identify use cases of the infrastructure for its users and complementors, and their correspondence with platform principles, such as openness, participation, and co-creation. These principles serve as a foundation for GaaP, and they were already introduced along upon the first mention of the term "Government as a Platform" in literature [3]. Collaboration of the government with citizens and private companies is even a part of most GaaP definitions [26]. **Platform management** dimension focuses on the establishment of the management activities of the infrastructure owners and on mapping them to platform management categories. This dimension is equally crucial because, without an effective orchestration of the platform, value cannot be created. As a platform owner, the government has an important role of coordinator and facilitator of the co-production of the services [6]. The management dimension is supposed to include design decisions related to four pillars of GaaP proposed by Millard [5]: facilitation and orchestration, provision of tools, management of assets, and ensuring public value.

The table below represents an adjusted version of the table proposed by Kuhn et al. [45] and provides a description of each content dimension, outlining their characteristics and purposes.

Content dimension	**Characteristics**	**Purpose**
Platform architecture	Platform core, boundary resources, ecosystem, components' connection and interaction	Identify the software components of the infrastructure and map them into a platform structure
Platform roles	Platform owner, complementor, user	Identify the stakeholders of the infrastructure and their mapping to platform roles
Platform openness	Openness, participation, co-creation	Identify the infrastructure use cases and their implementation in order to map them to the levels of openness, participation, co-creation
Platform management	Facilitation and orchestration, provision of tools, management of assets, ensuring public value	Identify the management activities of the infrastructure owners and map them to platform management categories

Table 4.1.: Content dimensions of design decisions [45]

4.2. Structural Dimensions

Another part of the literature research was focused on design decisions as one of the desired artifacts of this thesis. Literature analysis revealed that design decisions on their own can also be considered from different perspectives, namely from the perspectives of their structural components. In scientific papers, a design decision never stands alone as a single taken action [61], it always comes together at least with the problem that caused this action and the explanation of why exactly this action was taken [14, 62]. The cursory reading of the interviews confirmed our findings: the interviewees tell about making decisions from different perspectives. They do not only mention a particular solution but also talk about the issue which this solution is supposed to solve and the reason behind the choice of the solution. Taking this into account, we decided that using only content dimensions for the classification of design decisions is not enough, the structural dimensions should also be considered for comprehensive coding.

In literature, design decision components appear under different names and not all are always present explicitly [63]. Besides the common elements such as concern, solution, and rationale [64], some decisions also include requirements, consequences, artifacts, and stakeholders [61]. For this thesis, we adapted the decision structure proposed by Potts & Bruns [14] and put its three components - issue, alternative, and justification - as the basis of structural dimensions of identified design decisions. Table 4.2 represents these structural dimensions. **Issue**, also referred to as *Problem*, *Motivation*, or *Decision topic*, expresses the agents' problem to be solved and the origins that motivated the respective decision [61]. Explaining first the issue that is being resolved provides others with the context of design options and enables them to better comprehend the strategy. According to Falessi et al. [62], understanding the concern is the first step in the software architectural design process, and it focuses on extracting the most critical needs from the big, ambiguous problem description. **Alternative**, also described as *Solution* in the pattern model, constitutes one of several options to address the issue. It is a choice available for a given decision [62]. This component is the core of decision-making, and it directly relates to the process of stakeholders' needs fulfillment. **Justification**, often referred to as *Rationale* or *Argument*, clarifies the reasons for the choice or rejection of the corresponding alternative. This component is crucial because well-structured design justifications can help designers track the explored issues and alternatives as well as their evaluations [63].

Structural dimension	**Description**	**Purpose**
Issue	Problem to be solved; motivation for the decision	Provides context of design options; enables better understanding of strategy
Alternative	One of several options to address the issue	Directly relates to the process of stakeholders' needs fulfillment
Justification	Reason for the choice or rejection of the corresponding alternative	Helps to track the explored issues and alternatives as well as their evaluations

Table 4.2.: Structural dimensions of design decisions

4.3. Coding Concept

To develop a comprehensive coding schema for the detailed interview analysis, we join the content dimensions with the structural dimensions and construct a two-facets matrix, shown in Table 4.3, where the x-axis represents structural components, and the y-axis depicts the content aspect of identified design decisions. This results in 12 questions which are supposed to be answered by the interviews. To that end, the interviews are systematically analyzed. The coding of the interview data with this matrix is carried out as follows. First, the structural affiliation of the component is identified. After dividing design decisions into issues, alternatives, and justifications, we go through the *alternative*-column and answer the question in each cell, i.e., define architectural, organizational, openness, and management alternatives. Architectural alternatives implement platform components and construct connections between them. Organizational alternatives determine the platform roles and responsibilities of platform stakeholders. Openness alternatives realize the core platform principles, such as openness, participation, and co-creation. Management alternatives depict the management activities of platform owners. If the component is an alternative, it can directly be mapped to one of the content dimensions according to its characteristics and purpose, which is not the case for issues and justifications. An issue is often solved by alternatives from different content dimensions and cannot always be mapped to only one of them, whereas justification on its own cannot be assigned to any content dimension because it is tightly connected to the alternative it justifies. Therefore, issues and justifications are mapped to a content dimension indirectly, depending on the content dimension of an alternative they are related to. After assigning all alternatives to the content dimensions, we find corresponding justifications for them, addressing the questions of the *justification*-column. Finally, we focus on the *issue*-column, and for each issue identify by which alternatives it is solved. Since exactly an alternative transmits the main idea of a design decision, it determines affiliation with the content dimension of the whole design decision.

	Issue	**Alternative**	**Justification**
Platform architecture	Which issues are solved by architectural alternatives?	What are the architectural alternatives?	What are the justifications for those architectural alternatives?
Platform roles	Which issues are solved by organizational alternatives?	What are the organizational alternatives?	What are the justifications for those organizational alternatives?
Platform openness	Which issues are solved by openness alternatives?	What are the openness alternatives?	What are the justifications for those openness alternatives?
Platform management	Which issues are solved by management alternatives?	What are the management alternatives?	What are the justifications for those management alternatives?

Table 4.3.: Coding matrix

In the following, we summarize the steps of applying the coding schema to interview data and add some details to the coding process:

1. **Assignment of identified components to structural dimensions**.
   The interview transcripts are analyzed; components of the made design decisions are identified and assigned to the structural dimensions: *issue* (red), *alternative* (green), *justification* (blue), with the corresponding color marking in the text.

2. **Description of components**.
   All identified components are put into an Excel spreadsheet. Each component is placed in a separate row and given attributes such as *component ID*, *interview*, *structural dimension*, *name*, *description*, *quote*, *content dimension*.

3. **Assignment of identified alternatives to content dimensions**.
   The components identified as alternatives are directly assigned to the content dimensions according to their characteristics and purpose.

4. **Construction of design decisions**.
   Correlations between the components of design decisions are found; alternatives are matched to issues, and justifications are matched to alternatives. Identified issues and justifications are indirectly assigned to content dimensions, depending on the alternatives they refer to. Mapped components represent complete design decisions. Similar design decisions are identified and merged into one general decision.

5. **Assignment of structured design decisions to content dimensions**.
   Based on the content dimension of the corresponding alternative, the structured design decisions are classified into the content dimensions.

Applying the coding schema to the interview data results in a list of complete design decisions classified by content dimensions.

5. Design Decisions

5.1. Issues as Triggers for Design Decisions

Design decisions are always taken in the case of an arisen issue, i.e., issues act as triggers for them. Therefore, it is important to first introduce all identified issues to understand the context in which the detected decisions were caused.

Our analysis of the interviews revealed a total of 19 issues, which the respondent countries encountered before, during, or after the implementation of the GaaP model. 2 issues were faced by all three countries, 10 issues affected two of three countries, and 7 issues were mentioned by one of the countries. Considering the content aspect of the issues, most of them relate to the platform architecture. For instance, *Necessary components*, *Interoperability of systems*, *Data security*, and *Inefficient procurement mechanism* deal with secure and efficient construction of the system and connection of its components. Issues that can be solved by both management activities and applying basic platform principles include *Low usage of public services* and *Resistance in using digital identity*. In addition, platform management involves addressing the *Lack of communication of services to citizens* and establishing *Connectivity among countries*. Finally, only two issues concern the roles and duties of platform stakeholders: *Lack of clear responsibility* and *Low usage of public services*. Table 5.1 summarizes the identified issues and provides information about the countries where they occurred and a range of alternatives proposed for their resolution. The issues that were most frequently discussed and mentioned by all three countries are *Necessary components* and *Low usage of public services*. The former involves considering which technical components should be included in GaaP, which are the most important platform elements that form the basis of GaaP, and why exactly they should be implemented first. The latter one investigates how to engage members of different parties to use digital public services more actively. In the following, we consider this issue in detail as an example.

