administrative sciences

MDPI

Article

A Systematic Literature Review on Existing Digital Government Architectures: State-of-the-Art, Challenges, and Prospects

Baseer Ahmad Baheer *, **David Lamas** and **Sónia Sousa**

School of Digital Technologies, Tallinn University, Narva maantee 25, 10120 Tallinn, Estonia; drl@tlu.ee (D.L.); scs@tlu.ee (S.S.)

* Correspondence: bbaheer@tlu.ee; Tel.: +372-5375-4954

Received: 12 February 2020; Accepted: 16 April 2020; Published: 22 April 2020

check for updates

Abstract: System architecture plays a crucial role in the establishment of Digital Government infrastructure. Over recent decades, various architectures have been introduced by scholars for the establishment of Digital Government infrastructure. However, there is no uniform agreement on Digital Government architecture concepts required for Digital Government infrastructure. To more thoroughly examine the Digital Government architecture introduced in this article, we collected 103 papers published between 2003 and 2020 retrieved from five leading literature databases. To conduct our research, we followed best practice scholarly accepted guidelines for researchers. Per the guidelines, we formulated research questions and employed an approach based on specific inclusion and exclusion criteria to meet our research goals. Our study found evidence that there is a lack of knowledge in terms of the state-of-the-art in Digital Government infrastructure and its challenges concerning existing Digital Government architectures. We identified a set of primary Digital Government architecture characteristics and building blocks on which the Digital Government infrastructures are built. These components are meant to improve the design of future Digital Government systems and applications. Furthermore, our research revealed a need for designing a reference architecture to provide government organizations with the best practice knowledge of already existing Digital Government architectures.

Keywords: Digital Government; e-government; architecture; challenges; characteristics; components; building-blocks

1. Introduction

Increasingly, governments across the world consider Digital Government to be a political priority Tambouris et al. (2014), and in recent years significant capital has been invested in the development and adoption of Digital Government services by public bodies Meneklis et al. (2005). Despite all the good intentions, efforts, and considerable investments in Digital Government projects, a majority of these projects (60–85%) fail Heeks (2005), and the existing investment and development efforts are often ineffective and a massive waste of funds. Furthermore, the Digital Government environment has developed rapidly, yet Digital Government systems are less dependable and up-to-date, as compared to e-business and e-commerce Sedek et al. (2012).

In the context of the Digital Government, some particular requirements or concerns must be taken into account, not only during the implementation phase but also at the early design or architecture modeling phases Meneklis and Douligeris (2007). Literature sheds light on the failure's cause, which is ineffective project management, unrealistic planning Anthopoulos et al. (2016), lack of adequate ICT infrastructure Joshi et al. (2017), and a significant difference between project design and the reality that comes into play while implementing the design Heeks (2003). The Digital Government's success level is heavily influenced by widely-held views regarding maturity models Joshi and Islam (2018), technical standards and formal design practices Meneklis et al. (2005) to design sustainable Digital Government services.

To-date, multiple case studies demonstrate that architectures aid the successful implementation of Digital Government initiatives and strategies Martin et al. (2004). Numerous architectures have been developed, but there are documented challenges regarding these architectures to assist governments in establishing operable and effective Digital Government infrastructure. Consequently, it can lead to reductions in Digital Government project failures Tambouris et al. (2014). Hornnes et al. (2010) claim that architecture in the public ICT area should be regarded as an essential component of a state information infrastructure. Additionally, it should be adjusted to different principles and meet a broader spectrum of needs rather than solely conventional types of infrastructures, including specific executive, administrative, and organizational context that it targets.

Yet, in the context of Digital Government, the problems are mostly associated with implementation, not strategies Rabaiah and Vandijct (2011). Thus, many studies have illustrated that architecture design is one of the significant strategic steps towards the successful implementation of Digital Government. The design of a Digital Government architecture favors reflection of multiple aspects, including legal, organizational, semantic, and technical views EU European Commission (2019). In this presented work, we particularly want to highlight the technical view, including the high-level technical building-blocks that constitute the Digital Government architectures, specifically the software components and the used architectural style and standards.

Architecture should be viewed both as a risk-mitigating tool and as an organizational shaping method to minimize project failure and handle risk in organization networks Janssen and Klievink (2012). The crucial characteristic of the architecture is that it can be regarded as a common communication channel between various stakeholders of an information system Meneklis and Douligeris (2007). Conclusively, in the context of Digital Government, an architecture gives an overall overview of Digital Government components, i.e., building-blocks and connections between components Sedek et al. (2011).

More investigation is required concerning the design of Digital Government architecture to reach the adaptability and accountability requirements of Digital Government infrastructure (Janssen 2007; Hornnes et al. 2010). There are numerous articles available in the corpus of literature pertaining to Digital Government that deal with the Digital Government infrastructure and implementation. Based on the collected literature, this paper attempts to analyze particular literature dealing with Digital Government architectures systematically. Results from international studies have illustrated that design-reality gaps Heeks (2003), ineffective project management, and unrealistic planning, are the most common reasons for the Digital Government project failure (Anthopoulos et al. 2016; KPMG 2017). Considering the high failure rate of Digital Government projects, rapid technology advancement, and newly defined requirements by the governments, we reason that it is appropriate at this stage to provide common ground for the comparison and evaluation of available Digital Government architecture—based on the challenges that face Digital Government development today and from the architectural perspective. New regulations and contemporary technologies will have increasing influence over future interactions, specifications, new services, and enhancement of existing services Giorgi and Hauptman (2007). Furthermore, this study aims to investigate what has been documented in the literature as the main components or architecture building-blocks for the establishment of a Digital Government infrastructure.

This work is based on published articles in scientific venues, and due to its approach, it ignores works disseminated through other venues such as technical, white papers, and policy documents. It is a limitation, but it ensures that the approach is systematic, and it has strengths in terms of making sure that people understand the process.

The outcome of this study could provide insights for guiding future research regarding the development of a sound reference architecture that adjusts to government strategies and policies, and corresponds to current technological changes and reduces complexity and confusion surrounding Digital Government implementation. Furthermore, the outcomes could provide practitioners with some insights geared towards strategic business goals formulation.

2. Related Work

In the corpus of Digital Government research literature, there is a dearth of examples of reviews on Digital Government architecture. This is due in large part to the fact that Government Architecture (GA) is a relatively new discipline in which core concepts are only gradually emerging Janssen et al. (2013). As a result, there has been relatively scant attention from researchers on investigations of the causal factors behind the failures of many Digital Government projects in developing countries.

In this regard, Dada (2006) conducted a literature review exploring the reasons why many Digital Government projects fail in developing countries. This literature review provides a foundation for our study by demonstrating a relevant background for practitioners and those involved in the implementation of Digital Government applications. This research employs Heeks (2003) 'archetypes of failure', which refers to gaps between the design of the technology and the reality of the context using some of the contemporary literature. This article does not attempt to investigate the challenges from an architectural perspective.

Digital Government implementation is an ongoing process, and its development is conceptualized in stages Almarabeh and AbuAli (2010). Accordingly, researchers are increasingly aware of how architecture is essential to the conceptualization of Digital Government development (Agarwal et al. 2017; Cellary and Strykowski 2009; Peristeras and Tarabanis 2004) and in establishing government-wide guidelines to develop ICT infrastructure Azad et al. (2008). Case studies demonstrate that the use of appropriate architecture can lead to the successful facilitation of Digital Government initiatives and strategies Martin et al. (2004). In reviewing various Digital Government literature, it becomes evident that architecture is used to guide design decisions Janssen and Kuk (2006).

A study was conducted by Moreno et al. (2014) to examine some of the developed enterprise architecture for government in various countries, including Korea, the USA, Canada, Spain, Australia, Brazil, the UK, and Colombia. The review presents a comparison of the architecture domains used in each framework. The primary objective of the study is to create the Colombian Government Enterprise Architecture Framework and to establish its principles, standards, and guidelines. This study outlines the Colombian Government Enterprise Architecture Framework principles, which are citizen service excellence, an investment with a reasonable cost/benefit ratio, rationalization, standardization, interoperability, feasibility on the market, technological neutrality, and federation. This study merely provides a set of principles, guidelines, and standards, and does not present the architecture itself nor the associated components.

At the higher stage of Digital Government evolution, the problem of interoperability arises and becomes one of the main obstacles of further Digital Government development Cellary and Strykowski (2009). Therefore, the study of interoperability in Digital Government has increased in recent years, and researchers are developing interoperable architectures for Digital Government (see for example (Marques et al. 2011; Sedek et al. 2014; Luna-Reyes et al. 2012; Paul and Paul 2012; Guijarro 2007)).

Accordingly, Sedek et al. (2011) conducted a systematic literature review on the topic of interoperable architecture for Digital Government portals, published within 2001–2011. As revealed in the findings of Sedek et al., Service Oriented Architecture (SOA), a one-stop portal service center, semantic web services, integrated and interoperable Digital Government, and layered architectures are the most common current Digital Government architectures. However, several other studies report enterprise (Agarwal et al. 2017; Rehman and Shamail 2014; Moreno et al. 2014; Janssen and Cresswell 2005), hybrid and distributed (Sedek et al. 2013; Meneklis and Douligeris 2007), decentralized Ye et al. (2013), and multi-agent-based (Usman et al. 2006; Zeeshan Ali Ansari and Imran Khan 2008; García-Sánchez et al. 2008) architecture as well, which are not addressed in the study by Sedek et al. The authors found that the majority of Digital Government architecture implements G2G and G2C, and most of them (59%) adopt Service Oriented Architecture or Web Services. However, the authors claimed that the architecture analyzed lacks detailed descriptions concerning structural and extra-functional properties. Thus, further investigation and precise formulation are required to produce an architecture capable of achieving a high level of interoperability and reliability. The review demonstrates how most Digital Government architecture achieves higher integration (including horizontal or vertical integration) maturity but not in the area of interoperability. The review addressed the quality attributes of architecture, which are security, reliability, usability, and performance.

Helali et al. (2011) conducted a study of Digital Government architectures in 2011, where they concentrated on the architectural design of the Digital Government from the software engineering perspective. The study focused on architectural design principles, the high level of software components that constitute the architecture, and the related technology. The authors investigated several Digital Government architectures or best practices that are built in different contexts including architecture for mobile government Gouscos et al. (2005), Geneva State Digital Government Sandoz (2009), one-stop government portal architecture Gugliotta et al. (2005), the architecture of a European e-government Project Glassey (2002), and European Commission e-mayor project (e-mayor, 2004) Kaliontzoglou et al. (2007). The findings show that only three out of seven architectures, use specific architectural standards that permit better reuse of design principles. The results reveal a set of principle features or architecture attributes that are essential for designing a Digital Government architecture. These characteristics are grouped into intrinsic characteristics, namely, interoperability, flexibility, compatibility, traceability, symmetry, cross-border characteristics, scalability, legality, cost consideration, and easy to learn, and extrinsic characteristics, namely, privacy, accessibility, transparency, mobility, and responsibility. These characteristics will enable us to conduct a comparative analysis of contemporary Digital Government architecture presented in recent years. However, this study neither evaluates the quality of the architectures nor defines the common high-level components that constitute the Digital Government architecture.

