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Factors that influence the dominance of an enterprise reference architecture: A comparative case study - Appendices

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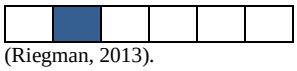
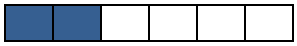
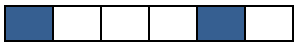
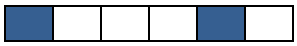
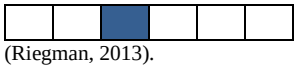
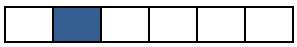
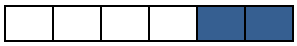
Appendix 1: Description of the factors favouring the emergence of single or multiple designs

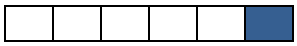
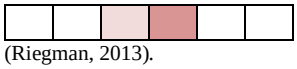
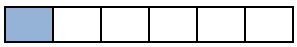
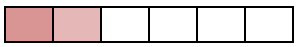
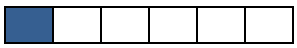
This table provides an extensive overview and description of the factors and their impact in the literature on standards battles. The first column shows the name of the factor. The second column provides a formal definition of the factor and a description of its impact. It illustrates whether the factor promotes the dominance of a single standard or the co-existence of many, or both at the same time. It also shows the intensity of its impact on the phases identified by Suarez (2004) and Riegman (2013). The third column explains the meaning of the factors and provides comments and practical examples. Companies may use this table to understand which factors lead to the dominance of a single standard, which favours the coexistence of several standards, and which play a role in a specific phase.

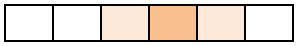
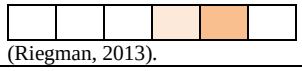
Favouring the emergence of a single design (light effect, moderate effect, strong effect)
Favouring both single and multiple designs (light effect, moderate effect, strong effect)
Favouring the co-existence of multiple designs (light effect, moderate effect, strong effect)

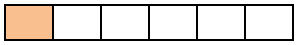
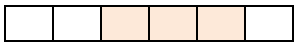
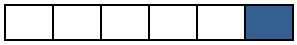
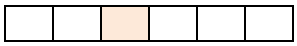
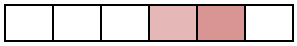
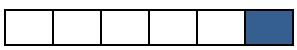
Factor	Definition and Phase	Explanation
Technology superiority	*"A standard is technologically superior when it has features that all this standard outperforms other standards"* (based on Schumpeter (1934), mentioned by Van de Kaa (2009)).  (Riegman, 2013).	This factor plays a prominent role when there are broad technical differences between competing alternatives (Suarez, 2004). For instance, Sony's Trinitron technology for TVs and RCAs shadow mask had several performance differences, and technology superiority played an important role. Betamax and VHS had fewer differences in performance, and as such, technology superiority played a minor role.
Fitness for use	*"The extent to which the product successfully serves the purposes of the user during usage. Parameters for Fitness for Use include: quality of design, quality of conformance, abilities, and field service*" (Juran, 1980: 629).	By involving multiple stakeholders, firms can adapt the standard to their requirements, thus making it more suitable for their use. This factor played a central role in the battle between Blu- ray and HD-DVD. Many Blu-ray stakeholders requested changes to the standard. By accommodating their requirements, ICT pioneers and film companies have colossal market shares in their industries. This helped