Low usage of public services was mentioned as an essential problem in 12 interviews by all three respondent countries (05-IT: "A problem is how to make members of the different sides join from the point of view of the public sector and are there incentives?"). Government as a Platform will not work properly if citizens do not use digital public services. In this case, no collaboration between the different parties, and thus, no value co-creation is possible. Even Estonia, one of the most successful countries in implementing GaaP, questions how to make public services attractive and how to induce citizens and private companies to use them more actively (09-EE: "...how to make it attractive to people..."). According to the interviews, many other issues contribute to the *Low usage of public services*. For example, Estonia and Italy point out the *Lack of digital transformation culture* as one of the reasons. They claim that both citizens and politicians miss the culture of digital transformation. Citizens do not trust the government, and politicians do not understand the need for digital transformation (01-IT: "The culture is missing."; 02-IT: "Non-trust in this country is pretty high."; 11-EE: "...there has to be a very clear understanding why this change has to be undertaken."). As a result, the use of public services is very low among the different actors. Estonia and Italy also mention the *Lack of skills among citizens* as a related problem: many people are unable to deal with digital services because they lack digital literacy (10-EE: "For example, the government launched a system to register for Covid vaccination and very few were able to register for vaccination because of lack of education experience."). Until citizens acquire general digital skills, the usage of public services will not increase (07-IT: "The key issue that concerns us is that of competencies; if you don't solve that, you won't solve anything."). Finally, Italy notes that people do not actively use public services because of the *Lack of communication of services to citizens* (04-IT: "...in reality, services have been developed, but no communication has been carried out."; 07-IT: "...the public administration has not taken care to make proper communication."). Even if the services are user-friendly and citizens are able to use them, they will not do that if the government does not inform them about the availability of these services.

Issue ID	Name	Issue	Countries	# Alt.
1	**Necessary components**	Which technical components should be included in GaaP?	Estonia, UK, Italy	5
2	**Connectivity among countries**	How to ensure efficient and smooth operational connectivity among different countries?	Italy	1
3	**Lack of digital transformation culture**	There is a lack of digital transformation culture among citizens and politicians. Citizens do not trust the government, and politicians do not understand the need for digital transformation.	Estonia, Italy	1
4	**Fragmentary government**	The government is fragmentary: administrations aim to keep sovereignty, do not want to collaborate, and cannot come to a single solution.	UK, Italy	0

5	**Lack of competent employees in the public sector**	There is a lack of competent employees in the public sector. Young and skilled people from the private sector do not want to work for the government.	UK, Italy	1
6	**Interoperability of systems**	How to ensure interoperability between different systems?	Italy	2
7	**Management of data**	How are the data and information managed at different levels?	Estonia, Italy	3
8	**Low usage of public services**	How to engage members of different sides to use digital public services?	Estonia, UK, Italy	11
9	**Lack of communication of services to citizens**	Communication work is missing: the government does not inform citizens about developed services in a proper way.	Italy	1
10	**Resistance in using digital identity**	How to encourage citizens to use digital identity?	Estonia, UK	6
11	**Lack of skills among citizens**	Many people cannot deal with digital services because of the lack of digital literacy.	Estonia, Italy	1
12	**Data privacy**	How to guarantee privacy of citizens' data?	Estonia, Italy	5
13	**Data security**	How to protect the platform from possible cyber attacks and guarantee citizens' data security?	Estonia, Italy	4
14	**Secure collaboration with the private sector**	How to collaborate with the private sector in a confidential way?	Estonia	0
15	**Inefficient procurement mechanism**	The procurement mechanism of services is complex, costly, and does not always provide necessary products.	UK, Italy	2

16	**Lack of proper governance of digital transformation**	Organizational transformation related to digital transformation is poorly managed and is not supported by clear guidelines.	Italy	0
17	**Lack of clear responsibility**	There is no clear legal responsibility for project coordination.	Estonia, Italy	1
18	**Hierarchy in internal organization**	Leaders in public administration lack competencies and do not hand over the processes to more skilled people because of the prevailing hierarchy within the organization.	Italy	0
19	**Inconsistent political leadership**	Constant changing of political leadership hinders quick and smooth digital transformation.	UK	0

Table 5.1.: Identified issues

5.2. Design Decisions

Applying the coding schema to the interview data yields 19 issues, 44 alternatives, and 53 justifications. Mapping these components together results in 11 three-layer, 3 two-layer, and 5 one-layer design decision trees. The three-layer trees, i.e., those that have all three components - issue, at least one alternative, and at least one justification - represent complete design decisions. There are, however, also trees, consisting only of an unsolved issue or an issue and an alternative without any justifications. Since exactly an alternative depicts a working approach for solving a problem and contains the most valuable information, we consider two-layer trees also as valid design decisions. In essence, each alternative assigned to a particular issue is regarded as an independent design decision. In sum, 14 two- and three-layer trees mapping 44 design decisions are created. A detailed catalogue of all design decision trees can be found in the addendum.

The assignment of the identified design decisions indicates the following findings. The most numerous dimension is the architectural one: 16 design decisions describe relevant platform elements and their connectivity structure. Then, the management dimension follows with 11 decisions, focusing mostly on the methods for enhancement of public service usage. The openness dimension includes 3 design decisions, fulfilling the main platform principles: openness, collaboration with other platform agents, and value co-creation, whereas the organizational dimension includes 2 decisions related to the responsibilities of platform actors. The rest 12 design decisions are more generic and refer not only to the implementation of GaaP, so we create the fifth separate dimension for them - **miscellaneous**. Design decisions in this dimension are very diverse and include, for example, *Free Internet access*, *Trainings on data security*, and *Educational programs on digital literacy*.

Table 5.2 shows all identified design decisions in each content dimension, including the number of correspondent justifications to each decision in brackets.

Content dimension	**Design decisions**	
Platform architecture	• Digital identity (3) • Payment service (2) • Notification system (3) • Interoperability system as necessary component (1) • Information website with access to public services (0) • Single national registry platform (1) • Common APIs and standards (1) • Data tracker (1)	• Interoperability system for data management (2) • Two digital identities (2) • "Verify" system (1) • Digital marketplace (4) • Distributed architecture for data management (1) • Distributed architecture for data security (2) • Blockchain for data encryption (1) • Decentralized solutions (1)
Platform roles	• Politicians' publicity in use of public services (1)	• Special responsible section (0)
Platform openness	• Public-private partnership for the promotion of public services (4) • Lower barriers for small and medium companies (2)	• Public-private partnership for the promotion of digital identity (2)

Platform management	• Project of digital inclusion (1) • Certification system with once-only principle (1) • Options switch off (0) • Incentives (1) • No value in paper (1) • Data privacy laws (0)	• Transparency (1) • User research and product tests (0) • Compulsory digital identity (2) • Automatic provision of digital identity (1) • Cheap digital identity (0)
Miscellaneous	• Development of a clear understanding of the need in digital transformation (0) • Adjustment of regulations within PA and attraction of young employees (0) • Guidelines for regulation of relationships between data providers (1) • Easy services (1) • Mobile app (1)	• Trainings on the use of public services (2) • Free Internet access (1) • Useful services (1) • Educational programs on digital literacy (0) • Once-only principle (1) • Trainings on data security (0) • Building security in design (0)

Table 5.2.: Identified design decisions

Data analysis shows that 43 of the 44 design decisions discussed in the interviews are successful and contribute to solving a problem. Only one decision, made in the UK, is identified as failed: *"Verify" system*. Like the other surveyed countries, the UK encountered high resistance to using digital identity among its citizens. To overcome this issue, the UK government decided to implement the "Verify" system, which is an alternative to the eID system that verifies one's personality through third parties (16-UK: "The way it worked was that you had to prove your identity to the government through an exchange where the providers were all non-government entities."). This decision is beneficial, because the "Verify" system is built without the creation of a single database that stores critical personal data, and hence, it increases citizens' trust. However, this alternative does not work properly and cannot fully replace the functionality of digital identity, since not all e-government services support it (16-UK: "...but it works only for 25 services, so it was not adopted as a once-only single sign-in."). The UK government acknowledges this limitation and plans to bring the eID system back to the public.

In order to gain insight into the construction and content of single design decisions, an exemplary design decision tree is presented and one of its exemplary design decisions is examined.

Figure 5.1 depicts the design decision tree *Necessary components*. The issue at the root is the lack of clarity about which technical components should be included in GaaP. Five alternatives from the architectural dimension implementing five different platform elements were revealed to solve this problem. All alternatives are rather complementary in this tree, i.e., the mentioned elements are not mutually exclusive and can all be implemented. The most popular solutions, which were mentioned by all three countries, are *Digital identity*, *Interoperability system as necessary component*, and *Information website with access to public services*. *Digital identity* serves as a unique identifier of citizens, storing their personal information, and as a shared key for databases (10-EE: "Whichever authority you go to, there is one identifier, and they are all connected."). *Interoperability system as necessary component* enables the communication between databases and guarantees smooth data exchange between different authorities (13-EE: "X-road was developed to transport data from different databases to service providers and at the same time to have an environment that is secured and standardized."). *Information website with access to public services* acts as a "one-stop shop" with many public services at a single point (16-UK: "...GOV.UK has many other services..."). *Payment service* and *Notification system*, which both create an essential environment for developing main services (16-UK: "Payments and notification allow government departments to be freed up and focus on the things that they are actually doing for the user and solve their problems."), have only been implemented in the UK and Italy. Figure 5.2 provides a closer view on the design decision *Digital identity* with exemplary quotes from interviews on each decision component.