Similarly, Dang and Pekkola (2017) conducted a systematic literature review on Enterprise Architecture (EA) in the public sector. The authors claim that the EA concept has received significant attention from public sector actors around the world, and most public sector EA studies (56.25%) focuses on EA development. However, the study recommends that further research is required concerning EA to address some problems associated with EA research and governance structure, EA management, and security. The authors have not addressed any other architectural style nor compared the existing EAs.

European Union completed a pan-European project Electronic Simple European Networked Services (e-SENS) in 2017 by involving 100 public and private actors from 22 Member State countries NRW Ministry of Justice NRW Germany (2015). This project aimed to promote interoperability and the deployment of cross-border digital public services through generic and re-usable technical components, based on the building blocks of the Large Scale Pilots (LSP). e-SENS introduced consolidated building-blocks with a strong focus on e-ID, e-Documents, e-Delivery, Semantics, and e-Signature based on the achievement of previous Large Scale Pilot projects (e.g., PEPPOL on e-Procurement, eCode on e-Justice, STORK and STORK II on e-ID and e-Signature). e-SENS supports the implementation of various EU policies and promotes reaching compliance with Digital Government related legislation such as eIDAS. The result of this project has also gained attention outside Europe. Various countries such as Australia, Canada, Malaysia, and Singapore are interested in possibly reusing e-SENS solutions for their requirements EU European Commission (2020b). The result of this project has been handed over to further EU digital services programs such as Connecting Europe Facility (CEF)—CEF digital 2018 Wisniewski et al. (2016)—and The Once-Only Principle (TOOP). This transition aimed to ensure that no knowledge or experience from the e-SENS project is lost, and the building blocks remain sustained as stable components of Europe's digital ecosystem.

CEF EU European Commission (2020a) provides support and guidance to an interoperable EU-compliant digital solution. CEF added some new building blocks (e.g., e-Invoicing, e-Translation, e-Archiving, Context Broker) to facilitate secure cross- border digital interactions between citizens, businesses, and public administrations.

The TOOP project started in 2017 to ensure that public bodies take action to share data, and citizens and companies supply certain standard information only once to a public administration NRW Ministry of Justice NRW Germany (2017). TOOP aims to provide a generic federated architecture that can connect different registries containing base data and Digital Government architectures in various countries by applying standards Krimmer et al. (2017). Thus far, various European countries have started to implement TOOP at the national level, but its cross-border implementation is still fragmented and limited Tepandi et al. (2019).

European Interoperability Reference Architecture (EIRA) EU European Commission (2019) is a reference architecture with a specific focus on the interoperability aspects of digital public services in Europe. It is not the intention of the EIRA to provide a comprehensive end-to-end guide to all building-blocks to be considered for the design of any system. EIRA follows Service-Oriented architectural design, covering the structural, behavioral and governance aspects of an interoperable digital public service in alignment with European Interoperability Framework (EIF). EIRA does not address the other architectural building-blocks that they do not focus on the interoperability. We believe EIRA is a relevant architecture to be discussed here. Even though it is not scientifically proven yet in a form of peer-reviewed publications.

While the reviews presented to highlight the growth in Digital Government architecture, there remain knowledge gaps concerning contemporary Digital Government architectural characteristics, challenges, and the main components or architecture building-blocks for establishing a Digital Government infrastructure. Governments across the globe have developed their own forms of Digital Government architecture, based on the specific requirements of their countries. Hence, the purpose of carrying out a detailed systematic literature review is to analyze the existing Digital Government architectures to identify the documented primary Digital Government architecture characteristics, challenges, and the key architecture building blocks that constitute Digital Government architecture at the infrastructure level.

3. Research Method

We undertook this systematic literature review to collate and synthesize evidence on the existing Digital Government architectures.

Several methods (e.g., PRISMA Moher et al. (2015), Cochrane Anderson et al. (2016)) have been adapted by researchers to conduct a systematic literature review. The references (Khan and Park 2013; Lyzara et al. 2019; Sánchez-Torres and Miles 2017) show that the most suitable method for performing a systematic literature review in the Digital Government research domain is the Kitchenham et al. (2009) method. To complement our review, we followed Anderson et al. (2016) and Keele Staffs (2007) general guidelines as well. As we concentrate in this article on the architectural design of Digital Government systems according to a software engineering point of view, therefore the Kitchenham et al. (2009) method is the most appropriate method to adapt. This guideline was derived from three existing guidelines used by other researchers and has been adapted to reflect specific problems of software engineering research. Consequently, considering the nature, aim, and objectives of our study we employed Kitchenham et al. (2009) guidelines and adjusted them to our research domain. This includes planning the review, conducting the review, and presenting the findings of the review. The following sections explain these phases. Three researchers have independently assessed the articles which were collected and deemed it appropriate to carry out analysis on. Each author independently participated in the revision process described above and additionally to ensure results validity the article was reviewed by an independent review expert on the subject at the European Commission.

3.1. Planning the Review

We propose the review by introducing research objectives and questions applicable to our research goals. We developed the search strategy, its scope, and criteria, which are presented as follows.

3.1.1. Review Objectives and Research Questions

Digital Government application requires continuing consideration in the future Saghafi et al. (2008). Thus, developed countries became aware that to foster mature Digital Government development, it is necessary to have a centrally-governed strategy.

As defined, the system architecture is the conceptual interpretation that describes the data flow, arrangement, and relation between the elements of the system, providing a detailed field of vision Dutta et al. (2017). Architecture is a systematic and structured mechanism that creates a pathway for the advanced ICT sector and gives an integrated approach at organization Janssen and Klievink (2012). Architecture is an essential part of Digital Government implementation, which assists correlated projects to establish systems that comply with Digital Government guidelines and strategies Al-Nasrawi and Ibrahim (2013). Additionally, it ensures that the Digital Government is well-arranged and designed and provides utility. It encourages architects from all over management to tackle a common ground of Digital Government understanding and its implementation Al-Nasrawi and Ibrahim (2013). Digital Government studies address a number of noteworthy points that should be considered to increase Digital Government efficiency. Firstly, users and stakeholders should participate in system development, and public institutions should collaborate closely when creating software solutions. Secondly, business requirements should determine the types of technical solutions offered, which will streamline business processes and workflows Martin et al. (2004). Architecture can reduce risk levels and assist organizations in navigating away from potential project failure Janssen and Klievink (2012). Studies that are carried out in the governmental development project field demonstrate that very little public project work includes sufficient use of architecture as a risk management tool. The readiness of technical infrastructure serves as a basis for application development and is more straightforward for the organization to cope with the development Klischewski and Abubakr (2010). Case studies prove that architecture development can be a favorable outlook also to accessing interoperability, but it must be competently adapted and carried out as a tool for the improvement of business operations Klischewski and Abubakr (2010). With the increased use of various architectures for Digital Government infrastructure, it is of the utmost importance to study the role of existing Digital Government architectures Janssen and Klievink (2012). Therefore, the primary objectives of this work are to:

- Describe what has been documented as a common understanding of Digital Government architectures;
- Identify Digital Government architecture characteristics, and existing associated challenges concerning the implementation of Digital Government infrastructure;
- Identify documented architecture building-blocks for establishing Digital Government infrastructure.

In order to comply with these objectives, we developed the following research questions:

1. What are the existing forms of Digital Government architecture found through literature review?

The first research question aims to find and analyze the existing body of knowledge concerning Digital Government architecture. It collects various types of architectures and presents the best-practices available.

2. What are the characteristics of Digital Government architecture and the associated challenges?

Considering the scope of our review, we examine the characteristics and challenges in terms of the relevance of Digital Government architectures such as scalability, interoperability, reusability, security, etc. (As defined in Section 4). Our second research question aims to address the primary characteristics of Digital Government architecture and the challenges that the existing architectures face.

3. What are the basic architecture building blocks found in Digital Government architectures?

The third research question seeks basic architecture building block that serve as a foundation for designing Digital Government architecture. Thus, guiding public bodies to build Digital Government infrastructure.

3.1.2. Search Strategy

The scholarly article by Kitchenham et al. (2009) was employed as a reference for this research. After clarifying research objectives and questions, we proceeded with a search strategy to investigate relevant empirical studies corresponding to the objective of this review. The process of forming the strategy included search sources consisting of electronic databases such as ACM, IEEE, Springer Link, and ScienceDirect along with other journals, and conference papers. These literature databases were selected as our main literature review target was the Software Engineering and Information Systems domains, and these databases disseminate articles in the field of Information System and Software Engineering. While the authors acknowledge that other databases include publications from all domains, which are of scientific interest. Yet, we aimed to narrow our search down to a field that we acknowledge as having a lack of consistent understanding and mapping of the Digital Government architectures from an Information Systems and Software Engineering perspective. To further make sure that our review is as exhaustive, rigorous, and comprehensive as possible, we adopted the following approaches:

- We screened for articles in the list of top journals and conference proceedings described by Levy and Ellis (2006).
- We use backward and forward reference searching as described by Webster and Watson (2002) which included searching for references cited in the articles and once certain articles were selected, they were further screened to identify other articles which cite them.

Initially, the scientific papers were retrieved from electronic databases then became a source for classifying other significant studies applicable to the review. Moreover, a Digital Government reference library[1] was added to enrich the academic sources which shows in the Table 1 below.

Table 1. Search strategy.

Electronic databases	ACM Digital Library IEEE Xplore Digital Library Springer Link ScienceDirect Digital Government Reference Library Version 14.0
Type of searched literatures	Journal and Conference Papers
Search string	(e-government OR electronic government) AND architecture
Language of the study	English
Publication period	From 2003 to 2020

The search criteria were formed by a search string made of the e-government OR electronic government and architecture keywords. These keywords were used as search strings in each database with the relevant query formats. The stated point is clearly illustrated in Table 2.

[1] Digital Government Reference Library (DGRL), which was previously named Electronic Government Reference Library (EGRL) Version 14.0, has become an indispensable tool for the Digital Government scholars. http://faculty.washington.edu/jscholl/dgrl/.

Table 2. Number of identified studies throughout the different rounds of our systematic search.

		Round 1		Round 2	
Database	**Retrieved**	**Included**	**Excluded**	**Included**	**Excluded**
ACM Digital Library	50	23	0	18	5
IEEE Xplore Digital Library	49	43	6	39	4
SpringerLink	297	24	273	23	1
ScienceDirect	129	18	111	15	3
Digital Government Reference Library				8	
Total	525	108	396	103	13

We used two kinds of search strings to search at a general level and then narrowed the search down. The listed search strings were used to search broadly to clarify the concepts about an architecture. To narrow the search down, we used a combination of 'architecture' with our specific research domain, particularly 'e-government or electronic government'. We searched the included literature using the search strings in regular expressions format by combining them with AND and OR operators. We used OR boolean operator to combine e-government and electronic government because both of the spellings were relevant to our search objective; therefore, they were included. We used AND operator to join e-government and electronic government keywords with architecture. A complete list of queries is available in Appendix A, found at the end of this article.

This way, we retrieved all the data related to Digital Government architecture, and it helped us to make sure that we include all kinds of architectures in the search area. The number of results is displayed per database in Table 2.