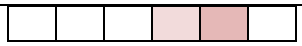
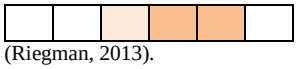
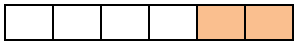
	 (Riegman, 2013).	the company gain a broader network and achieve dominance (De Vries & Van den Ende, 2013).
Complementary assets	*"Those other goods needed to successfully commercialize a certain format"* (Van de Kaa et al., 2011: 1404).  (Riegman, 2013).	Complementary assets include objects used in conjugation with the main product, increasing its overall value. The higher the number of complementary assets, the higher the value of the main product, increasing its likelihood of achieving dominance (Riegman & de Vries, 2013).
Firm's credibility	*"A recognized brand name and sponsorship of de-facto standards creates expectations for the potential success of a new technology"(*Den Uijl, 2015: 38).  (Riegman, 2013).	Klepper and Simons (2000) demonstrated that having an established reputation granted radio firms an advantage over new entrants in the emerging TV industry, also known as "dominance by birth-right". Sony's credibility played a central role in overcoming Nintendo's leadership position in the game console industry (Gallagher & Park, 2002).
Timing of entry	*"Point in time at which the first products in which the format is implemented enter the market"* (Van de Kaa et al., 2011: 1404).  (Riegman, 2013).	The technology that is first to market can benefit from increasing returns to adoption and a head start in establishing an installed base (Den Uijl, 2015: 38), helping the company to create an established reputation (Suarez, 2004). An early entry in R&D activities enables the company to learn faster (Suarez, 2004). However, it could also cause a lock-in effect, especially in fast-paced markets. In other words, by investing early in a technology, a firm may be stuck in a technology that is not likely to result in the dominant design (Suarez, 2004).
Marketing communications	*"Creating market awareness regarding the availability of a technology, informing the customer of its strengths, and influencing customer and industry perception regarding its potential success*" (Den Uijl, 2015: 38).  (Riegman, 2013).	Many models have underlined the importance of creating expectations for a new technology or a new design (Suarez, 2004). Pre-announcements can create a hype and positive customer expectations, while at the same time causing them to wait before adopting a competitor design (Suarez, 2004). For instance, Sony used this strategy when it pre-announced PlayStation 2, exactly one year before its real launch in the market and a week after Sega launched its 128-bit Dream Cast console (Suarez, 2004). The dominance of a design is mostly influenced by communication marketing: External communications, "*the content and topics that are mentioned in the communication*", the organisation of internal communication, "*the*

		knowledge management within the consortium", and the organisational planning, "*the rational planning process of organising Marketing Communications*" (Argam, 2011, p.47).
Size of a firm's installed base of users	*"The number of users applying a particular technology at a certain moment in time, the number of users of products of a particular firm, or the number of products in use"* (Den Uijl, 2015: 38).  (Riegman, 2013).	This refers to the number of people who have adopted and are using the technology and can be categorised as users. The higher the number of users, the higher the technology's adoption rate, resulting in an increased likelihood of becoming dominant (Katz & Shapiro, 1985).
Regulation and institutional intervention	Regulatory interferences of governmental or official institutions during the standards battle (Suarez, 2004).  (Riegman, 2013).	The government may interfere in the standards battle by mandating a particular technology, thus making it the domain design (Suarez, 2004).
Big fish	*"A player (other than the group of format supporters) that can exercise a lot of influence by either promoting or financially supporting a format or by exercising buying power that is so great that this will tip the balance for the format to become dominant in the market"* (Van de Kaa et al., 2011: 1405).  (Suarez, 2004)	The government or any other powerful institution may increase the likelihood of a standard becoming dominant by massively purchasing it. Alternatively, it could simply promote and sponsor it (Suarez, 2004).
Network effects	*"Products for which the utility that a user derives from consumption of the good increases with the number of other agents consuming the good"* (Katz & Shapiro, 1985: 424).	The stronger the network effects, the higher the probability of a technology gaining dominance.