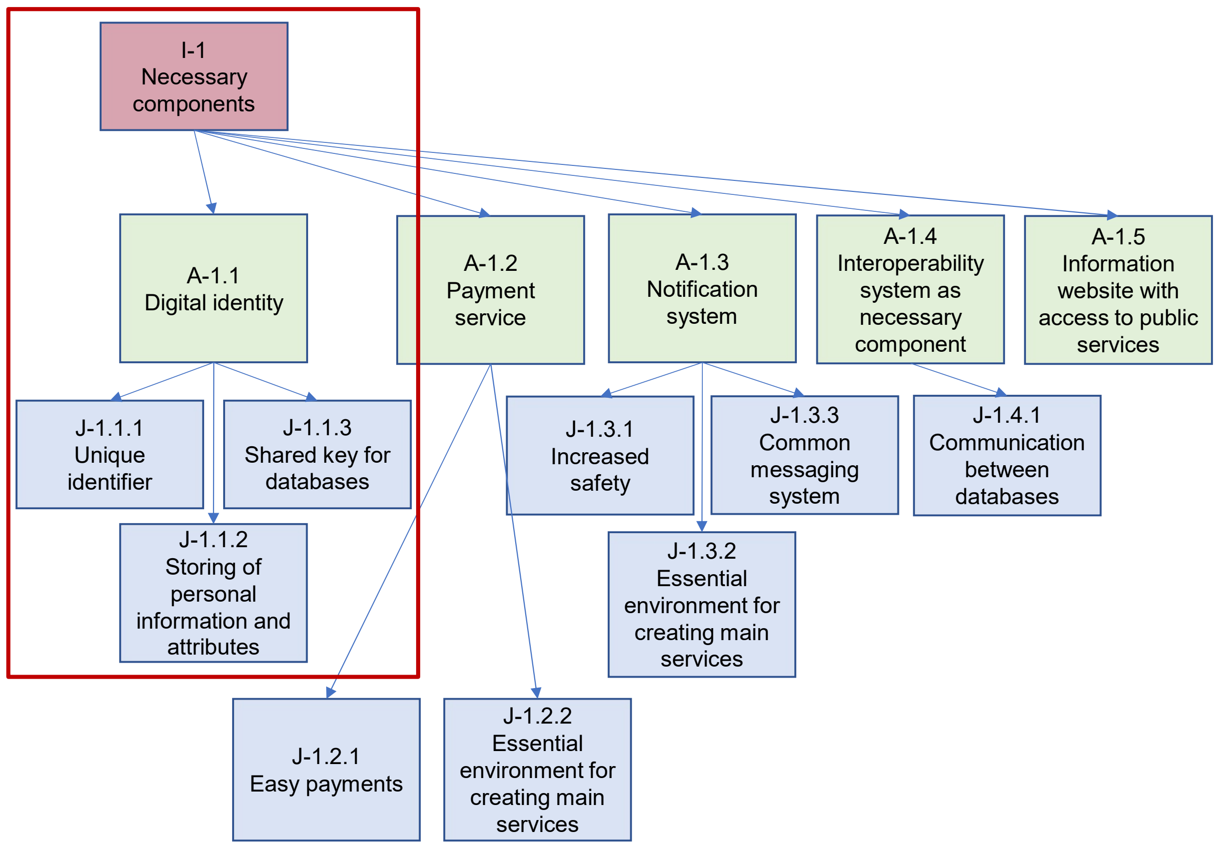


Figure 5.1.: Design decision tree "Necessary components"

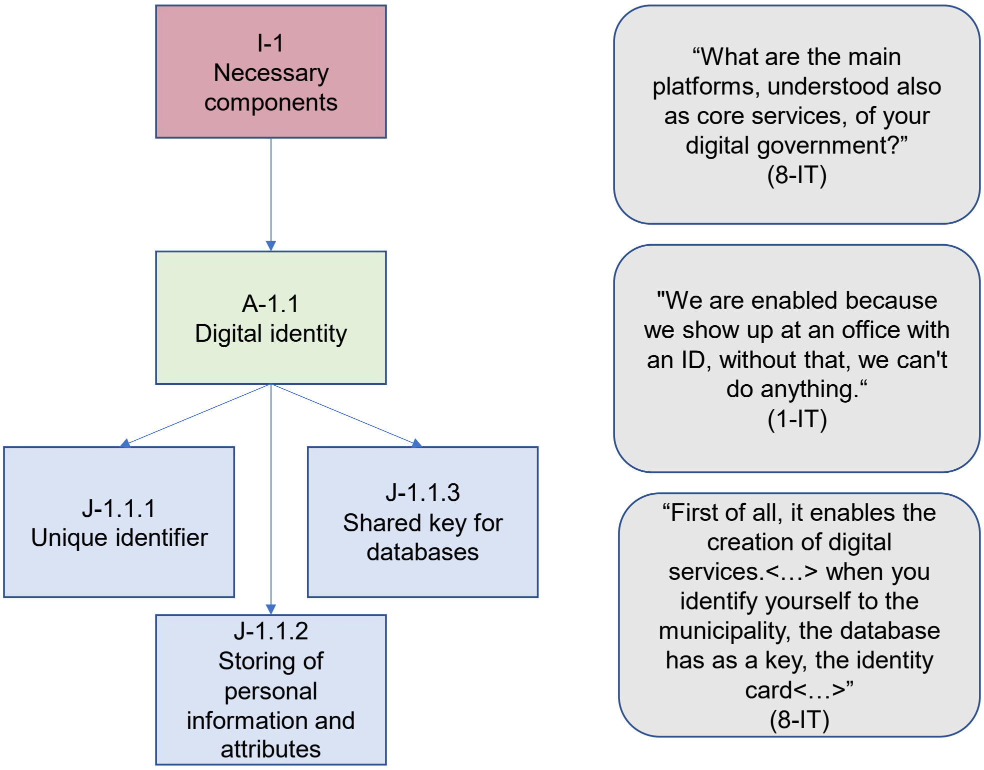


Figure 5.2.: Design decision "Digital identity"

The design decision *Digital identity* was mentioned by all interviewed countries as a crucial component of Government as a Platform (01-IT: "We are enabled because we show up at an office with an ID, without that, we can’t do anything."; 10-EE: "The most important thing that Estonia has is <...> a personal code unique to everybody."; 15-UK: "We are now asking to rethink at national identity service and do it again."). This design decision belongs to the architectural content dimension, because the alternative *Implement digital identity* describes the construction of a platform component and its integration into the platform infrastructure. Three justifications were mentioned as the reasons why all three countries considered digital identity as a basis for GaaP and chose this alternative. First, digital identity serves as a unique identifier of citizens and can be used by all authorities (10-EE: "Whatever authority you go to, there is one identifier, and they are all connected."). For citizens, it is beneficial because they do not need to apply for multiple IDs and can use a universal one for all services, whereas public administrations profit from having a common identification system that facilitates retrieving data. Second, digital identity allows storing personal information about citizens including their relevant attributes (03-IT: "Obviously, the ID card has unique potential because information can be recorded inside like those attributes."). This enables personalization of services and rids users from repeated provision of personal information to every authority. Finally, digital identity facilitates data matching while providing a shared key for databases and interoperability systems (15-UK: "Until we can’t solve the identity problem, you have the matching data problem."; 08-IT: "How are you going to make interoperability and digitization between administrations if there is no unique-shared key?").

6. Design Patterns

Applying the *rule of two* to 44 identified design decisions yields 7 design patterns encompassing different aspects of platform engineering in the public sector (Table 6.1). Architectural patterns emphasize that for a successful GaaP realization, not only *Distributed architecture* is needed, but also such components as *Identity, interoperability, and interface* should be implemented. Meanwhile, digital identity plays such a crucial role in the functioning of GaaP that one of the management patterns suggests making it compulsory for everyone (*Compulsory digital identity*). The management pattern *User-centric services with incentives*, as well as the patterns *Public-private partnership* from the platform openness dimension and *Educational programs* from the miscellaneous dimension ultimately aim to increase citizens' use of digital public services in different ways. *Transparent data management* is no less important design pattern for platform engineering, however, it cannot be assigned to one particular content dimension, as it is based on both architectural and management design decisions. Overall, 5 of the 7 patterns are confirmed by the practical experience of all three surveyed countries, while the 2 other patterns (*Distributed architecture* and *Compulsory digital identity*) are applied in two of the three case studies.