3.1.3. Inclusion and Exclusion Criteria

To determine whether certain search results should be included, inclusion and exclusion criteria were formulated. A number of results found in each database were filtered by reading the abstract, keywords, introduction, and conclusion.

3.1.4. Inclusion Criteria:

Five inclusion criteria were developed to guide the authors in gathering the relevant studies for this review.

- The paper is peer-reviewed publication.
- The language of the study is English.
- The study is relevant to the given search criteria.
- The papers report an empirical study and are published in peer reviewed journals and/or conferences.
- The selected studies from all the above-listed databases were published during 2003–2020. We chose the databases for specific periods. In the databases, the number of retrieved articles varied. To have an average number of articles we filtered them by year. (such a time frame was chosen to as exhaustive as possible and not exclude essential papers).

3.1.5. Exclusion Criteria:

We also included four exclusion criteria to strengthen the evidence search process when deciding on the relevance of each article screened.

- Studies that do not address Digital Government and its architecture as a main focus of the research.
- Studies that do not discuss the challenges among existing Digital Government architecture.
- Articles that do not define or describe the Digital Government architecture.
- Studies that do not refer to architecture building blocks of Digital Government architecture.

3.2. Conducting the Review

This section serves the purpose of presenting the findings of our research and extracting information from the appropriate databases.

3.2.1. Study Search and Selection:

Based on our search strategy (Section 3.1.2), electronic databases were chosen and by using inclusion criteria (Section 3.1.3) relevant studies were retrieved. In the initial search, we retrieved 525 studies from electronic databases, as shown in Table 2. The Digital Government Reference Library (DGRL) Version 14.0 contains 10,299 references, and we found that many articles lacked sufficient information for inclusion in our study, or they were duplicated. Thus, only eight articles were taken from this library. It is noteworthy that all the papers used in this research are explicitly peer-reviewed. The vast majority of the obtained articles fell under the criteria. Because of the limitations of the search mechanisms while using the search string to the entire textual content of the paper, a considerable amount of studies were then left out. One-hundred three (103) of the pre-selected articles were taken into account with inclusion criteria, and the remaining were excluded since they did not address Digital Government and its architecture as the main focus of their research. According to NVivo coding, 58 studies defined or described the Digital Government architectures in general and 28 in particular. Consequently, 41 discussed challenges among Digital Government architectures, and 44 studies addressed architecture building blocks of Digital Government architecture.

3.2.2. Data Extraction and Article Classification

Our data extraction process includes the following steps: (Step 1) Defining research questions for analyses; (Step 2) select bibliographical databases and search keywords; (Step 3) retrieve the data and apply the including and excluding criteria—defined and assessed independently by the authors; (Step 4) extract the data from the selected articles; (Step 5) reporting and publishing the analyses—using tables.

According to Yusuf et al. (2016), Digital Government is a relatively new discipline that is reaching maturity with time and can be viewed from multidisciplinary perspectives, amongst which are computer science and information systems. Therefore, we first determined one of the three research disciplines, including computer science, information systems, and software engineering, which was followed by research topic classification. According to Kitchenham et al. (2009), the objectives of data extraction are required to document the data retrieved from the primary studies correctly. Data extraction methods should be formulated by the research questions and the study quality criteria. In addition to this, it included information about the name of research, date, title, authors, journal, and publication details. We planned the data extraction process to allocate primary information from the included number of studies. Data synthesis was performed through automatic and manual processes. We used a qualitative data analysis tool, NVivo, which classifies, combines, and analyses non-numerical and unstructured data. We added all the studies to the reference management tool, Mendeley. Subsequently, we exported all the references and attached files from Mendeley and imported them to NVivo. The sources were automatically classified by Nvivo, and the necessary attributes such as context, Digital Government type, and architectural style were added. The next step consisted of conducting the literature review, and the included studies were coded to find themes, topics, and theories. We created coding containers called 'nodes' to group evidence sources accordingly. For this purpose, three primary nodes were created to classify the literature addressing all the three research questions. For article classification, we used the NVivo tool called 'Source Classification'. We sorted papers by type (e.g., journal, conference paper), publication year, context, and relevant research questions.

We used the MS Excel tool to collect data into a spreadsheet and thereafter, perform some comparative analysis. We extracted the following data and entered into the spreadsheet:

- Title of the article
- Publication year
- Digital Government Model (What Digital Government Model does the architecture support?)
- Context
- Architectural pattern or style
- Quality attributes
- Technologies
- Components
- Challenges

We read abstracts as well as entire articles in accordance with the defined data extraction process.

4. Discussion of the Results

In this section, we present the findings of our review and answer our research questions based on the results of our systematic literature review.

4.1. Overview of Studies

Figure 1 describes the year-wise distribution of the 103 selected studies from 2003 until 2020. There is quite a remarkable inconstancy, but some trends are also distinctly evident. The selected studies met the inclusion criteria and defined in Section 3.1.4. While the earliest study dates back to 2003, and the research on Digital Government architecture appears to have increased from 2003 until 2010. We did not find any significant studies related to our research topic before 2003. Since its peak in 2010—when fourteen articles were published—there has been a steady decrease in the number of articles published per year. A reason for this reduction may be that in recent years new research topics have gained more attention. Consequently, researchers have begun to focus on those topics and have moved away from Digital Government infrastructure research, particularly the design of contemporary Digital Government architecture.

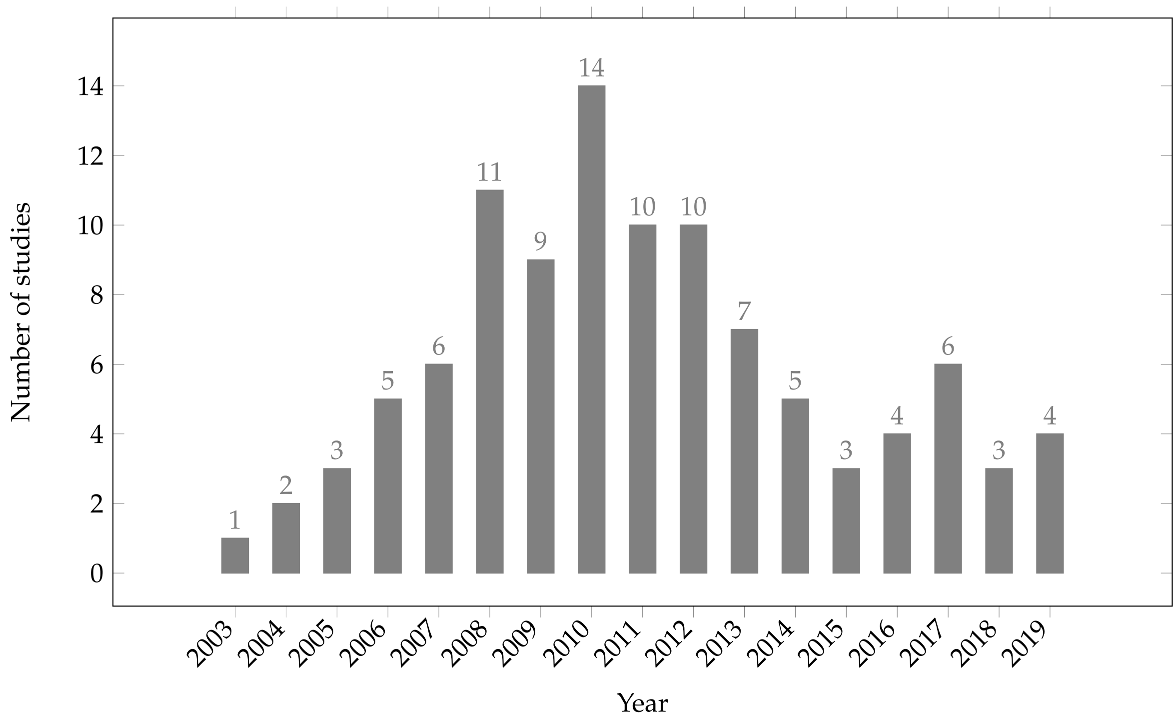

Figure 1. Year-wise distribution of selected studies.

4.2. Existing Architectures

- RQ1: What are the existing forms of Digital Government architecture found through literature review?

Through this systematic literature review, we found that several forms of Digital Government architecture exist in the literature and are available to the public domain. Table 3 summarizes the existing study of Digital Government architectures and provides a summary of 28 architectures selected from 103 articles. The selected papers are those that proposed new or advanced the existing Digital Government architecture. Table 3 compares Digital Government architecture against the Digital Government model (e.g., G2C, G2B, G2G), publication year, context, architectural pattern (e.g., Service Oriented Architecture (SOA), Enterprise Architecture (EA)), quality attributes, and used standards, technologies, and recommendations.

Table 3. Summary of existing Digital Government architectures.

No.	Architecture Name	Year	Model	Context	Architectural Pattern	Standards, Technologies, and Recommendations
1	A secure e-Government platform architecture for small to medium sized public organizations Kaliontzoglou et al. (2005)	2004	G2G, G2C	General	Web Services	XML, SOAP, WSDL, UDDI, OASIS WSS, XAdES, PKI, SAML
2	Engineering and Technology Aspects of an e-Government Architecture Based on Web Services Meneklis et al. (2005)	2005	G2G, G2C	General	Web Services	XML, WSDL, UDDI, SOAP, EJB, RMI, XSLT, TSP, XAdES, OCSP, SAML, SSL/TLS, XForms
3	Multi-Agent Based Semantic e-Government Web Service Architecture using Extended WSDL Usman et al. (2006)	2006	G2G, G2C	General	Agent-Based, Web Services	SOAP, WSDL, OWL-S, UDDI
4	A Component Based Software Architecture for e-Government Applications Beer et al. (2006)	2006	G2G	General	Reference Architecture	Java, JBoss, JDBC, WebDAV, LDAP, XML, HTTP, XSLT
5	Towards a Service-Oriented Architecture for Demand-Driven e-Government Lankhorst (2007)	2007	G2G, G2C	Dutch	SOA, Web Services	XML, SOAP, WSDL, SAML, BPEL
6	An e-government Platform Based on Multi-tier Architecture Zhang et al. (2008)	2008	G2G, G2C	China	Web Services	REST
7	Utilizing Owl-S in Multi-Agent Based Architecture for Semantic EGovernment Services Zeeshan Ali Ansari and Imran Khan (2008)	2008	G2G, G2C	General	Agent-Based, Web Services	XML, SOAP, WSDL, UDDI, BPEL4WS, OWL-S
8	e-government Based on Cloud Computing and Service-Oriented Architecture Cellary and Strykowski (2009)	2009	G2G, G2C	General	SOA, Cloud Computing	REST

Table 3. Cont.