	 (De Vries, 2020)	
Switching costs	*"Costs for the consumer when switching from using one technology to another"* (Den Uijl, 2015: 38).  (Riegman, 2013).  (Riegman, 2013).	High switching costs may cause a "lock-in" effect. Shifting to an alternative might be too expensive, resulting in network effects to be hindered (Katz & Shapiro, 1985). More specifically, this is likely to happen when multiple designs are introduced in the market one after the other, each creating its base and serving its segment of customers (Klemperer, 1987). However, high switching costs promote a single dominant design when it has already emerged (Den Uijl, 2006; Egyedi, 1996).
Regime of appropriability	*"Environmental factors that govern an innovator's ability to capture the profits generated by an innovation' (Teece 1986). It is the ability of a firm to protect an innovation from imitation by competitors (Lee et al. 1995).*  (Riegman, 2013).  (Riegman, 2013).  (Riegman, 2013).	Appropriability consists of six aspects: patents, secrecy, lead-time, learning curve, efficiency sales, and service effort (Levine et al., 1987). Teece (1986) identifies three legal instruments: patents, copyrights, and trade secrets. The regime of appropriability is likely to mediate the power of the technology superiority factor. The bolder the firm's appropriability regime, the higher its likelihood to achieve dominance (Teece, 1986). However, protecting a technology can dramatically decrease its likelihood of becoming a dominant design, given the high risk and the fear of vendor lock-in. When a technology is completely open and lacking an appropriability regime, it will attract more firms willing to create complementors to use the technology, thus boosting its emergence as a dominant design. Furthermore, appropriability regimes increase the likelihood of localised monopolies within specific market niches (De Vries et al., 2011).
Characteristics of the technological field	*"The structure and all the dynamics of the market and technological field (specific dynamics, rules of engagement and information sharing practices"* (Den Uijl, 2015: 39).  (Riegman, 2013).	As Garud et al. (2002: 197) point out, "within technological fields, the meaning of artifacts and patterns of interaction among actors emerge through a negotiated process". Within the same technological sector, various technological trajectories compete for dominance. This implies that the ability of a firm to reach an agreement with other players, such as customers, suppliers, firms producing complementary products in the same field partly depends on the structure and dynamics of the sector itself – such as the number and power of other players (Garud & Rappa, 1995). Research in industrial economics has shown that the early market structure along the whole value system can influence firms' standardisation efforts, making it harder or easier to achieve a dominant design (David & Greenstein, 1990).

Distinct features in product niches and consumer communities	Dissimilar value propositions between competing designs, which then attract different market segments (De Vries, De Ruijter, & Argam, 2011).  (Riegman, 2013).	When the competing designs have different characteristics, they offer different advantages and meet the needs of different segments in the market. This leads to each design developing its own installed base, and no overall winner (Arthur, 1990; De Vries et al., 2011).
Gateway technology	*"Establishes compatibility between non-compatible systems by enabling conversion from one side to the other"* (Den Uijl, 2015: 39).  (Riegman, 2013).	A gateway technology establishes ex-post compatibility between non-compatible systems. If it exists and is cheap and easy, it will prevent the emergence of a single dominant design (De Vries, et al., 2011).
Multi-channel system	*"Hybrid product able to accommodate multiple designs"* (De Vries, 2019)  (Riegman, 2013).	Firms that have invested in adapting to multiple interfaces are not likely to drop them to adopt a single standard. Dropping an interface would stop interoperability with artifacts using the standard specifying that interface, at the cost of market support for that standard. Formulated differently, keeping multiple interfaces allows multiple standards to coexist (Riegman, 2013).
Persistency	*"Continued strong support for the design even if it is clear that it will not win"* (De Vries, 2019).  (Riegman, 2013).	Recent history shows cases of firms that continue to invest in their technologies, despite little to no possibility of winning the battle. Due to this continuing support, the situation of multiple formats continues, and the likelihood of achieving a single, dominant format decreases (De Vries, De Ruijter, & Argam, 2011). Sony is an example in the flash memory card battle. It continued to invest in its own technologies, making them compatible with its products only (De Vries, De Ruijter, & Argam, 2011).
Speed in technological development	A technologically fast-paced scenario where new technologies are introduced in the market frequently, before the previous technology had the opportunity to achieve dominance (De Vries, De Ruijter, & Argam, 2011).  (Riegman, 2013).	If a new technology is introduced in the market before the competition ends, no single dominant design will emerge. Consequently, the higher the speed in technological development, the fewer the chances of a design winning the battle (De Vries, De Ruijter, & Argam, 2011).