Design pattern	**Description**
Identity, interoperability, and interface	Implement three essential components that form a good basis for Government as a Platform: digital identity, interoperability system, and interface for accessing public services
Distributed architecture	Implement distributed architecture, where the system is decentralized and data is distributed across different databases, to keep information secure and prevent the platform from cyber-attacks
Transparent data management	Make operations with users' data transparent and guarantee citizens the freedom of information to ensure their data privacy, avoid full government control, and enhance their trust in digital platforms and in the government in general
Public-private partnership	Collaborate with private sector companies and use them as a foundation to promote digital public services

User-centric services with incentives	Make public services useful and simple for citizens, engage users in the designing process through collecting feedback, and provide incentives to encourage platform agents to use public services
Educational programs	Organize free educational programs on the use of digital public services and general digital topics to improve citizens' skills and eliminate digital illiteracy
Compulsory digital identity	Make digital identity compulsory for everyone, in order to ensure its high usage and rapid integration into public services

Table 6.1.: Identified design patterns

In the following, we describe the revealed design patterns in detail, using the structure mentioned in Chapter 2 and supporting each pattern with examples of its application in the interviewed countries and concrete design decisions from which it was derived.

Identity, interoperability and interface

Context Implementing first platform components.

Problem Engineering a platform in the public sector starts with the implementation of the main components which enable the basic functionality of the platform. However, because of the absence of guidelines on implementation, it is unclear which components are the most essential ones and should be developed first.

Solution Build three essential components: digital identity, interoperability system, and interface for accessing public services. These three components constitute a good basis for Government as a Platform, and they are crucial for the development of further public services. Digital identity serves as a unique identifier, storing citizens' personal information, and it is used by all authorities. Without digital identity, GaaP cannot work properly, as this component facilitates data matching, providing a shared key for databases and interoperability systems, and thus enables the creation of other digital services. An interoperability system is essential for communication between databases and smooth data exchange between authorities. It is a connector for all decentralized public services. The interface for accessing public services, which is usually represented in the form of an information website or a mobile app, acts as a "one-stop shop", which allows people to quickly find all desired public services in one place.

Examples Estonia has provided every citizen with an electronic ID and integrated it into all public services. The country has also built *X-Road* - infrastructure for connecting between different public databases, whose model is also adopted in other countries. Additionally, the portal *estiee.ee* plays the role of the interface for accessing public services. Italy has built the necessary components as follows: it has introduced two digital identities (*SPID* and *CIA*) for different purposes and developed a public connectivity system (*SPC*) for interoperability and *IO.app* for accessing public services. The UK, in contrast, has implemented interoperability not in the form of a particular system but as a framework, based on open standards. Public services in the UK are accessed via the *GOV.UK* portal.

Decisions *Digital identity*, *Interoperability system as necessary component*, *Information website with access to public services*

Distributed architecture

Context Ensuring citizens' data protection and prevention of cyber-attacks.

Problem Government authorities are filled with sensitive data that has been collected over many years, including critical information about citizens and private companies. The data constitutes the major part of the platform and serves as a foundation for all public services. Hence, it is the most valuable and vulnerable asset of the platform. Since the government is constantly subject to cyber-attacks, the platform has to be securely protected from possible data breaches. The question is: what is the safest way to keep sensitive data secure?

Solution Implement distributed architecture, where the system is decentralized and data is stored across different databases, which exchange information by means of a communication network. The information has to be divided by different institutions and not allocated centrally. Distributed architecture makes information more secure, as hackers need to access a huge number of databases to collect valuable data. If they just hack one spot, they only get a limited amount of encrypted data that is not useful for them.

Examples In Estonia, data is distributed by different authorities, and databases are connected via the interoperability system X-Road so that they can query and exchange information with each other. This architecture is one of the main reasons why there have been no cyber-attacks in Estonia in recent years. Likewise, Italy has adopted a distributed architecture and even made it mandatory in the constitution.

Decisions *Distributed architecture for data security*

Transparent data management

Context Ensuring citizens' data privacy and avoidance of full government control.

Problem When using digital public services, citizens provide a lot of personal information to the government. This data is sensitive and should only be accessible to the authorities for which it is intended. If the data is protected insufficiently, it can fall into the wrong hands, or the so-called "Big Brother" situation may arise, i.e., full government control over citizens. To avoid this, secure the data, and increase citizens' trust in authorities, efficient data protection in terms of privacy should be guaranteed.

Solution Make data management transparent, so that users can see what kind of their personal data, how, and by whom is collected, stored, and accessed. Citizens should have freedom of information that ensures that they have the right to request access to government-held information. If a person notices unusual activity on the part of an authority related to their personal data, they should be allowed to request its reason and detect a possible violation. This right to ask for the reason why the data was accessed can be guaranteed by data privacy laws. Transparent data management and the freedom of information ensure the privacy of citizens' data, help to avoid full government control, and enhance citizens' trust in digital platforms and in the government in general.

Examples All three interviewed countries transparently operate user's data and provide freedom of information to their citizens. In the UK and in Italy, there are corresponding laws and acts which guarantee the right of people to acknowledge which data is stored by which authority, whereas Estonians have an online data tracker in their personal accounts, so they are always aware of who and when accesses their data.

Decisions *Data privacy laws*, *Transparency*, *Data tracker*

Public-private partnership

Context Introduction and promotion of digital public services.

Problem Encouraging citizens to use digital public services is very challenging. Often, people do not understand the benefits of these services, have no motivation to use them or do not possess relevant skills for that. However, without high usage of digital public services, GaaP cannot create public value and loses its significance. Therefore, digital public services should be introduced and promoted duly, so that citizens are interested in using them.

Solution Collaborate with the private sector and use it as a foundation to promote digital public services. Without the commercial sector, public services frequently do not have applicability. The same services in the private sector are used on a daily basis and are more useful for citizens. It is easier first to integrate the services into the private sector, raise citizens' awareness of them, and after people become accustomed to the services, extrapolate them into the public sector. A further benefit of a partnership with companies is the fact that having the same services and tools in both private and public sectors releases people from learning new things. They will not have to acquire additional skills for using digital public services if they are already familiar with these services in the commercial sector. Moreover, private companies frequently promote services to the public by providing trainings on their usage. While the government builds the system, private companies help to inform society about their existence and teach people to apply them. Finally, collaboration with the private sector enables continuous innovation, since the private sector is supposed to invest in public services.

Examples In Estonia, telecom companies and banks have created a foundation to promote internet-based services, in particular, digital identity. For them, this is beneficial because digital identity enhances data protection and makes private companies more trustworthy, while the government profits from financial support and increased usage of digital identity.

Decisions *Public-private partnership for promotion of public services*, *Public-private partnership for promotion of digital identity*

User-centric services with incentives

Context Encouraging platform agents to use digital public services.

Problem The usage of digital public services among citizens is low for many reasons. Some people do not trust the government; others do not understand the need for transformation and prefer using traditional forms of services. GaaP loses its significance if people do not use digital public services and do not collaborate with the government. In order to create public value, all parties: the government, citizens, and private companies should cooperate with each other. The question is: how to encourage platform agents to use digital public services more actively?

Solution Make digital public services user-centric and provide people incentives for their usage. User-centricity implies many aspects. First, services should be useful for people: if the service solves the real problems of customers and brings value to them, they will find it and use it anyway. Second, services should be easy to use: most people are not IT experts, so they prefer tools that are very simple, intuitive, and do not require many steps. The easier the service is to use, the wider the audience it will reach. User-centricity also includes engaging citizens in the design of the services, which can be achieved through conducting user research, testing the product before launching it, and collecting users' feedback on it. Finally, along with user-centricity, it is important to develop incentives and ways to encourage people to use services. At the very beginning, this plays a crucial role in building the first impression of the user experience. The incentives could be a cash bonus or the fact that some new features and extra opportunities are available only through the new digital mode. Realization of these aspects adds up to citizens' comprehension of the advantages of digital public services and increases their service usage.

Examples Apart from making digital public services valuable and easy to use, surveyed countries have integrated some incentives for citizens to use these services. Estonia has accelerated tax refunds to one week instead of 6 months when using an online submission form. Italy has introduced the cashback bonus system for users of the public IO app. The UK constantly conducts user research and follows a classic agile methodology for software development, which involves a tight feedback loop.

Decisions *Easy services*, *Incentives*, *Useful services*, *User research and product tests*

Educational programs

Context Elimination of citizens' digital illiteracy and improving their skills in using digital public services.

Problem Many people are unable to deal with digital services because of the lack of respective skills. Sometimes they do not understand how a particular service works, and sometimes they are simply not digitally trained and find it difficult to switch from a traditional form of service to a new digital one. If many citizens are not sufficiently skilled, the usage of public services will be very low, and "the digital division" will increase.

Solution Organize free educational programs on the usage of digital public services and general digital topics. These programs will improve people's digital literacy, familiarize them with the services, and help them understand the benefits of GaaP. Educational campaigns can take the form of digital support, online courses, or life skills training by other learners. If people gain the skills to use digital services, they will find them simpler and more convenient than non-digital ones and, as a result, the usage of digital public services will increase.