No.	Architecture Name	Year	Model	Context	Architectural Pattern	Standards, Technologies, and Recommendations
9	A Trustworthy Identity Management Architecture for e-Government Processes Khan and Hayat (2009)	2009	G2C	General	N/A	N/A
10	A Security e-government Model Based on Service-oriented Architecture Wei and Yan (2010)	2010	G2G	General	SOA	SOAP, WSDL, UDDI, XML
11	Researching and Designing the Architecture of Egovernment based on SOA Yan and Guo (2010)	2010	G2G, G2C	General	SOA, Web Services	XML, SOAP, WSDL, UDDI
12	Transforming the Greek e-Government Environment towards the e-Gov 2.0 Era Drogkaris et al. (2010)	2010	G2G, G2C	Greece	Web Services	Web 2.0
13	A General Interoperability Architecture for e-Government based on Agents and Web Services Marques et al. (2011)	2011	G2G, G2C	General	Agent-Based, Web Services	XML, WSDL, UDDI, HTTP, SSL/TLS
14	An Architecture For e-Government Social Web Applications Brustel et al. (2012)	2012	G2C	General	SOA	Java, JavaScript, Wicket
15	e-Government Application Using Service Oriented Architecture with an Integration of SWORD AsmethalJeyarani (2012)	2012	G2G, G2C	General	SOA, Web Service	REST
16	Interoperable SOA-Based Architecture for e-Government Portal Sedek et al. (2012)	2012	G2G, G2C	General	SOA	XML, SOAP, WSDL
17	A Hybrid and Distributed Architecture for An Interoperable One-stop e-government Portal Sedek et al. (2013)	2013	G2G, G2C, G2B	Malaysia	SOA	SOAP, REST, CORBA, RMI, JMS, EJB
18	A Service-Oriented Integration Platform to Support a Joined-Up e-Government Approach: The Uruguayan ExperienceGonzález et al. (2012)	2014	G2G, G2C, G2B	Uruguay	SOA, Web Services	XML, SOAP, HTTPs, LDAP, XSLT, JBoss, WSDL, OWL
19	A Hybrid Architecture for One-stop e-government Portal Integration and Interoperability Sedek et al. (2014)	2014	G2G, G2C	Malaysia	SOA	Java (Liferay), JSR, WSRP
20	An architecture using formal interaction protocols for business process integration in e-government Tebib and Boufaida (2015)	2015	G2G, G2C	Algeria	Agent-Based	XML, UDDI

Table 3. Cont.

No.	Architecture Name	Year	Model	Context	Architectural Pattern	Standards, Technologies, and Recommendations
21	Enterprise Architecture for e-government Agarwal et al. (2017)	2017	G2G, G2C, G2B	India	EA	N/A
22	Census Web Service Architecture for e-Governance Applications Dutta et al. (2017)	2017	G2G, G2C	General	SOA	XML, SOAP, UDDI
23	A Layered Architecture for Open Data: Design, implementation and experiences Cordasco et al. (2018)	2018	G2C, G2G	General	SOA	REST, DKAN, Drupal, DEEP
24	A Model and Architecture for Building a Sustainable National Open Government Data (OGD) Portal Idowu et al. (2018)	2018	G2C, G2G, G2B	Nigeria	SOA	REST, XML, JSON, RDF
25	A Feasible Community Cloud Architecture for Provisioning Infrastructure as a Service in the Government Sector Rodrigues de Castro (2019)	2019	G2G, G2B	Brazil	SOA	REST, VMs, NoSQL, LDAP
26	Cloud based architecture for interoperability of Data e-government Services Oumkaltoum et al. (2019)	2019	G2G, G2B	General	SOA	VMs, XML
27	e-Government Architectural Planning Using Federal Enterprise Architecture Framework in Purwakarta Districts Government Defriani and Resmi (2019)	2019	G2G, G2B	Indonesia	SOA	SOAP, UDDI, XML, HTTP
28	Preserving Privacy of Integrated e-Government Information-Architecture Approach AlAbdali et al. (2019)	2019	G2G, C2G, G2C	General	SOA	N/A

The earliest architecture was introduced in 2004. The number of architectures increased between 2006 and 2012 and decreased to two architectures in 2018, but increased to four architecuters in 2019 as at the time of concluding our literature search. Since we ceased our search at the end of 2019, it is possible there may be more interesting architecture introduced from January 2020 to date.

The results suggest that there has not been a steady increase in the number of works produced on Digital Government architecture from 2012 to 2018. The results also reveal that during recent year, Digital Government architectures have received significant attention from the researchers though, it requires to leap forward by embodying the contemporary technologies and methodologies that will not merely improve the performance of Digital Government but also speed up the pace of innovation.

Concerning the Digital Government model, most architectures implement G2G and G2C. Only seven out of twenty-eight architectures support G2B. Therefore, the most implemented Digital Government models are G2G and G2C.

The success of utilizing the architecture in the Digital Government can be assessed from a different perspective, particularly, architectural patterns. An architectural pattern is a set of principles, conventions, and guidelines to define the structure of a system concerning a pattern of structural organization Garlan and Shaw (1993). Conducted literature review shows that Digital Government architectures adopt various architectural patterns. Recent research such as (Dutta et al. 2017;

Sedek et al. 2013; Cellary and Strykowski 2009) found that SOA-based architecture is more suitable for Digital Government and according to our findings, most architecture (57%) adopts SOA. Other literature (Agarwal et al. 2017; Janssen and Kuk 2006; Zheng and Zheng 2011; Larsson 2011) revealed that Enterprise Architecture has become increasingly popular. Considering the technological aspects of the reviewed architectures, we found that the majority of the architecture employs XML-based technologies, i.e., WSDL, RDF SPARQL, and Web Services, i.e., SOAP and REST, which shows that XML-based technologies and Web Services are the most natural choice candidate technologies and standards to support and base Digital Government systems Meneklis et al. (2005). Furthermore, Web Services are considered the most suitable technology for implementing SOA Yan and Guo (2010), and that's is why most of the SOA based architecture leverages Web Services technology González et al. (2012). However, Usman et al. (2006), Marques et al. (2011), Zeeshan Ali Ansari and Imran Khan (2008) argue that there are numerous limitations of Web Services, which include manual discovery, transaction management, service composition, scalability, reliability, and robustness. So multi-agent technology and OWL-S (Web Ontology Language for Services) should be used with web services to overcome the shortcomings of Web Services.

In some other studies (Dutta et al. 2017; Sedek et al. 2012; Cordasco et al. 2018; AlAbdali et al. 2019), the emphasis has been put on layered architectures to support the adequate separation between Digital Government components such as access layer, data layer, e-government layer, e-business layer, and infrastructure.

There have been several studies (e.g., Cellary and Strykowski 2009; Rodrigues de Castro 2019; Oumkaltoum et al. 2019) related to cloud-based architectures that should be applied in the public sector. Cloud computing permits to achieve interoperability and customer-centricity for receiving all the digital public services in one place through shared IT infrastructure resources.

Yet, the clamor for data to be opened up across the public sector is growing. Therefore, some recent studies have been carried on to develop open government data architectures (Idowu et al. 2018; Cordasco et al. 2018; Oumkaltoum et al. 2019).

As the result reveals, each attempt tackled the complexity of Digital Government from a certain perspective and there is no uniform agreement on Digital Government architecture concepts to fulfil the requirements of the design of Digital Government infrastructure.

4.3. Characteristics and Challenges

- RQ2: What are the characteristics of Digital Government architectures and the associated challenges?

As mentioned previously, several instances in the research literature and case studies report that the rates of failure for Digital Government projects are high. However, few studies examine these failures to understand what went wrong and why, and what lessons might be learned. It is thus important to understand these challenges, particularly those associated with Digital Government architectures, to eliminate or reduce such failures.

During the early stages of our systematic review, we identified a set of common characteristics of the Digital Government architectures to provide a common ground for the comparison and evaluation of available Digital Government architectures based on the challenges that face Digital Government development today from the architectural perspective.

Helali et al. (2011) discussed 'intrinsic' and 'extrinsic' characteristics of Digital Government architecture. Intrinsic characteristics refer to architectural specifications themselves and their integration with other systems. The list of the characteristics is described as follow:

1. Interoperability and integration between data and applications (AlAbdali et al. 2019; Defriani and Resmi 2019) and with various information systems (Helali et al. 2011; Cellary and Strykowski 2009; Sedek et al. 2011).
2. Having a secure architecture to ensure higher security of hardware and software to build trust with users (Helali et al. 2011; Cellary and Strykowski 2009; Sedek et al. 2011).

3. Adaptability to changing requirements that can have technical, socioeconomic, legal, and/or political nature Janssen (2007).
4. Flexible integration of architecture's components (Helali et al. 2011; Sedek et al. 2011) to better align business processes and technologies Janssen et al. (2003).
5. Reusability of components to be used in more than one system (Mohamed et al. 2012; AlAbdali et al. 2019).
6. Resilient to changes in the service environment Yan and Guo (2010).
7. Compatibility of Digital Government architecture with the already existing infrastructure, such as legacy system and multiple public institutions integration in different environments Helali et al. (2011).
8. Providing citizens the Single Sign-On (SSO) service through a standard interface or a single window for all electronic services offered by the public sector (Drogkaris et al. 2010; Zeeshan Ali Ansari and Imran Khan 2008; Kaliontzoglou et al. 2005).
9. Traceability of system operations performed by specific system users Helali et al. (2011).
10. Usability i.e., providing functions that are required for better system performance (Helali et al. 2011; Cellary and Strykowski 2009).
11. Cross-border characteristics i.e., providing Digital Government services in an international context and managerial settings in terms of G2C and G2G Helali et al. (2011).
12. Scalable to host a large number of digital services (Helali et al. 2011; Sedek et al. 2011).
13. Legality i.e., providing Digital Government services according to relevant legislation and judiciary Helali et al. (2011).
14. Cost-effective i.e., The architecture should be implemented in a way that the deployment and operation resources are kept to a minimum (Helali et al. 2011; Sedek et al. 2011; Cellary and Strykowski 2009).
15. Technological neutrality: The architecture must ensure that no components included in its definition advocate specific suppliers Moreno et al. (2014).
16. Platform independence: The architecture is not dependent on particular technology platform implementation nor assumes a particular technology Moreno et al. (2014).
17. Minimal learning curve i.e., giving limited training to government employees to implement or use the architecture Helali et al. (2011).
18. Comprehensibility: The architecture should be well-defined, and understandable with strategic clarity by the Digital Government leaders Agarwal et al. (2017).
19. Citizen-Centric: The Architecture must be designed in a way to support the strengthening of the relationship between citizens and the government Moreno et al. (2014).

The extrinsic characteristics in Digital Government architecture focus on its user. It includes the protection of user privacy AlAbdali et al. (2019), accessibility for all user segments, mobility (i.e., the citizen can access to Digital Government services without changing their geographical location), and responsibility of every operation executed on the system must be assigned to a unique classified legal personality Helali et al. (2011).

For our comparative analysis, we found similar architecture characteristics and challenges. Some of the characteristics those were missing from any architecture were considered as a challenge to architecture. These characteristics or quality attributes were analyzed from different perspectives, including software engineering, digital government, and other specific types of digital government architectures (e.g., SOA and EA).

From software architecture perspectives, Shaw and Garlan (1995) proposed that software architectures should have a detailed architectural description, which serves as a basis around which system properties can be given in detail. Therefore, it serves as a crucial role in introducing the ability of a system to achieve its overall system requirements. In addition, the architectural description addresses precise specifications of software components that are "extra-functional properties of components including structure, packaging, environmental dependencies, representation, and performance, also the nature of interactions among components, and the structural characteristics of the configurations"

Shaw and Garlan (1995). Our findings show that most architectures (90%) are lacking detailed architectural description of the structure, structural properties, and specifications of components.