Application drives design	Effect of purchase decisions beings based on other features than the standard used (De Vries, De Ruijter, & Argam, 2011).  (Riegman, 2013).  (Riegman, 2013).	If the standard relates to a product feature that plays a minor role in the purchase decision, the competing standards' installed base will continue to grow. There will then be no reason for both standard promoters to terminate their use (De Vries, 2019). For example, in the case of complementary goods such as flash memory cards, consumers did not base their choice on the specification of the flashcards themselves. Instead their choice depended on the specifications of the host product itself, e.g., a camara. They will not consider the set of compatible products and their features, particularly when a gateway technology is present as well. From the consumer perspective, the drawback of having multiple formats can be easily overcome (De Vries, De Ruijter, & Argam, 2011).
Pricing strategy	*"Temporally price below cost in order to build an installed base"* (Van de Kaa, Van den Ende, De Vries, & Van Heck, 2011: 1404).  (Riegman, 2013).	A penetration pricing strategy allows a design to rapidly reach a wide share of the market, thus contributing to the emergence of a single design (Katz & Shapiro, 1994). However, when technologies are cheap, customers are not likely to pay attention to their specifications, thus decreasing the possibility of achieving a single design (De Vries, De Ruijter, & Argam, 2011).
Cross-side network effects	Increasing the value of a two-sided platform for users on one side by the growth of users to the other side. (Riegman, 2013).  (Riegman, 2013).  (Riegman, 2013).  (Riegman, 2013).	Each two-sided platform has to deal with a common problem: gaining enough momentum (number of users) on one side of the market to make it worthwhile for the other side to join. This situation will likely result in "excess inertia", leading multiple platforms to coexist (Hagiu & Eisenmann, 2007). This situation can worsen when new platforms only show their value once a network has been established. The result is no design and no competition (Farrell & Saloner, 1986).
Same side network effects	Increasing the value of a platform when more users from the same side adopt it. (Riegman, 2013).  (Riegman, 2013).	Same side platforms can suffer from "excess inertia", a situation in which users wait and see whether to adopt the new design, leading to the co-existence of multiple designs (Srinisvasan, Gary, & Rangaswamy, 2006). This situation can worsen when no design emerges because the benefits from adopting a technology can only be appreciated in the long run when it has built a wide network (Riegman, 2013).

	 (Riegman, 2013).	
Local network effects	Increasing value of a platform for a user when more users from a small subset adopt it. (Riegman, 2013).  (Riegman, 2013)	In case users mainly interact within a local network, the networks effects apply at this level and not at the level of the market as a whole. Then it hardly matters of other local networks use another standard. This discourages the emergence of a single dominant standard (Blind, 2011).
Low costs of development and maintenance of designs	Low costs for creating and updating a standard make it more attractive for firms to create their own design rather than purchase the licensing fees for another (De Vries, De Ruijter, & Argam, 2011)  (Riegman, 2013).	This is especially true if fixed costs are low (Blind, 2011). Firms are generally more motivated to develop their competing designs to prevent dependency and increase financial returns (Riegman, 2013). When the costs of maintaining a design remain low over time, firms developing a design will incur less loss from staying in the market and are less likely to give up.
Fear of monopoly	*"Decision of an entity not to support a design with the purpose of preventing it from gaining a dominant position in the market"* (Riegman, 2013: 66).  (Riegman, 2013).	Fear of monopoly occurs when an entity decides not to support a design to prevent it from gaining a dominant position in the market (Riegman, 2013). A single design is more likely to acquire a larger network share as time goes by. Fear of monopoly has a larger impact during the last phases of the dominance process (Riegman, 2013).
Interference of competition authorities	Competition authorities intervene during the dominance process to check, investigate, and stop any player that displays anti-competitive conduct.  (Riegman, 2013).	This occurs particularly during the last phases, when a single design has already emerged (Riegman, 2013).
Timing of fast followers	The ability of industry players to learn quickly from early entrants and launch competing designs	Fast followers may enter the market and learn from early players' mistakes before creating an installed base, thus favouring the existence of multiple players (Riegman, 2013).

	accordingly (Riegman, 2013).  (Riegman, 2013).	