Examples In addition to various online courses, the UK has conducted a program of digital inclusion in the form of a service called "Assisted Digital", which helps people to make digital transactions and provides an option to do something on their behalf. Estonia organized a number of campaigns on general digital issues, such as cyber-security and safe behavior on the Internet. These campaigns helped to reduce digital division among citizens and improve their motivation to switch to digital public services.

Decisions *Trainings on the use of public services*, *Educational programs on digital literacy*

Compulsory digital identity

Context Encouraging platform agents to use digital identity.

Problem There is a general resistance among citizens in using digital identity. The reasons for that include high mistrust of the government, lack of understanding of the need for digital transformation, and unwillingness to go through the application process, among others. Digital identity is, however, one of the most essential platform components, and it plays a crucial role, serving as a unique identifier for citizens and enabling data exchange between different databases. GaaP cannot work effectively without a digital identity, so it is critical to encourage people to use it on a regular basis.

Solution Since digital identity is such an important component that should be implemented at the very beginning of platform engineering, the safest way to ensure its high usage and fast integration in public services is to make it compulsory for everyone. Citizens should be obliged to have a digital identity by law, and all public administrations should be required to use digital identities as credentials to access e-government services. This way, most of the society will use digital identity, and further public services can be easily developed with its integration.

Examples Estonia has set a very precise legal requirement: every citizen must have a digital identity. One is not required to have a passport, but possession of an electronic ID card is mandatory. Thanks to this compulsion, the number of people having a digital identity has enormously increased, and the Estonian government has expanded the variety and effectiveness of public services by integrating digital identity into them. Italy has made it compulsory for the authorities (rather than citizens), as an authentication method in digital public services, which has also led to more people using digital identities, since they did not have a choice of how to log in to public services.

Decisions *Compulsory digital identity*

7. Discussion

This thesis aimed to derive design patterns for platform engineering in the public sector based on the experience of three countries that succeeded in this domain. This goal was achieved by addressing three research questions. First, we developed a coding scheme for the interview analysis. Second, we stressed the design decisions made by the interviewed countries in implementing the GaaP model. Finally, we extracted design patterns from the identified design decisions.

The resulting list includes 7 patterns and summarizes good design practices across all dimensions of platform engineering in the public sector. Subsequently, it provides a comprehensive overview of the common design ideas used by Estonia, the UK, and Italy, which can be put in place for the efficient implementation of the GaaP model by the governments of other countries. Overall, the analyzed countries noticeably focus on the architecture and management of the platform when implementing GaaP. Most of the design decisions involve the construction of the platform components, the structuring of the system, enabling a smooth stakeholder interaction, or the proper delivery of services to users. These findings are very natural, as these steps constitute the most essential and at the same time challenging parts of platform engineering. The architecture of the platform is the foundation of the whole system, which not only enables the creation of all public services but also makes the platform secure and open for agent collaboration. Platform management plays an equally significant role since the government acts as a coordinator and facilitator of the co-production of services. Effective orchestration is an essential prerequisite for the delivery of public value.

As we mentioned earlier, the derived design patterns are supposed to serve as a common solution approach to governmental platform engineering. However, can they be applied to all countries and serve as a guideline and foundation for platform engineering in the public sector, i.e., be considered as design principles? To address this question, we first need to clarify the difference between the two artifacts. A design pattern is operational knowledge gained from practice and used for solving recurrent problems. A design principle, on the other hand, is "a fundamental rule or law, derived inductively from extensive experience and/or empirical evidence, which provides design process guidance to increase the chance of reaching a successful solution", according to Fu et al. [22].

Our design patterns are actually extracted from experience and empirical evidence and, according to the interviews, lead to successful solutions to the respective problems (which constitutes the first half of the definition of a design principle). Indeed, some of them were not only proven in practice but their maturity was also discussed in the literature. A good example is the interoperability system from the *Identity, interoperability, and interface* design pattern, which is a boundary resource that enables communication between databases. Bygstad & Hanseth [9] emphasized the importance of such boundary resources as a part of the platform since they allow various user services to exchange data with the core. Further, design pattern *Public-private partnership* contains the key idea of the 3rd. lesson of O'Reilly [3] "Design for participation", which implies building a platform in a way such that users, including private companies, are capable of doing most of the work. Public-private collaboration was also discussed by Millard [5] under the term *open engagement* as one of the mechanisms for public value delivery. Another extracted design pattern that goes along with modern research is *User-centric services with incentives*, which includes usefulness, simplicity, and user-friendliness among other aspects. In fact, the studies show that user-friendliness is a crucial part of most of the benefits of GaaP for citizens [45, 26, 6]. In practice, user-centricity not only brings value to citizens in the form of useful, customized, and simple services but also increases the motivation to use them in the first place, enhancing the overall value of the platform. The next argument in favor of considering derived patterns as design principles is the fact that they worked in countries with different geopolitical, economic, and population characteristics. Estonia, the UK, and Italy differ in their land area, population size, legal and government systems, GDP, government spending, digital literacy, and many other parameters that play a significant role in the implementation of GaaP. This gives high hopes for positive outcomes in the case of extrapolation of the described patterns to other countries, especially in the context of Europe.

Nevertheless, the generalizability of the results is limited by the number of examined cases. Design principles are something formal, grounded, and proved many times. Three case studies might be too few to conclude the applicability of patterns in all countries without exception. Even though Estonia, the UK, and Italy each have unique characteristics and development histories, on a global scale, they might appear to be rather similar in comparison to the countries that fall on the opposite side of the global rankings in one or multiple of the parameters listed in the previous paragraph. For example (which is quite extreme but greatly demonstrates the point), it is not reasonable to assume that China with its socialist market economy and a population of over 1.4 billion people would apply the public-private partnership design pattern. Moreover, some patterns did not work properly in one of the observed countries because of its particularities. For instance, the decision to introduce digital *identity* in the UK failed as citizens did not trust the government and resisted using the unique identifier that would be storing their personal data. Even *Public-private partnership* could not help to promote digital identity in the UK and made the situation more complicated instead (15 - the UK: "We tried to create an ecosystem in the commercial world that allows people to create an identity which they could use on commercial services like the post office, but also on government, and I think we just made it too complicated for ourselves..."). Another issue that challenges the transformation of design patterns into design principles is the limitation of *the rule of two*. This evaluation criterion is quite handy and suitable for our research, but it is not always sufficient to evaluate the functionality of a pattern. For example, *Payment* and

Notification systems are also valid as essential platform components according to the rule of two. However, we do not include them in the pattern list because Estonia managed to implement GaaP with only three major components, omitting payment and notification services. They are therefore not the key platform elements without which the GaaP model cannot be implemented and hence could be excluded from the pattern. Another example is *Interface* as a necessary component that represents a navigation portal with access to e-government services. All interviewed countries implemented this so-called "one-stop shop", since it allows citizens to quickly and easily find the desired digital public services and all relevant information in one place. Studies show though that, rather than using sophisticated navigation, people are increasingly deploying advanced search tools with autocomplete and predictive search results to directly access the service they want in one or at most two clicks [5]. Consequently, the issue of converting our design patterns into design principles remains debatable.

From our research, we can also conclude that this list of design patterns is not final, and there are definitely more of them. Once again, the revealed 7 patterns are founded on the collected data and refined by *the rule of two*. We only considered the alternatives mentioned by the respondents, not all possible ones. For each problem, there could be more possible solutions. In addition, some successful design decisions mentioned only by one country were filtered out by the evaluation criterion, although they seem to be very good decisions that could also be applied in other countries. Two of such excluded decisions are the creation of *Digital marketplace* and *Lower barriers for small and medium companies*. The UK set up a digital marketplace with hundreds of suppliers inside and lowered barriers for small and medium enterprises so that they have an opportunity to sell their services to the government. This decision not only provided a great stimulus for small businesses locked out by the bigger players and created a new industry around digital practitioners, but also significantly extended the range of skilled suppliers, enhanced the variety and quality of services, and reduced government expenses in this field. With all these benefits, both of the above decisions have the potential to become valuable design patterns for other countries. The 1st. lesson of O'Reilly "Open standards spark innovation and growth" confirms the maturity of these decisions: low barriers to entry to a market enable participants to invent the future. Other potential design patterns derived from decisions include *Common APIs and standards*, *Special responsible section*, *Trainings on data security*, and *Once-only principle*. Besides, the interviewed countries were not yet able to develop a functional approach to 5 of the identified issues during their ongoing platform engineering journey. The problems of *Fragmentary government*, *Secure collaboration with private sector*, *Lack of proper governance of digital transformation*, *Hierarchy in internal organization*, and *Inconsistent political leadership* sound like common barriers which could be faced by many countries. Hence, a working solution for them could expand our list of design patterns.