The review reveals that different kinds of architectures have been introduced in the research area. Service-Oriented, Enterprise, and Agent-Based architectures are becoming the prominent paradigms for building Digital Government systems. A number of frameworks and standardization have been taken into account while designing the architectures. While a significant amount of studies fail to pinpoint the idea of state-of-the-art standards utilization in the architecture design and implementation stages Meneklis et al. (2005). In other words, the majority of these architectures are presented in the shape of informal diagrams.

Developing and implementing any of these architectures in the Digital Government comes along with specific challenges. As previously mentioned, Service Oriented and Enterprise Architectures have been mainly used in the context of the Digital Government; however, SOA, EA, and Digital Government are two different phenomena with their aims and objectives Maheshwari et al. (2011). A recent comparative study of EAs—which are adapted by the world's leading digital nations (Denmark, Australia, South Korea, Estonia, and Singapore)—reveals that there is not a generic best EA approach for all countries Mayakul et al. (2019). EA and SOA are recommended for single organizations that have an integrated management structure. However, government structure is much broader than a single organization, and it is comprised of separate agencies (ministries, governorates, and municipalities) (Janssen et al. 2013; Klischewski and Abubakr 2010). Considering the structure of government, various other challenges of EA are widely known in Digital Government, such as implementation ability and governance (Isomäki and Liimatainen 2008; Klischewski and Abubakr 2010), legislative and socially rooted boundaries (Klischewski and Abubakr 2010; Larsson 2011; Isomäki and Liimatainen 2008), and lack of shared infrastructure (Klischewski and Abubakr 2010; Isomäki and Liimatainen 2008). Furthermore, Larsson Larsson (2011) argues that EA in the public sector, to a large extent, is immature. There is also a lack of empirical studies focusing on how to utilize EA, particularly in public sector reforms, successfully Isomäki and Liimatainen (2008).

Similarly, the use of SOA in inter-organizational networks, i.e., the government, has the drawback that creates 'spaghetti' of the connected and interdependent systems Janssen (2007). In some cases, SOA implementation is considered as vendor-driven and technology-first approach, and it results in technology lock-in, interoperability challenges, lack of technology neutrality, and vendor-specific. It would take a long time for less IT experienced organizations to implement SOA Klischewski and Abubakr (2010).

Multi-tier and service-oriented architectures combining reusable service modules or component-based approach, which are considered to tackle flexibility and compatibility issues, reduce the complexity, implementation time, and the development and communication cost (Zhang et al. 2008; Mohamed et al. 2012; Paul and Paul 2012; Janssen et al. 2003; Brustel et al. 2012; Machado and Parente de Oliveira 2011).

We found that over the last few years, interoperability has been in the center of Digital Government practices and research. A recent work Mondorf and Wimmer (2017) claims that interoperability continues to be a significant challenge in many countries, particularly in European countries that require active management of architecture solutions, and Enterprise Architecture (Paul and Paul 2012; Guijarro 2007; Scholl et al. 2011) has the potential to increase the level of support for interoperability projects. On the contrary, some other researchers have discovered that SOA and Web Service are believed to improve Digital Government interoperability (Sedek et al. 2012; Sedek et al. 2011; Yan and Guo 2010; Zeeshan Ali Ansari and Imran Khan 2008), adaptability and accountability Janssen (2007). On the other hand, Marques et al. (2011) argue that agent-based architecture is a natural choice for an interoperability architecture for Digital Government, and besides technical aspects, legal and social aspects must also be taken into consideration. This review finds that there is not a unified perspective nor commonly accepted architectural style for an interoperability architecture for Digital Government.

However, Interoperability framework (Klischewski and Abubakr 2010; Al-Nasrawi and Ibrahim 2013), technology neutrality Dutta et al. (2017), inter-organizational collaboration, information integration (Klischewski and Abubakr 2010; Buccella and Cechich 2009; Janssen 2007), clear processes Janssen (2007), standardization of information technology management in public administration Moreno et al. (2014), utilizing Web Service Technologies (Zeeshan Ali Ansari and Imran Khan 2008; Sedek et al. 2012; Janssen 2007; Dutta et al. 2017); are believed the primary requirements to achieve an interoperable one-stop Digital Government. Meanwhile, Klischewski and Abubakr (2010) believe that "policy matters" concerning Digital Government interoperability, principally because of dedicated integration objectives and implementation rules should lead to collaboration.

Success or failure of a Digital Government application is highly dependent on security Marques et al. (2011), and it is one of the main features which has been addressed in most of the architectures such as (Wei and Yan 2010; Fugini 2007; Al-Nasrawi and Ibrahim 2013; Almutairi and Khan 2016). The primary security problems in Digital Government are secrecy and integrity, identity management, authentication and authorization, and non-repudiation (Wei and Yan 2010; Khan and Hayat 2009). Therefore, the security of the Digital Government should be vested in network, application and service, user-service interaction, and business integration levels (Wei and Yan 2010; Fugini 2007).

Lack of system integration, unified standards for information description, flexibility, adaptability, compatibility, scalability, reusability, performance, detailed architectural descriptions, structural properties, specifications of components, technological neutrality, and stakeholders trust, are the other commonly-cited challenges we uncovered in the existing architectures (Wang et al. 2009; Brustel et al. 2012; Zhang et al. 2008; Mohamed et al. 2012; Anthopoulos et al. 2010; Lankhorst 2007).

Our findings address the primary challenges related to existing Digital Government architecture to meet the goal of an effective Digital Government. These challenges include limitations that touch on the various aspects of the existing Digital Government architecture — concerning the implementation of Digital Government infrastructure. Therefore, we see a need to design a reference architecture that provides an organization with best practices insight of already existing architecture Saay and Norta (2016). A sound reference architecture will ensure to establish an efficient technical Digital Government infrastructure. Once the technical infrastructure is available, we can assume that further application development and organizational advancement will be much easier Klischewski and Abubakr (2010). Organizational advancement and technical infrastructure should be developed in parallel. Otherwise, massive change management efforts will be required, and the possibility of failure will be much higher.

4.4. Basic Architecture Building Blocks

- RQ3: What are the basic architecture building blocks found in the Digital Government architectures?

To answer the third research question, we examined the common essential architecture building blocks on which the existing Digital Government architectures are built. These components will assist Digital Government practitioners in establishing or improving the design of existing or future Digital Government infrastructure and applications. Moreover, identifying the architecture building blocks for Digital Government projects is of the utmost importance for future successful implementations of Digital Government that would save governments significant amounts of time, research, money and avoid failures. Recognizing these components will reduce confusion surrounding Digital Government implementation and building successful and sustainable Digital Government infrastructure.

Table 4 depicts the common components or architecture building blocks that we found in the architectures. It describes each component briefly and presents details on what services does each component provides.

Table 4. Summary of basic architecture building blocks found in the existing architectures.

Component	Description	Provides
Kernel or Authentication Service Provider (Beer et al. 2006; Khan and Hayat 2009; Wei and Yan 2010; Zhang et al. 2008; Lankhorst 2007)	This component is responsible to control the end-user access to the system.	Traceability, Users Authentication Zheng and Zheng (2011) & Authorization, Logging, document & workflow management, and Access Control
Digital Identification or Identity Provider (Agarwal et al. 2017; Leitold 2011; Janssen and Kuk 2006; Lenz and Zwattendorfer 2015)	This includes Electronic Entity Databases, and provides a unique digital identity for all the citizens, immigrants, and state organizations.	Identification, Single-Sign-On, Security, Authentication, and Authorization
Public Key Infrastructure (Kaliontzoglou et al. 2005; Marques et al. 2011; Janssen and Cresswell 2005; Janssen and Kuk 2006)	This component is responsible for managing the operation of infrastructure services such as registration, key generation and certification for all public servants and citizens who participate in the secure environment.	Security and Interoperability
Data Exchange or Government Enterprise Bus (Agarwal et al. 2017; Zhang et al. 2008; Sedek et al. 2014; González et al. 2012; Sedek et al. 2012; Wei and Yan 2010; AlAbdali et al. 2019)	We found various names for this component such as Middle Layer, Middleware, Digital Government Service Bus, Interoperability Framework, Content Bus, or Enterprise Service Bus, in the literature, but same meaning. It is a set of standards, specifications, and APIs that would facilitate consistent communication and exchange of information among Government databases and computer systems Agarwal et al. (2017); Mohamed et al. 2012.	Security, Integration, and Interoperability
Service Provider (Wei and Yan 2010; Khan and Hayat 2009; Dutta et al. 2017; Sedek et al. 2013; Lenz and Zwattendorfer 2015)	It is a platform that provides various government services to users, such as citizens and government organizations.	One-stop service delivery
Service Registry (Wei and Yan 2010; González et al. 2012; Buccella and Cechich 2009; Dutta et al. 2017; Sourouni et al. 2008)	It is responsible for publishing, describing, searching and finding Digital Government services to allow public agencies to invoke required services.	Security and Scalability
Service Discovery (García-Sánchez et al. 2008; Sourouni et al. 2008; Yu 2008)	This component queries the accessible service repositories for services that meet the user's or system's requirements.	Service discovery, One-stop service delivery
Digital Government One-stop Portal (González et al. 2012; Sedek et al. 2013; Sedek et al. 2011; Machado and Parente de Oliveira 2011; Sedek et al. 2012; Anthopoulos et al. 2010; Joshi et al. 2017)	It is responsible to provide centralized Digital Government services to service consumers, including citizens and state organizations via a single access point.	Effective Service Sharing, Reusability, One-stop service delivery

We found eight architecture building blocks for Digital Government architecture. Authentication Service Provider (Kernel) ensures that the end-user can access to the system. It enables Traceability, Users Authentication and Authorization, Logging, document and workflow management, and Access Control. Digital Identification (Identity Provider) is responsible for electronic entity databases and provides a unique digital identity for all the citizens, immigrants, and state organizations. It provides Single-Sign-On, Security, Authentication, and Authorization. Public Key Infrastructure is in charge of managing the operation of infrastructure services such as registration, key generation, and certification for all civil servants and citizens who participate in the secure environment—thus enabling Security and Interoperability. Data Exchange (Government Enterprise Bus, Middle Layer, Middleware, Digital Government Service Bus, Interoperability Framework, Content Bus, or Enterprise Service Bus) is a set of standards, specifications, and APIs that would facilitate consistent communication and exchange of information among Government databases and computer systems. It provides Security, Integration, and Interoperability. Service Provider is a platform that offers various government services to users, such as citizens and government organizations. It provides One-stop service delivery. Service Registry is responsible for publishing, describing, searching, and finding Digital Government services to allow public agencies to invoke required services. It enables security and scalability. Service Discovery is responsible to perform queries to search the accessible service repositories for services that meet the user's or system's requirements. Digital Government One-stop Portal is responsible for providing centralized Digital Government services to service consumers, including citizens and state organizations, via a single access point. It provides Effective Service Sharing, Reusability, and One-stop service delivery.