Appendix 2: Description of Cases

1.1.1 TOGAF

TOGAF, The Open Group Architecture framework, was first developed in the early 1990s, with its first publication in 1995 (The Open Group, 2018). TOGAF represents a methodology for the development of technical architecture. More specifically, it provides tools and methods for helping in the acceptance, production, use, and maintenance of the EA. Thus, this framework is based on an iterative process model supported by best practices and a reusable set of architecture artefacts (The Open Group, 2018).

TOGAF comprises four architectural domains (The Open Group, 2018):

- Business architecture: describes the business strategy, governance, key processes, and organisation and the interrelations between them;
- Data architecture: describes the structure of an organisation's logical and physical data assets and data management resources;
- Application architecture: describes the structure and interactions of the applications as groups of capabilities that provide essential business functions and manage data assets;
- Technology architecture: describes the logical software and hardware capabilities needed to support the development of business, data, and applications services. It includes ICT infrastructure, network, communication, etc.

TOGAF comprises six main core concepts (The Open Group, 2018):

- The architecture development model (ADM) (https://www.opengroup.org/togaf): a step-wise process for developing and implementing the EA. The ADM includes establishing an architecture framework, developing architecture content, transitioning, and governing architectures' realization. All these activities are carried out by following an iterative cycle comprising ten phases.
- ADM supporting guidelines and techniques: the rules needed for the application of the architecture.
- ADM content framework (https://pubs.opengroup.org/architecture/togaf91-doc/arch/Figures/34_contentfwk5.png): a complete model of architectural work products. It provides extensive descriptions of the deliverables, artifacts within deliverables, and architectural building blocks.
- Enterprise continuum (https://pubs.opengroup.org/architecture/togaf91-doc/arch/Figures/39_entcon.png): a view of the architecture repository that offers ways for classifying architecture and solutions artifacts as they change from generic foundation architectures to organisation-specific architectures. In other words, it offers a framework and context to support the leverage of relevant architecture assets in executing the ADM.
- Reference models (https://pubs.opengroup.org/architecture/togaf91-doc/arch/Figures/44_iiirm5.png): The TOGAF Technical Reference Model (TRM), which provides a model and a taxonomy of generic platform services, and the Integrated Information Infrastructure Reference Model (IIIRM), which contains the

critical components for developing, managing, and operating an integrated information infrastructure.

- Architecture capability framework (https://pubs.opengroup.org/architecture/togaf9-doc/arch/Figures/02_concepts4.png): a set of resources, best practices, and information offered to assist the architect in getting used to the architecture practice in the organisation.

1.1.2 Gartner Architecture

Gartner currently provides a business-outcome-driven reference architecture to meet the challenges of increasing uncertainty and growing dynamics (Brand, 2020).The Gartner reference framework employs three architecture viewpoints, each described by the logical, conceptual, and implementation points of view (Tritsiniotis, 2013). The framework comprises the business, information, and technology viewpoints, bridging the business and information sides gap. Following Gartner, the starting point to develop an architecture is business goals, representing the architecture requirements (Tritsiniotis, 2013). Later, these requirements were translated to the architectural and infrastructural design. Gartner developed an integrated EA process model for implementing the EA. The EA process model's fulcrum is a cycle describing the current and future architectural states along with a gap analysis between them (Tritsiniotis, 2013).