Despite its limitations, we believe this research makes a valuable contribution to the existing knowledge of platform engineering in the public sector by providing good practices for implementing the Government as a Platform model. To the best of our knowledge, none of the prior studies has proposed a specific practical approach to designing a civil platform. Gawer [8], Jacobides et al. [34], and Bygstad & Hanseth [9] examined platform ecosystem architecture and broached the subject of Information and Communication Technology (ICT) in the public sector. Millard [5], Cordella & Paletti [6], and Brown et al. [7] explored platform ecosystem governance and analyzed the impact of ICT on social values. O'Reilly listed rather general theoretical lessons about platform engineering, learned from private companies, which should drive practitioners in building GaaP. All these scientific works consider the platform and the GaaP concepts from diverse perspectives and highlight their characteristic features, but they do not provide particular recommendations for actions to construct them efficiently. In contrast, our derived design patterns can serve as a good starting point and an initial guideline for the realization of the GaaP model. They allow governments of different countries to refer to the solutions that were proven in practice to some of the specific platform engineering problems as well as determine which aspects could be especially noteworthy and make the implementation successful.

8. Conclusion

Government as a Platform is a promising concept that takes the public sector to a new level of functioning. It benefits citizens in the form of user-friendly services and the opportunity to participate in service development, whereas the government profits from increased efficiency and reduced costs. This concept is, however, challenging and relatively new, so concrete techniques to realize it are still lacking in the literature. The goal of the thesis was to fill this gap and propose practices that could serve as a good foundation and initial guide for designing a platform in the public sector. We accomplished this in three steps by addressing our research questions, namely, generating an appropriate coding schema for extraction of design decisions based on their dimensions, identifying design decisions made by Estonia, the UK, and Italy that succeeded in the GaaP implementation, and deriving design patterns from the practical experiences of these countries.

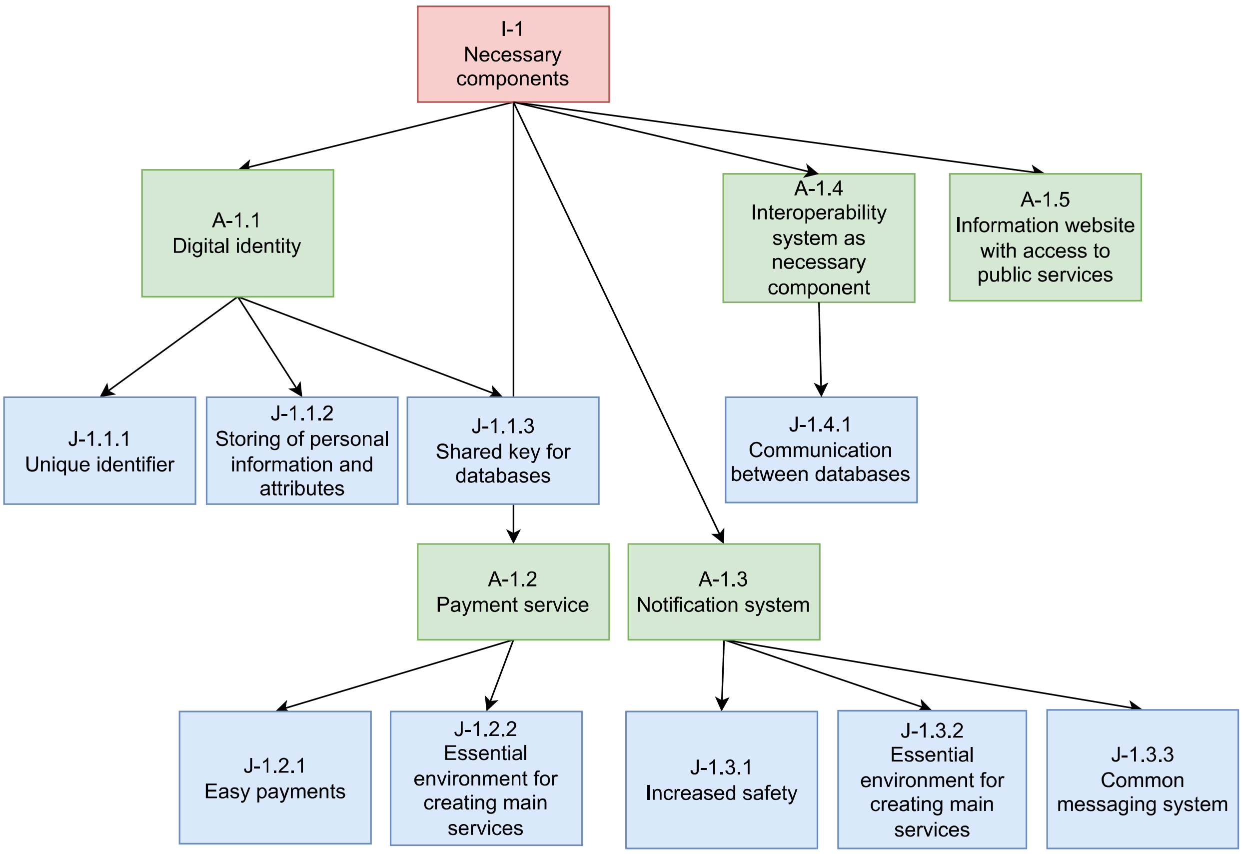
The developed coding schema represents a matrix that classifies decisions from two perspectives: their structure and their content. This schema proved itself to be a suitable approach for the data analysis in this study. Content dimensions are essential for describing the scope of a decision within the GaaP model, while structural dimensions give a comprehensive overview of the problem that caused this decision and the reason for choosing a particular solution. 44 identified design decisions describe the handling of issues in different dimensions: platform architecture, platform roles, platform openness, and platform management. They also underline the aspects on which the interviewed countries focused the most during the GaaP construction and the part of the implementation that was the most problematic. Finally, 7 derived design patterns generalize decisions filtered by the evaluation criterion and provide valuable practices for designing a platform in the public sector. Proven in practice and partly supported by theory, the patterns build orientation for other countries during the application of the GaaP concept. The results of our research give insights into diverse perspectives of platform design, e.g., which components to implement, how to structure the system, and what is the best way to motivate citizens to use digital public services, among others.

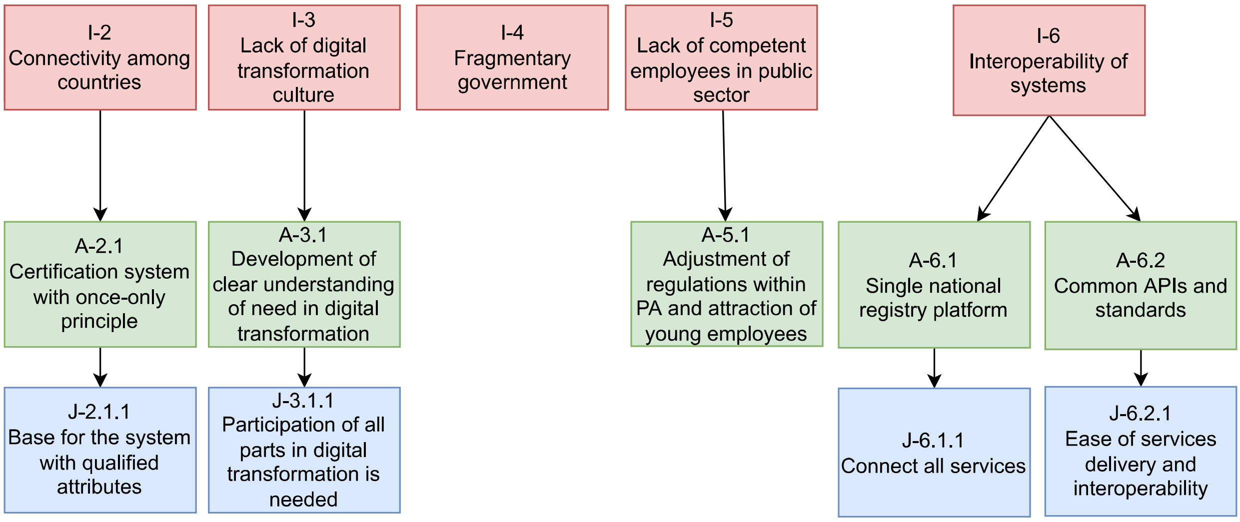
While we emphasize the contributions of our research, as we discussed in the previous chapter, it is still subject to some limitations. The number of analyzed cases is restricted to three countries. In order to increase confidence in the general applicability of patterns and derive further design techniques, more countries with characteristics different from Estonia, the UK, and Italy must be examined. The applied evaluation criterion for converting decisions into patterns is not optimal either. According to Coplien [55], the pattern must relate to at least three known uses in practice to ensure the re-usability of the proposed solution. Due to the small number of case studies, we had to narrow this requirement to two uses. Future work could extend a variety of examined countries, increase the number of case studies, and apply Coplien's *rule of three* for pattern validation.