5. Conclusions

This study identifies state-of-the-art Digital Government architectures and addresses the knowledge gap in the research area. The main objective of this review is to study existing best practices and assist Digital Government practitioners with establishing or improving the design of existing or future Digital Government infrastructure and applications. In this article, we developed a broader understanding of the use of architecture and prominent paradigms for establishing Digital Government infrastructure. We focused on existing Digital Government architecture, the characteristics of a Digital Government architecture, challenges associated with these forms of architectures, and the architecture building blocks of existing Digital Government architectures. For this purpose, we followed the guidelines proposed by Kitchenham et al. (2009) and adjusted them to our research domain and objectives. We identified 103 articles that are highly relevant to Digital Government architecture. We investigated 28 forms of architecture and found the common fundamental architecture building blocks presented in them. The identified set of architecture building blocks can be employed by the governments while establishing their Digital Government infrastructure.

A series of architectures have been taken into consideration in the development of the Digital Government. Service-oriented, enterprise and multi-agent-based architectures are becoming the prominent paradigms for building Digital Government systems. Our findings reveal that there is no uniform agreement on Digital Government architecture concepts to fulfill the requirements of Digital Government infrastructure.

Public organizations around the globe utilize different forms of Digital Government architectures, and analyzing and comparing the maturity of these architectures is a challenging job as they differ in scope, specifications, and complexity. For this purpose, we defined a set of common essential characteristics of Digital Government architecture to perform the analysis and benchmarking. We believe that all the specified architectural characteristics are crucial for the design of Digital Government architecture. However, the presented architecture does not support all of them (See Appendix B). We have presented similarities, differences, challenges, and essential components of the Digital Government architectures, which is meant for IT practitioners in the public sector to determine vital factors in successful planning, implementation, and management of Digital Government technological infrastructure.

5.1. Limitations

There are four major limitations in this study that could be addressed in future research.

Firstly, the Digital Government is found to be interdisciplinary by nature. However, this paper does not consider the socio-economic, legal, political, organizational aspects of the Digital Government.

This review puts emphasis on the technical aspects of the Digital Government because of the knowledge gap we found in the research area.

Secondly, the number of identified components is limited and not sufficient for designing Digital Government architecture.

Thirdly, the availability of up-to-date literature in the field of Digital Government architecture. Since we ceased our search at the end of 2019, there may be more interesting architecture introduce from the beginning of 2020 to date.

Fourthly, there is a lack of literature regarding Digital Government architecture and infrastructure for least developed countries compared to developing and developed countries.

At this stage, we do not propose a universal Digital Government architecture, but we introduce a set of characteristics and architecture building blocks for the design of Digital Government architecture. We analyzed best practices in Digital Government architectures and identified commonalities and design patterns among the existing architectures. The findings of the review need to be adjusted to a wide-ranging concepts and needs, including the specific executive, administrative, and organizational side of Digital Government.

5.2. Future Work

Digital Government infrastructure development is complex by nature, and it is usually subject to continuous discussion. To effectively overcome with Digital Government implementation, scholars tend to ease the process by bringing abstraction trough architecture modeling. Therefore our future work focuses on the design of reference architecture. Reference architecture for diverse domains -software engineering Peristeras and Tarabanis (2004), e-commerce Janssen and Cresswell (2005), e-learning Isomäki and Liimatainen (2008), or business collaboration Agarwal et al. (2017), for instance, can be found. While there is a lack of adequate reference architecture for the Digital Government. Our future work fills the gap by designing Digital Government reference architecture that specifies the government structure to facilitate the development of high-quality Digital Government infrastructure.

Our future work is primarily focused on requirement gathering (strategic requirements and quality attributes), design, and evaluation of Digital Government reference architecture. This reference architecture will be finalized in several cycles. The requirement gathering cycle unites the business needs of organizational and technical requirements to the design cycle. To evaluate the Digital Government reference architecture, we first evaluate to which extent reference architecture meets the set of requirements. We conduct a control-survey and workshops involving field experts and stakeholders using a modified version of a scenario-based method, namely, the Architecture Trade-Off Analysis Method Paul and Paul (2012). Finally, we compare the Digital Government reference architecture against best practices in the field of Digital Government architectures.

This reference architecture will help IT practitioners in the public sector to improve decision-making and determine primary factors for the successful planning, implementation, and management of Digital Government technological infrastructure.

Author Contributions: All authors (B.A.B., D.L., S.S.) contributed equally in the formulation of research questions, ideas, and search strategies. The collection of the data, as well as the preparation of the first draft of the manuscript, was conducted by the first author B.A.B. All authors contributed to the analysis and interpretation of the results, and the second and third authors validated and edited the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflicts of interest in this study.

Appendix A. Search Strings

Table A1. Search strings.

Database	Search String
ACM Digital Library	[[Publication Title: e-government] OR [Publication Title: electronic government]] AND [Publication Title: Architecture] AND [Publication Date: (01/01/2003 TO 01/01/2020)]
IEEE Xplore Digital Library	(((“Document Title”: e-government) OR “Document Title”: electronic government) AND “Document Title”: Architecture)
SpringerLink	’e-government OR electronic government AND “architecture”’ within Conference Paper between 2003 and 2019
ScienceDirect	“egovernment” OR “e-government” OR “electronic government ” AND “architecture” Year: 2003–2020, With e-government, architecture words in Title, abstract, keywords

Appendix B. Comparison of Presented Digital Government Architectures Agains the Characteristics

Table A2. Comparative table of Digital Government architectures (presented in Table 3) against the characteristics (presented in Section 4.3).

Characteristics / Architecture	Interoperability and Integration	Security	Adaptability	Flexibility	Reusability	Resilience	Compatibility	Single Sign on	Traceability	Usability	Cross-Border	Scalability	Legality	Cost-Effective	Technology Neutrality	Platform Independence	Easy to Learn	Comprehensibility	Citizen Centric	Privacy	Accessibility	Mobility	Responsibility
Architecture 1	X	X		X							X	X	X	X			X	X			X		
Architecture 2	X	X		X					X			X		X									
Architecture 3		X					X					X	X		X	X							
Architecture 4	X	X	X												X	X							
Architecture 5						X	X						X						X		X		
Architecture 6	X	X		X						X		X	X	X									
Architecture 7		X					X					X	X							X			
Architecture 8	X	X		X						X	X	X		X									
Architecture 9		X		X						X		X							X				
Architecture 10	X	X		X		X						X											
Architecture 11	X	X				X				X					X	X						X	
Architecture 12	X	X	X					X							X	X					X		
Architecture 13	X	X	X	X					X			X											X
Architecture 14		X		X								X				X	X		X			X	
Architecture 15	X	X					X							X	X	X							
Architecture 16	X			X									X	X	X	X							
Architecture 17	X		X									X		X									
Architecture 18	X	X											X							X			
Architecture 19	X				X							X	X	X	X	X							
Architecture 20	X	X								X		X											
Architecture 21	X	X								X			X	X							X		
Architecture 22	X	X		X	X		X					X											
Architecture 23	X	X		X	X	X	X	X		X		X	X	X	X	X	X	X		X	X		
Architecture 24	X	X		X	X	X	X					X						X	X	X			
Architecture 25	X	X	X	X	X	X	X					X	X						X	X			
Architecture 26	X	X		X		X	X					X			X	X			X	X	X		
Architecture 27	X	X		X	X	X	X					X	X	X	X	X							
Architecture 28	X	X		X	X	X	X	X					X	X	X	X				X			

References

Agarwal, Reshma, Vinay Thakur, and Radha Chauhan. 2017. Enterprise Architecture for e-Government. Paper presented at the 10th International Conference on Theory and Practice of Electronic Governance—ICEGOV '17, New Delhi AA, India, March 7–9; pp. 47–55. [CrossRef]

Al-Nasrawi, Sukaina, and Maysoun Ibrahim. 2013. An enterprise architecture mapping approach for realizing e-government. Paper presented at the 2013 IEEE Third International Conference on Communications and Information Technology (ICCIT), Beirut, Lebanon, June 19–21; pp. 17–21. [CrossRef]

AlAbdali, Hilal, Mohammed AlBadawi, and Mohamed Sarrab. 2019. Preserving privacy of integrated e-government information: Architecture approach. Paper presented at the 2019 2nd IEEE Middle East and North Africa COMMunications Conference (MENACOMM), Manama, Bahrain, November 19–21; pp. 1–5.

Almarabeh, Tamara, and Amer AbuAli. 2010. A general framework for e-government: Definition maturity challenges, opportunities, and success. *European Journal of Scientific Research* 39: 29–42.

Almutairi, Badr, and Ahmad Raza Khan. 2016. Persistent architecture for optimizing web service for e-government implementation. Paper presented at the 2016 IEEE International Symposium on Systems Engineering (ISSE), Edinburgh, UK, October 4–5; pp. 1–4.[CrossRef]

Anderson, Lindsey, Neil Oldridge, David R. Thompson, Ann-Dorthe Zwisler, Karen Rees, Nicole Martin, and Rod S. Taylor. 2016. Exercise-based cardiac rehabilitation for coronary heart disease: Cochrane systematic review and meta-analysis. *Journal of the American College of Cardiology* 67: 1–12. [CrossRef]

Anthopoulos, Leonidas G., Vasilis Gerogiannis, and Panos Fitsilis. 2010. The impact of enterprise architecture's absence in e-Government development: The Greek case. Paper presented at the 2010 International Conference on Information Society, London, UK, June 28–30; pp. 122–27.

Anthopoulos, Leonidas, Christopher G. Reddick, Irene Giannakidou, and Nikolaos Mavridis. 2016. Why e-government projects fail? An analysis of the healthcare. gov website. *Government Information Quarterly* 33: 161–73. [CrossRef]

AsmethalJeyarani, R. 2012. e-Government application using service oriented architecture with an integration of SWORD. Paper presented at the 2012 International Conference on Emerging Trends in Science, Engineering and Technology (INCOSET), Tiruchirappalli, India, December 13–14; pp. 381–84. [CrossRef]

Azad, Muhammad Abul Kalam, Md. Ashik Ali Khan, and Mahbubul Alam. 2008. Government enterprise architectures: Present status of Bangladesh and scope of development. Paper presented at the 2nd International Conference on Theory and Practice of Electronic Governance—ICEGOV '08, Cairo, Egypt, December 1–4; p. 459. [CrossRef]

Beer, Daniel, Raphael Kunis, and Gudula Runger. 2006. A component based software architecture for e-government applications. Paper presented at the First International Conference on Availability, Reliability and Security (ARES'06), Vienna, Austria, April 20–22; pp. 8–1011. [CrossRef]

Brustel, Jonas, Thomas Preuss, Carsten Schwenke, and Dirk Wieczorek. 2012. An Architecture for e-Government Social Web Applications. Paper presented at the 2012 Sixth International Conference on Complex, Intelligent, and Software Intensive Systems, Palermo, Italy, July 4–6; pp. 395–400. [CrossRef]

Buccella, Agustina, and Alejandra Cechich. 2009. A semantic-based architecture for supporting geographic e-services. Paper presented at the 3rd International Conference on Theory and Practice of Electronic Governance—ICEGOV '09, Bogota, Colombia, November 10–13; p. 27. [CrossRef]

Cellary, Wojciech, and Sergiusz Strykowski. 2009. e-government based on cloud computing and service-oriented architecture. Paper presented at the 3rd International Conference on Theory and Practice of Electronic Governance—ICEGOV '09, Volume 6, Bogota, Colombia, November 10–13; p. 5. doi:10.1145/1693042.1693045.