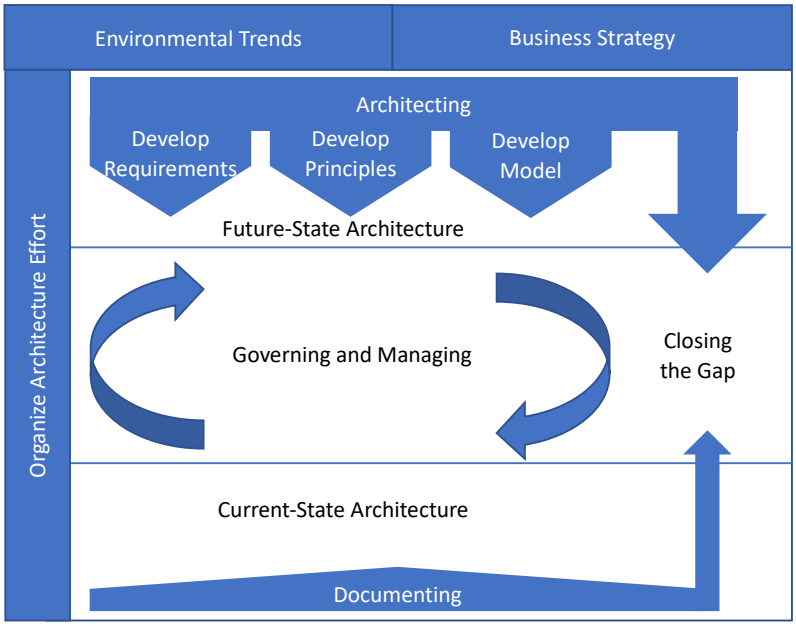


Figure 1 Gartner reference architecture (based on Desai, 2020)

1.1.3 NORA

NORA is a guiding instrument content provides the information for organising the information and management of the Dutch government (Nora, 2021c). NORA comprises four basic elements: principles, standards, building blocks, and a conceptual model (Nora, 2021c).

Principles

NORA's principles offer governmental organizations direction in the development and implementation of architectural frameworks (Nora, 2021a). Each principle is described using the TOGAF format: statement, rationale (explanation), and implications (Nora, 2021a). NORA uses basic and derived principles (Nora, 2021a). Basic principles focus on describing the quality of government services from the perspective of the wishes of society, citizens, and companies. In other words, they can be seen as goals (Nora, 2021a):

- BP01: *Customers get the service they need*
- BP02: *Customers can easily find the service*
- BP03: *Customers have easy access to the service*
- BP04: *Customers experience uniformity in the service through the use of standard solutions*
- BP05: *Customers are offered related services bundled*
- BP06: *Customers have access to information relevant to them*
- BP07: *Customers are not confronted with superfluous questions*
- BP08: *Customers can be confident that information will not be misused*
- BP09: *Buyers can trust that the service provider will adhere to agreements*
- BP10: *Customers can provide input about the service*

Derived principles focus on describing how things should be get done (Nora, 2021a). In other words, they constitute guidelines for the operational level by setting concrete implications (Nora, 2021a):

- AP01: Services are reusable
- AP02: Disconnect with services
- AP03: Services complement each other
- AP04: Position the service
- AP05: Accurate service description
- AP06: Use standard solutions
- AP07: Use the rural building blocks
- AP08: Use open standards
- AP09: Preferred Internet channel
- AP10: Additional channel
- AP11: Equivalent result regardless of channel
- AP12: One-off request
- AP13: Source registrations are leading
- AP14: Report back to source holder
- AP15: Target limitation (AP)
- AP17: Information objects systematically described
- AP18: Spatial information via location
- AP19: User's perspective
- AP20: Personal approach
- AP21: Bundling of services
- AP22: No wrong door
- AP23: Automatic services
- AP24: Offer proactively
- AP25: Transparent services
- AP26: Customer has access
- AP27: A responsible organisation
- AP28: Appointments set
- AP29: The service provider complies with the standard

- AP30: Accountability for service delivery possible
- AP31: PDCA cycle in control quality
- AP32: Quality control at the highest level
- AP33: Baseline quality services
- AP34: Accountability for quality control
- AP40: Non-repudiation (principle)
- AP41: Availability
- AP42: Integrity
- AP43: Confidentiality (principle)
- AP44: Controllability

Standards

NORA defines a standard as *"A document containing a set of rules describing how people should develop and manage materials, products, services, technologies, tasks, processes, and systems."* (Nora, 2021e). More specifically, a standard (Nora, 2021e):

- represents an electronic document in which specifications or criteria for a product or service are set and explained;
- is set by a company, consortium, or by a recognized standardisation institution;
- is the outcome of a process in which the standard is developed, organised, and managed.