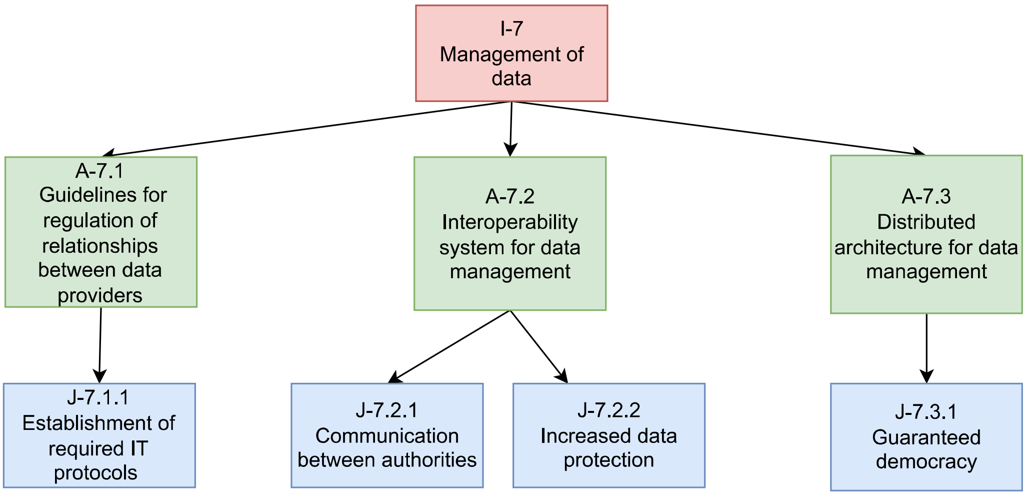
Overall, we believe that our research is of great relevance for both theoretical and practical applications, and we hope that the presented findings will support governments in successful platform engineering.

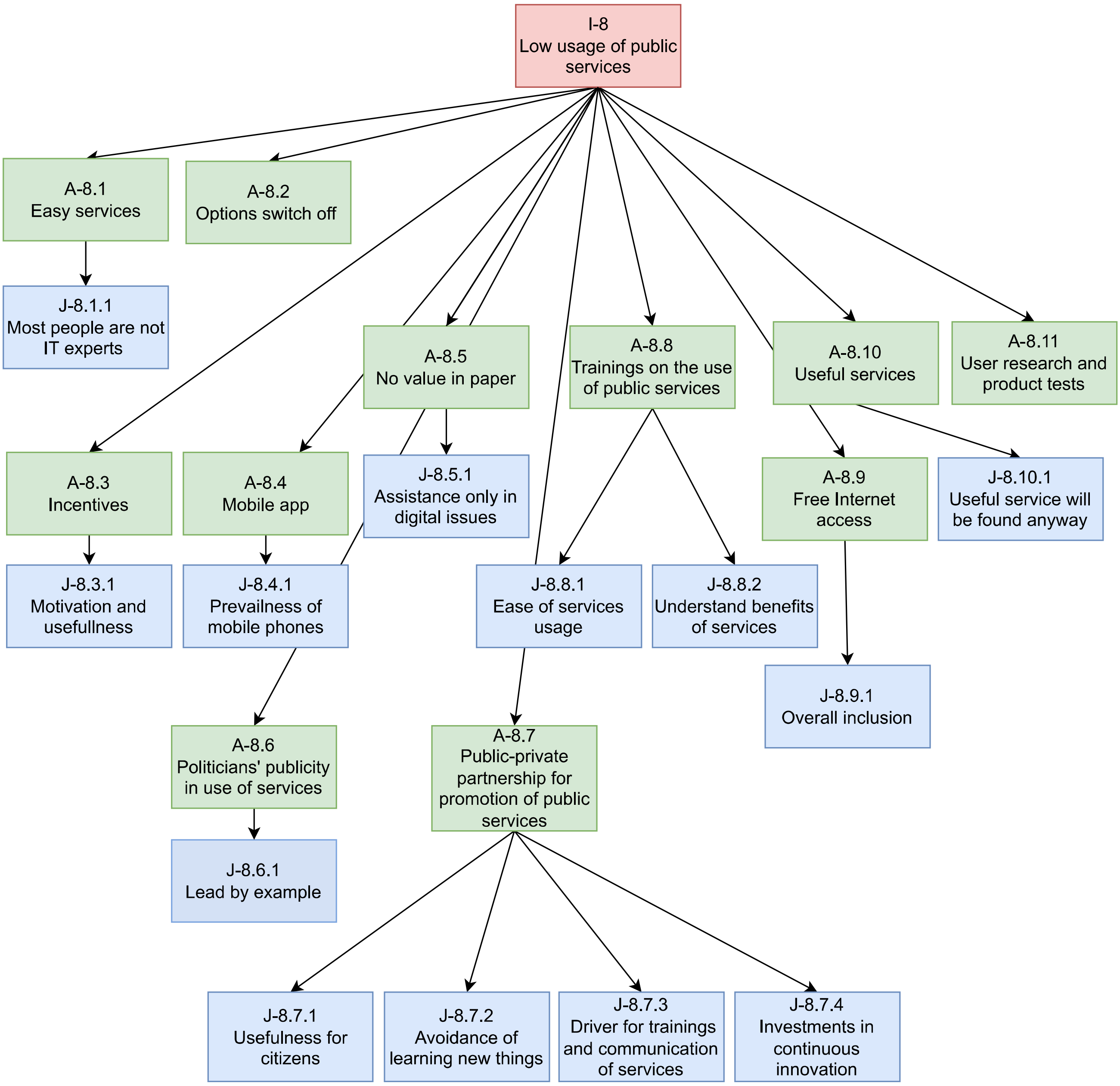
A. General Addenda

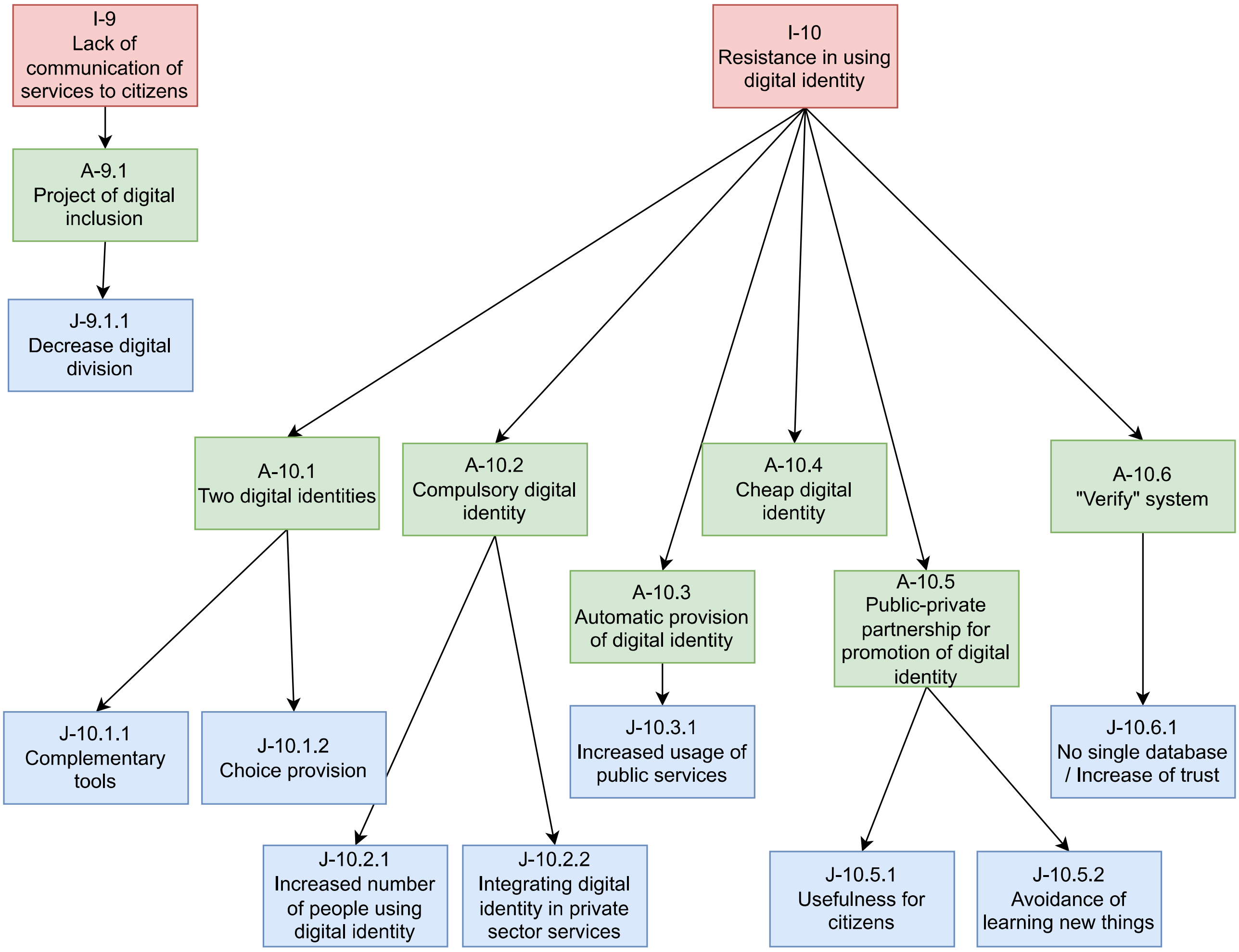
The following figures represent all identified design decisions in the form of trees.