Cordasco, Gennaro, Delfina Malandrino, Donato Pirozzi, Vittorio Scarano, and Carmine Spagnuolo. 2018. A layered architecture for open data: Design, implementation and experiences. Paper presented at the 11th International Conference on Theory and Practice of Electronic Governance, Galway, Ireland, April 4–6; pp. 371–81.

Dada, Danish. 2006. The failure of e-government in developing countries: A literature review. *The Electronic Journal of Information Systems in Developing Countries* 26: 1–10.

Dang, Dinh Duong, and Samuli Pekkola. 2017. Systematic Literature Review on Enterprise Architecture in the Public Sector. *Electronic Journal of e-Government* 15.

Defriani, Meriska, and Mochzen Gito Resmi. 2019. e-government architectural planning using federal enterprise architecture framework in purwakarta districts government. Paper presented at the 2019 Fourth International Conference on Informatics and Computing (ICIC), Semarang, Indonesia, October 16–17; pp. 1–9.

Drogkaris, Prokopios, Stefanos Gritzalis, and Costas Lambrinoudakis. 2010. Transforming the Greek e-Government Environment towards the e-Gov 2.0 Era. In *Electronic Government and the Information Systems Perspective. EGOVIS 2010. Lecture Notes in Computer Science*. Berlin and Heidelberg: Springer, vol. 6267, pp. 142–49. doi:10.1007/978-3-642-15172-9_14. [CrossRef]

Dutta, Ajay, M. Syamala Devi, and Manish Arora. 2017. Census Web Service Architecture for e-Governance Applications. Paper presented at the 10th International Conference on Theory and Practice of Electronic Governance—ICEGOV '17, New Delhi AA, India, March 7–9; pp. 1–4. doi:10.1145/3047273.3047390. [CrossRef]

EU European Commission. 2019. EIRA | Joinup. European Commission (DG Informatics)—ISA2 Programme. Available online: https://joinup.ec.europa.eu/solution/eira/release/v300 (accessed on 12 March 2020).

EU European Commission. 2020a. Cef Digital Home. Available online: https://ec.europa.eu/cefdigital/wiki/display/CEFDIGITAL/CEFDigitalHome (accessed on 15 April 2020).

EU European Commission. 2020b. e-sens: A Vision Becomes Reality. Available online: https://ec.europa.eu/digital-single-market/en/blog/e-sens-vision-becomes-reality (accessed on 15 April 2020).

Fugini, MariaGrazia. 2007. A Security Model and Architecture for Multichannel e-Government Systems. Paper presented at the Second International Conference on Availability, Reliability and Security (ARES'07), Vienna, Austria, April 10–13; pp. 917–24. doi:10.1109/ARES.2007.25. [CrossRef]

García-Sánchez, Francisco, Luis Alvarez Sabucedo, Rodrigo Martínez-Béjar, Luis Anido Rifón, Rafael Valencia-García, and Juan M. Gómez. 2008. A Knowledge Technologies-Based Multi-agent System for eGovernment Environments. Paper presented at the International Workshop on Service-Oriented Computing: Agents, Semantics, and Engineering, Estoril, Portugal, May 12. Berlin and Heidelberg: Springer, vol. 5006 LNCS, pp. 15–30. doi:10.1007/978-3-540-79968-9_2. [CrossRef]

Garlan, David, and Mary Shaw. 1993. An introduction to software architecture. In *Advances in Software Engineering and Knowledge Engineering*. Singapore: World Scientific, pp. 1–39.

Giorgi, L., and A. Hauptman. 2007. Review of foresight studies and emerging technologies on e-government. *e-government for Low Socio-Economic Status Groups*. Available online:Available online: https://www.researchgate.net/publication/220891728_eGovernment_for_Low_Socio-Economic_Status (accessed on 20 April 2020).

Glassey, Olivier. 2002. A One-Stop Government Architecture based on the GovML Data Description Language. Paper presented at the 2nd European Conference on EGovernment (ECEG 2002), Oxford, UK, October1–2; p. 9.

González, Laura, Raúl Ruggia, Jorge Abin, Guzmán Llambías, Raquel Sosa, Bruno Rienzi, Diamela Bello, and Fabricio Álvarez. 2012. A Service-Oriented Integration Platform to Support a Joined-Up e-Government Approach: The Uruguayan Experience. In *Advancing Democracy, Government and Governance. EGOVIS/EDEM 2012. Lecture Notes in Computer Science*. Berlin and Heidelberg: Springer, vol. 7452 LNCS, pp. 140–54. doi:10.1007/978-3-642-32701-8_13. [CrossRef]

Gouscos, Dimitris, Dimitris Drossos, and Giannis F. Marias. 2005. A proposed architecture for mobile government transactions. Paper presented at the Euro mGov, Brighton, UK, July 10–12.

Gugliotta, Alessio, Liliana Cabral, John Domingue, Vito Roberto, Mary Rowlatt, Essex County Council, and Rob Davies. 2005. *A Semantic Web Service-Based Architecture for the Interoperability of E-Government Services*. Wollongong, NSW, Australia: WISM; p. 21.

Guijarro, Luis. 2007. Interoperability frameworks and enterprise architectures in e-government initiatives in Europe and the United States. *Government Information Quarterly* 24: 89–101. doi:10.1016/j.giq.2006.05.003. [CrossRef]

Heeks, Richard. 2003. *Most e-Government-for-Development Projects Fail How Can Risks Be Reduced?* Manchester: Institute for Development Policy and Management, University of Manchester Manchester, vol. 14.

Heeks, Richard. 2005. *Implementing and Managing eGovernment: An International Text*. Thousand Oaks: Sage.

Helali, Rim, Ines Achour, Lamia Labed Jilani, and Henda Ben Ghezala. 2011. A Study of e-Government Architectures. In *E-Technologies: Transformation in a Connected World. MCETECH 2011. Lecture Notes in Business Information Processing*. Berlin and Heidelberg: Springer, vol. 78 LNBIP, pp. 158–72. [CrossRef]

Hornnes, Erik, Arild Jansen, and Øivind Langeland. 2010. How to Develop an Open and Flexible Information Infrastructure for the Public Sector? Paper presented at the International Conference on Electronic Government, Lausanne, Switzerland, August 29–September 2; vol. 6228 LNCS, pp. 301–14. [CrossRef]

Idowu, Lukman Lamid, Isa Ibrahim Ali, and Usman Gambo Abdullahi. 2018. A model and architecture for building a sustainable national open government data (ogd) portal. Paper presented at the 11th International Conference on Theory and Practice of Electronic Governance, Galway, Ireland, April 4–6; pp. 352–62.

Isomäki, Hannakaisa, and Katja Liimatainen. 2008. *Challenges of Government Enterprise Architecture Work—Stakeholders' Views*. Berlin and Heidelberg: Springer, vol. 5184, pp. 364–74. [CrossRef]

Janssen, Marijn, and Anthony Cresswell. 2005. Enterprise Architecture Integration in e-Government. Paper presented at the 38th Annual Hawaii International Conference on System Sciences, Big Island, HI, USA, January 3–6; p. 118b. doi:10.1109/HICSS.2005.243.

Janssen, Marijn, and Bram Klievink. 2012. Can enterprise architectures reduce failure in development projects? *Transforming Government: People, Process and Policy* 6: 27–40. [CrossRef]

Janssen, Marijn, and George Kuk. 2006. A Complex Adaptive System Perspective of Enterprise Architecture in Electronic Government. Paper presented at the 39th Annual Hawaii International Conference on System Sciences (HICSS'06), Kauia, HI, USA, January 4–7; vol. 4, p. 71b. doi:10.1109/HICSS.2006.6.

Janssen, Marijn, René Wagenaar, and Jaap Beerens. 2003. Towards a flexible ICT-architecture for multi-channel e-government service provisioning. Paper presented at the 36th Annual Hawaii International Conference on System Sciences, HICSS 2003, Big Island, HI, USA, January 6–9. doi:10.1109/HICSS.2003.1174331.

Janssen, Marijn, Leif Skiftenes Flak, and Øystein Sæbø. 2013. *Government Architecture: Concepts, Use and Impact*. Berlin and Heidelberg: Springer, vol. 8074 LNCS, pp. 135–47. doi:10.1007/978-3-642-40358-3-12. [CrossRef]

Janssen, Marijn. 2007. Adaptability and accountability of information architectures in interorganizational networks. Paper presented at the 1st International Conference on Theory and Practice of Electronic Governance—ICEGOV '07, Macao, China, December 10–13; p. 57. doi:10.1145/1328057.1328072.

Joshi, Pusp Raj, and Shareeful Islam. 2018. e-government maturity model for sustainable e-government services from the perspective of developing countries. *Sustainability* 10: 1882. [CrossRef]

Joshi, Pusp Raj, Shareeful Islam, and Syed Islam. 2017. A framework for cloud based e-government from the perspective of developing countries. *Future Internet* 9: 80. [CrossRef]

Kaliontzoglou, Alexandros, Panagiotis Sklavos, Thanos Karantjias, and Despina Polemi. 2005. A secure e-Government platform architecture for small to medium sized public organizations. *Electronic Commerce Research and Applications* 4: 174–86. doi:10.1016/j.elerap.2004.09.002. [CrossRef]

Kaliontzoglou, Alexandros, Basilis Meneklis, Despina Polemi, and Christos Douligeris. 2007. A Formalized Design Method for Building e-Government Architechtures. In *Secure e-Government Web Services*. Hershey: IGI Global, pp. 254–81.

Keele Staffs. 2007. *Guidelines for Performing Systematic Literature Reviews in Software Engineering*. Ver. 2.3 EBSE Technical Report. Available online: https://userpages.uni-koblenz.de/laemmel/esecourse/slides/slr.pdf (accessed on 20 April 2020)

Khan, Gohar Feroz, and Han Woo Park. 2013. The e-government research domain: A triple helix network analysis of collaboration at the regional, country, and institutional levels. *Government Information Quarterly* 30: 182–93. [CrossRef]

Khan, Sohail, and Amir Hayat. 2009. A Trustworthy Identity Management Architecture for e-Government Processes. Paper presented at the 2009 World Congress on Privacy, Security, Trust and the Management of e-Business, Saint John, NB, Canada, August 25–27; pp. 231–34. doi:10.1109/CONGRESS.2009.21. [CrossRef]

Kitchenham, Barbara, O. Pearl Brereton, David Budgen, Mark Turner, John Bailey, and Stephen Linkman. 2009. Systematic literature reviews in software engineering—A systematic literature review. *Information and Software Technology* 51: 7–15. doi:10.1016/j.infsof.2008.09.009. [CrossRef]

Klischewski, Ralf, and Ranwa Abubakr. 2010. Can e-Government Adopters Benefit from a Technology-First Approach? The Case of Egypt Embarking on Service-Oriented Architecture. Paper presented at the 2010 43rd Hawaii International Conference on System Sciences, Honolulu, HI, USA, January 5–8; pp. 1–10. doi:10.1109/HICSS.2010.92. [CrossRef]

KPMG. 2017. *Project Management Survey 2017—KPMG New Zealand*. Available online: https://home.kpmg/nz/en/home/insights/2017/04/project-management-survey-2017.html (accessed on 20 April 2020).