NORA refers to the following standards (Nora, 2021e):

- The open standards from the Dutch Standardization Forum (https://www.forumstandaardisatie.nl/) to which all Dutch governments have committed, by means of a 'Comply or Explain policy';
- List of recommended open standards of the Dutch Standardization Forum;
- The standards used by the Dutch municipals of the ERA "GEMMA Online";
- The standards used by the Dutch central government of the ERA "Enterprise Architectuur Rijk";

Building blocks

NORA defines a building block as a *"Provision that is part of the e-government infrastructure"* (Nora, 2021d). In other words, a building block can be seen as a product made up of a system of agreements. Therefore, governmental agencies can reuse these building blocks to ensure compatibility and interoperability (Nora, 2021). The use of building blocks is one of NORA's strategic goals. NORA includes 82 building blocks. The Digindentity (DigiD), the digital authentication service for governmental organisations and public service providers is one of its well-known building blocks (Nora, 2016, 2021g). Its purpose is to identify citizens online through their BSN (citizen service number). The National Register of Commerce, which contains a list of all entrepreneurs and legal entities in the Netherlands, is another example of a building block. "MyGovernment" provides citizens with a complete overview of their personal data at government organisations, digitally sending letters from governmental organisations, and following status transactions and affairs.

Themes

Themes represent the most active part of the NORA architecture (Nora, 2019b) as they represent elements for architects and content experts to exchange knowledge and experiences (Nora, 2019b). This broad community may comprise a wide range of stakeholders, such as architects and project leaders, who are committed to the theme and together want to find tools and best practices that make their work more enjoyable, effective, and efficient (Nora, 2019b). NORA has also set specific guidelines for the design of a new theme.

One of the well-known themes are APIs. APIs represent a vital element for the NORA architecture since they will ensure the easy exchange of data among different agencies complying with the architecture. It is therefore essential that APIs can be reused (Nora, 2021b). Mobility represents another topic constituting a theme (Nora, 2020a). Mobility is an important subject for the public sector, since both public employees and citizens expect access to many services from their mobile phones, such as paying taxes.

Many sub-architectures reference NORA, and all of them together make up the NORA family, which includes different levels of public administration in the Netherlands (NORA Nederlandse Overheid Referentie Architectuur, 2019a). Therefore, NORA represents the most abstract and general layer while its subsidiaries are more specific and suitable for a particular context The NORA family shares the same core values (NORA, 2019a).

Examples include: GEMMA, which is the municipal model architecture (Nora, 2018), DERA, which is the reference architecture for the cultural domain (Nora, 2020a), and PURA, which is the reference architecture for the public health sector (Nora, 2020b).

1.1.4 EIRA

The EIRA represents a four-view reference architecture aimed at achieving interoperability in digital public services across European sectors and countries (European Commission, 2021b). Interestingly, it ensures this interoperability by setting architecture building blocks. The EIRA shows four main characteristics (European Commission, 2021b):

- Use of common terminology to achieve common understanding and coordination: EIRA offers a set of straightforward building blocks to obtain a common understanding of the content of the necessary building blocks to develop interoperable public services;
- Reference architecture for the creation of digital public services: it provides a framework of reference to exploit reusable building blocks to create a digital public architecture;
- Technology-product-neutral and service-oriented architecture (SOA) style: it adopts a service-oriented style while exploiting ArchiMate as a modelling language;
- Alignment with EIF and TOGAF: EIRA complies with the context given in the European Interoperability Framework. In fact, the EIRA views correspond to the interoperability levels in the EIF: legal, organisational, semantic, and technical

interoperability. Furthermore, EIRA reuses the terminology and paradigms from TOGAF, such as architecture patterns, building blocks, and views.

More specifically, the EIF represents a complement of the EIRA, providing specific guidance on setting up and implementing interoperable digital public services (European Commission, 2021a). The EIF can be further categorised into three main areas, underlying principles, interoperability layers, and the conceptual model (European Commission, 2021a).