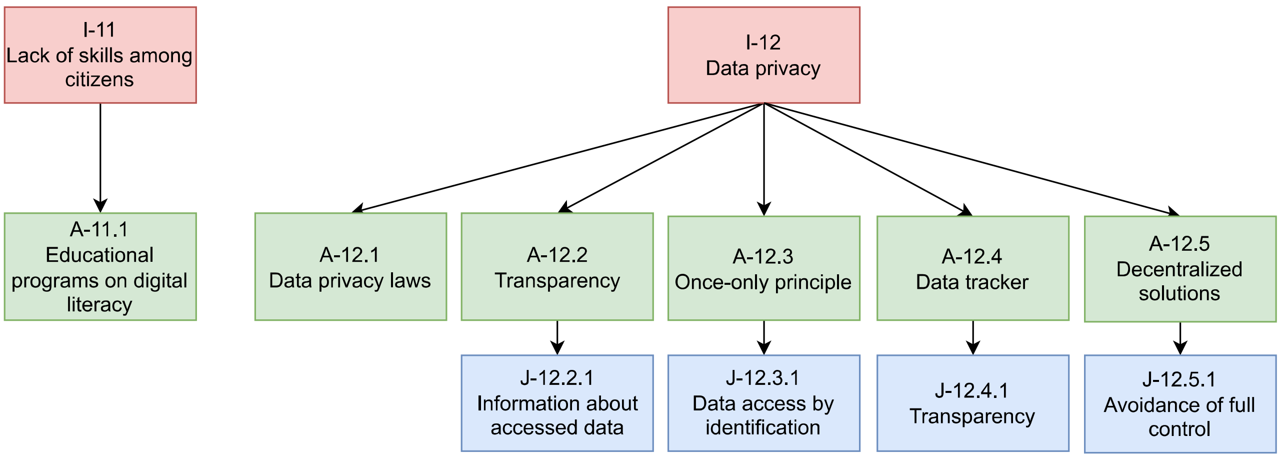



I-2
Connectivity among countries
I-3
Lack of digital transformation culture
I-4
Fragmentary government
I-5
Lack of competent employees in public sector
I-6
Interoperability of systems
A-2.1
Certification system with once-only principle
A-3.1
Development of clear understanding of need in digital transformation
A-5.1
Adjustment of regulations within PA and attraction of young employees
A-6.1
Single national registry platform
A-6.2
Common APIs and standards
J-2.1.1
Base for the system with qualified attributes
J-3.1.1
Participation of all parts in digital transformation is needed
J-6.1.1
Connect all services
J-6.2.1
Ease of services delivery and interoperability


I-7
Management of data
A-7.1
Guidelines for regulation of relationships between data providers
A-7.2
Interoperability system for data management
A-7.3
Distributed architecture for data management
J-7.1.1
Establishment of required IT protocols
J-7.2.1
Communication between authorities
J-7.2.2
Increased data protection
J-7.3.1
Guaranteed democracy


I-8
Low usage of public services
A-8.1
Easy services
A-8.2
Options switch off
J-8.1.1
Most people are not IT experts
A-8.5
No value in paper
A-8.8
Trainings on the use of public services
A-8.10
Useful services
A-8.11
User research and product tests
A-8.3
Incentives
A-8.4
Mobile app
J-8.5.1
Assistance only in digital issues
A-8.9
Free Internet access
J-8.10.1
Useful service will be found anyway
J-8.3.1
Motivation and usefullness
J-8.4.1
Prevailness of mobile phones
J-8.8.1
Ease of services usage
J-8.8.2
Understand benefits of services
J-8.9.1
Overall inclusion
A-8.6
Politicians' publicity in use of services
A-8.7
Public-private partnership for promotion of public services
J-8.6.1
Lead by example
J-8.7.1
Usefulness for citizens
J-8.7.2
Avoidance of learning new things
J-8.7.3
Driver for trainings and communication of services
J-8.7.4
Investments in continuous innovation


I-9
Lack of communication of services to citizens
A-9.1
Project of digital inclusion
J-9.1.1
Decrease digital division
I-10
Resistance in using digital identity
A-10.1
Two digital identities
A-10.2
Compulsory digital identity
A-10.3
Automatic provision of digital identity
A-10.4
Cheap digital identity
A-10.5
Public-private partnership for promotion of digital identity
A-10.6
"Verify" system
J-10.1.1
Complementary tools
J-10.1.2
Choice provision
J-10.2.1
Increased number of people using digital identity
J-10.2.2
Integrating digital identity in private sector services
J-10.3.1
Increased usage of public services
J-10.5.1
Usefulness for citizens
J-10.5.2
Avoidance of learning new things
J-10.6.1
No single database / Increase of trust


I-11
Lack of skills among citizens
A-11.1
Educational programs on digital literacy
I-12
Data privacy
A-12.1
Data privacy laws
A-12.2
Transparency
A-12.3
Once-only principle
A-12.4
Data tracker
A-12.5
Decentralized solutions
J-12.2.1
Information about accessed data
J-12.3.1
Data access by identification
J-12.4.1
Transparency
J-12.5.1
Avoidance of full control

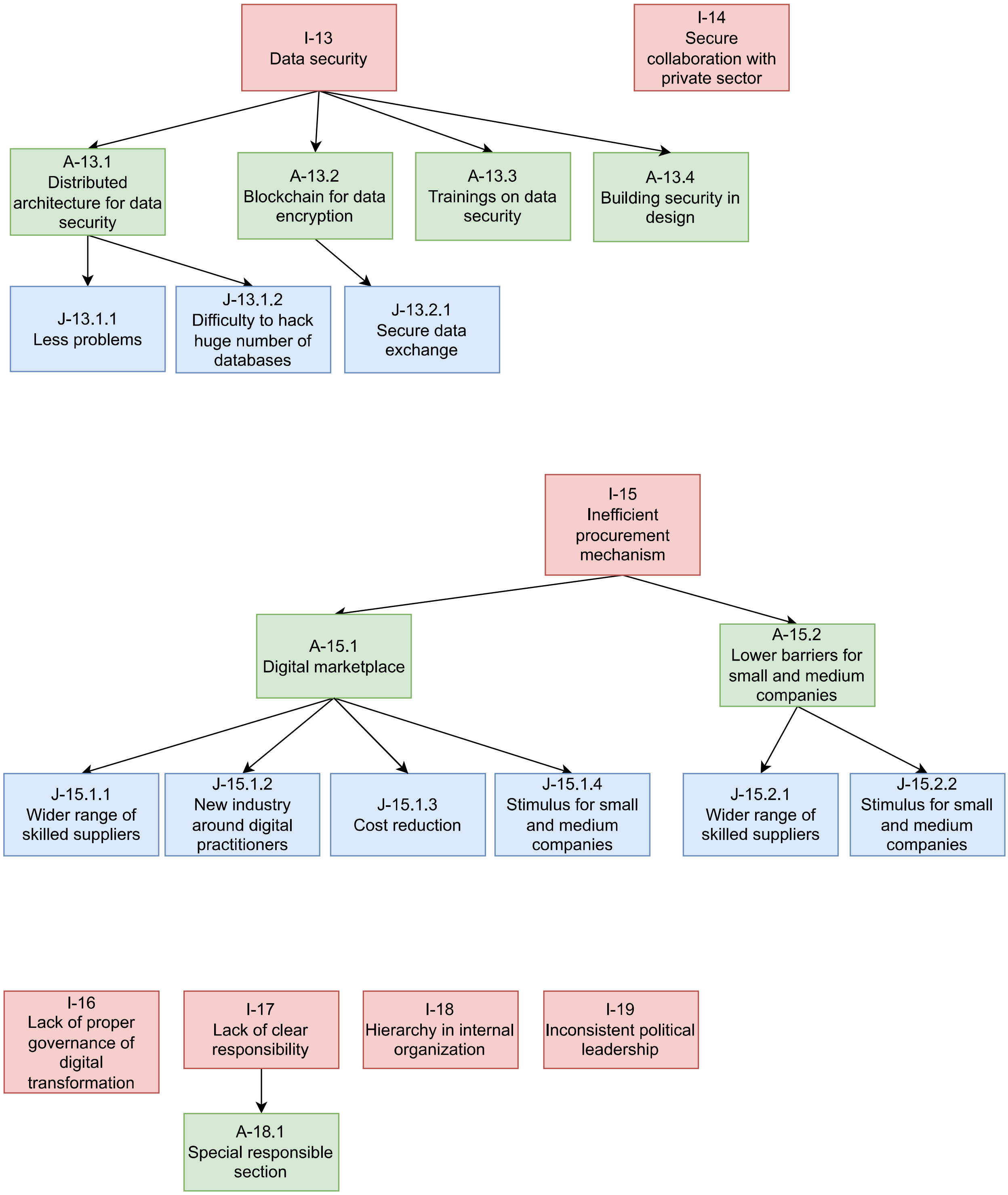


Figure A.1.: Design decision trees

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