Underlying principles

These principles guide policymakers to achieve interoperability and constitute fundamental behavioural aspects that drive interoperability actions (European Commission, 2021a). These principles can be divided into four different categories (European Commission, 2021a):

- Principles setting the context of EU actions on interoperability: subsidiarity and proportionality;
- Core interoperability principles: openness, transparency, reusability;
- Principles related to generic user needs: security, privacy, user centricity, inclusion, and accessibility;
- Principles for cooperation among public administrations: administrative simplification, preservation of information, and assessment of efficiency and effectiveness.

Interoperability layers

Interoperability layers embody different aspects of interoperability that should be addressed by every architecture (European Commission, 2021b). These layers include (European Commission, 2021b):

- Interoperability governance involves decisions on interoperability frameworks, roles and responsibilities, policies, and rules in the public sector. This represents a cutting-edge component since it affects both legal, organisational, semantics, and technical layers and requires common standards and specifications;
- Integrated public services governance involves ensuring interoperability, common planning, and coordination among public agencies. This involves setting interoperability agreements at all levels and establishing operational and change management procedures.
- Legal interoperability: involves complying with the rules set by the government's scope in which it operates, setting and respecting clear agreements about how to deal with differences in legislation across borders, and continuously checking legal barriers for cooperation to preserve and achieve coherence.
- Organisational interoperability involves aligning business processes, responsibilities, and expectations among public administrations, meeting users' requirements uniformly, and uniformly documenting their business processes.
- Semantic interoperability involves defining a precise format and meaning of exchanged data, with the overarching goal of obtaining straightforward and understandable information. Thus, semantic interoperability covers both semantic and syntactic aspects. Public administrations should start by setting an information

management strategy at the highest possible level to pursue priority and prevent fragmentation. For instance, this may include establishing taxonomies, codes, and a common enterprise vocabulary. Supporting the establishment of sector-specific and cross-sectoral communities can be helpful to achieve open information specification and encourage administrations to share their ways of doing on both national and European platforms.

- Technical interoperability involves achieving interoperability between infrastructures and applications linking systems and services. Interoperability affects interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols. Technical interoperability should be achieved and maintained using formal technical specifications.

Conceptual Model

The conceptual model (https://joinup.ec.europa.eu/collection/nifo-national-interoperability-framework-observatory/4-conceptual-model-integrated-public-services-provision) represents an asset for all EU governmental levels since it guides the planning, development, operation, and maintenance of integrated public services (European Commission, 2021c). It shows a modular structure that includes loosely linked service components. The conceptual model comprises the following essential components (European Commission, 2021d):

- Coordination function to ensure that changing necessities are spotted and that meaningful solutions are identified and spread. The following four phases are needed to achieve this: identification, planning, execution, and evaluation.
- Internal information sources and services to ensure that a shared infrastructure of reusable services and information sources can be used by the whole public sector, avoiding duplication of information. Public administrations should promote this by motivating people to reuse, publish, and aggregate their information.
- Basic registries: *"A base registry is a trusted and authoritative source of information, which can and should be digitally reused by others, where one organisation is responsible and accountable for the collection, use, updating and preservation of information. Base registries are reliable sources of basic information on data items such as people, companies, vehicles, licences, buildings, locations and roads."(European Commission, 2022).* Privacy rules and other regulations should regulate access to them. Every registry should also set up and implement a data quality assurance plan to ensure the quality of their information.
- Open data to ensure machine-readable data is available to others, transparency, fair competition, innovation, and a data-driven economy. Data should therefore be easy to find and process. Open data should be shared in non-proprietary formats.
- Catalogues to enable stakeholders to find reusable sources more easily. Various kinds of catalogues exist. For example, a specific catalogue is the European Interoperability Cartography (EIC), which is defined as the *"repository of interoperability solutions for European public administrations provided by Union institutions and Member States, presented in a common format and complying with specific re-usability and interoperability criteria that can be represented on the EIRA"* (European Commission, 2015).

- External information sources and services to ensure that public agencies can exploit services and information provided by third parties while developing European public services.
- Security and privacy to ensure that public administrations and their stakeholders are not vulnerable to cyberattacks. Security is essential for the exchange and storage of data among organisations.

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