Krimmer, Robert, Tarmo Kalvet, Maarja Toots, Aleksandrs Cepilovs, and Efthimios Tambouris. 2017. Exploring and demonstrating the once-only principle: A european perspective. Paper presented at the 18th Annual International Conference on Digital Government Research, Staten Island, NY, USA, June 7–9; pp. 546–51.

Lankhorst, Marc M. 2007. Towards A Service-Oriented Architecture for Demand-Driven e Government. Paper presented at the 11th IEEE International Enterprise Distributed Object Computing Conference (EDOC 2007), Annapolis, MD, USA, October 15–19; pp. 214–14. doi:10.1109/EDOC.2007.27. [CrossRef]

Larsson, Hannu. 2011. Ambiguities in the Early Stages of Public Sector Enterprise Architecture Implementation: Outlining Complexities of Interoperability. Paper presented at the IFIP—10th Conference on Electronic Government, EGOV 2011, Delft, The Netherlands, August 28–September 2. vol. 6846 LNCS, pp. 367–77. doi:10.1007/978-3-642-22878-0_31. [CrossRef]

Leitold, Herbert. 2011. Challenges of eID Interoperability: The STORK Project. In *IFIP PrimeLife International Summer School on Privacy and Identity Management for Life*. Berlin and Heidelberg: Springer, vol. 352 AICT, pp. 144–50. doi:10.1007/978-3-642-20769-3_12. [CrossRef]

Lenz, Thomas, and Bernd Zwattendorfer. 2015. Enhancing the Modularity and Flexibility of Identity Management Architectures for National and Cross-Border eID Applications. In *International Conference on Web Information Systems and Technologies*. Volume 246 of Lecture Notes in Business Information Processing. Edited by Valérie Monfort, Karl-Heinz Krempels, Tim A. Majchrzak and Žiga Turk. Cham: Springer International Publishing. pp. 123–43. doi:10.1007/978-3-319-30996-5. [CrossRef]

Levy, Yair, and Timothy J. Ellis. 2006. A systems approach to conduct an effective literature review in support of information systems research. *Informing Science* 9. [CrossRef]

Luna-Reyes, Luis F., Theresa A. Pardo, Djoko Sigit Sayogo, Giri Kumar Tayi, David F. Andersen, Jing Zhang, and Jana Hrdinova. 2012. Beyond Open Government: Ontologies and Data Architectures to Support Ethical Consumption. Paper presented at the 6th International Conference on Theory and Practice of Electronic Governance—ICEGOV '12, Albany, NY, USA, October 22–25; p. 1. doi:10.1145/2463728.2463730.

Lyzara, Ria, Betty Purwandari, Muhammad Fadhil Zulfikar, Harry Budi Santoso, and Iis Solichah. 2019. e-government usability evaluation: Insights from a systematic literature review. Paper presented at the 2nd International Conference on Software Engineering and Information Management, Bali, Indonesia, January 10–12 pp. 249–53.

Machado, Alexandre Lopes, and Jose Maria Parente de Oliveira. 2011. DIGO: An Open Data Architecture for e-Government. Paper presented at the 2011 IEEE 15th International Enterprise Distributed Object Computing Conference Workshops, Helsinki, Finland, August 29–September 2; pp. 448–56. doi:10.1109/EDOCW.2011.34. [CrossRef]

Maheshwari, Devender, Marijn Janssen, and Anne Fleur van Veenstra. 2011. A multi-level framework for measuring and benchmarking public service organizations: Connecting stages-of-growth models and enterprise architecture. Paper presented at the 5th International Conference on Theory and Practice of Electronic Governance—ICEGOV '11, Tallinn, Estonia, September 26–28; p. 73. doi:10.1145/2072069.2072083.

Marques, Fabio, Goncalo Paiva Dias, and Andre Zuquete. 2011. A general interoperability architecture for e-government based on agents and Web Services. Paper presented at the 6th Iberian Conference on Information Systems and Technologies (CISTI 2011), Chaves, Portugal, June 15–18; pp. 1–6.

Martin, Nigel, Shirley Gregor, and Dennis Hart. 2004. Using a common architecture in Australian e-Government—The Case of Smart Service Queensland. Paper presented at the 6th International Conference on Electronic Commerce—ICEC '04, Delft, The Netherlands, October 25–27; vol. 60, p. 516. doi:10.1145/1052220.1052285.

Mayakul, Theeraya, Prush Sa-Nga-Ngam, Wasin Srisawat, and Supaporn Kiattisin. 2019. A comparison of national enterprise architecture and e-government perspectives. Paper presented at the 2019 4th Technology Innovation Management and Engineering Science International Conference (TIMES-iCON), Bangkok, Thailand, December 11; pp. 1–6.

Meneklis, B., Alexandros Kaliontzoglou, Christos Douligeris, and Despina Polemi. 2005. Engineering and technology aspects of an e-government architecture based on Web services. Paper presented at the Third European Conference on Web Services (ECOWS'05), Vaxjo, Sweden, November 14–16; p. 12. doi:10.1109/ECOWS.2005.11.

Meneklis, Vassilis, and Christos Douligeris. 2007. Extending a Distributed System Architecture with e-Government Modelling Concepts. Paper presented at the 2007 IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications, Athens, Greece, September 3–7; pp. 1–6. doi:10.1109/PIMRC.2007.4394200. [CrossRef]

Mohamed, Mohamed Ali, Galal Hassan Galal-Edeen, Hesham Ahmed Hassan, and Ehab Ezzat Hasanien. 2012. An evaluation of enterprise architecture frameworks for e-government. Paper presented at the 2012 Seventh International Conference on Computer Engineering & Systems (ICCES), Cairo, Egypt, November 27–29; pp. 255–60. doi:10.1109/ICCES.2012.6408524. [CrossRef]

Moher, David, Larissa Shamseer, Mike Clarke, Davina Ghersi, Alessandro Liberati, Mark Petticrew, Paul Shekelle, and Lesley A. Stewart. 2015. Preferred reporting items for systematic review and meta-analysis protocols (prisma-p) 2015 statement. *Systematic Reviews* 4: 1. [CrossRef] [PubMed]

Mondorf, Ansgar, and Maria Wimmer. 2017. Contextual Components of an Enterprise Architecture Framework for Pan-European eGovernment Services. Paper presented at the 50th Hawaii International Conference on System Science (HICSS-50), Honolulu, HI, USA, January 4–7; pp. 2933–42. [CrossRef]

Moreno, Lina Marcela Morales, Javier Orlando Torres Páez, Alexandra Parra, and Diego Campos. 2014. The Colombian Government Enterprise Architecture Framework. Paper presented at the 2014 Conference on Electronic Governance and Open Society: Challenges in Eurasia—EGOSE '14, St. Petersburg, Russia, November 18–20; pp. 38–41. doi:10.1145/2729104.2729136. [CrossRef]

NRW Ministry of Justice NRW Germany. 2015. Electronic Simple European Networked Services. Available online: https://www.esens.eu/content/about-project (accessed on 15 April 2020).

NRW Ministry of Justice NRW Germany. 2017. The Only Once Principles (TOOP). Available online: https://www.esens.eu/content/toop-project-has-been-started (accessed on 15 April 2020).

Oumkaltoum, Barakat, Mohamed Mahmoud El Benany, and Omar El Beqqali. 2019. Cloud based architecture for interoperability of data e-government services. Paper presented at the 2019 Third International Conference on Intelligent Computing in Data Sciences (ICDS), Marrakech, Morocco, October 28–30; pp. 1–6.

Paul, Ami, and Varghese Paul. 2012. The e-Government interoperability through Enterprise Architecture in Indian perspective. Paper presented at the 2012 World Congress on Information and Communication Technologies, Trivandrum, India, October 30–November 2; pp. 645–50. doi:10.1109/WICT.2012.6409155. [CrossRef]

Peristeras, Vassilios, and Konstantinos Tarabanis. 2004. Governance enterprise architecture (GEA): Domain models for e-governance. Paper presented at the e 6th international conference on Electronic commerce—ICEC '04, Delft, The Netherlands, October 25–27; p. 471. doi:10.1145/1052220.1052280.

Rabaiah, Abdelbaset, and E. Vandijct. 2011. A strategic framework of e-government: Generic and best practice. In *Leading Issues in e-Government Research*. Cambridge: Academic Publishing International Ltd., pp. 1–32.

Rehman, Maria, and Shafay Shamail. 2014. Enterprise architecture and e-government projects in Punjab, Pakistan. Paper presented at the 8th International Conference on Theory and Practice of Electronic Governance—ICEGOV '14, Guimaraes, Portugal, October 27–30; pp. 458–59. doi:10.1145/2691195.2691215. [CrossRef]

Rodrigues de Castro, Klayton. 2019. A feasible community cloud architecture for provisioning infrastructure as a service in the government sector. Paper presented at the 20th Annual International Conference on Digital Government Research, Dubai, UAE, June 18–20; pp. 35–40.

Saay, Salim, and Alex Norta. 2016. A Reference Architecture for a National e-Learning Infrastructure. Paper presented at the 2016 IEEE/ACM 9th International Conference on Utility and Cloud Computing (UCC), Shanghai, China, December 17–20; pp. 404–9.

Saghafi, Fatemeh, Kolsoom Abbasi Shahkooh, and Behroz Zarei. 2008. A Proposal Framework for e-Government Foresight Based on Zachman Architecture Model in Developing Countries. Paper presented at the 2008 Third International Conference on Convergence and Hybrid Information Technology, Busan, Korea, November 11–13; vol. 1, pp. 236–41.doi:10.1109/ICCIT.2008.257. [CrossRef]

Sánchez-Torres, J. M., and I. Miles. 2017. The role of future-oriented technology analysis in e-government: A systematic review. *European Journal of Futures Research* 5: 15. [CrossRef]

Sandoz, Alain. 2009. Design principles for e-government architectures. Paper presented at the International Conference on e-Technologies, Ottawa, Canada, May 4–6; pp. 240–45.

Scholl, Hans Jochen, Herbert Kubicek, and Ralf Cimander. 2011. Interoperability, Enterprise Architectures, and IT Governance in Government. Paper presented at the International Conference on Electronic Government, Delft, The Netherlands, August 29–September 1; vol. 6846 LNCS, pp. 345–54. doi:10.1007/978-3-642-22878-0_29. [CrossRef]

Sedek, Khairul Anwar, Mohd Adib Omar, and Shahida Sulaiman. 2012. Interoperable SOA-based architecture for e-government portal. Paper presented at the 2012 IEEE Conference on Open Systems, Kuala Lumpur, Malaysia, October 21–24; pp. 1–6. doi:10.1109/ICOS.2012.6417636. [CrossRef]

Sedek, Khairul Anwar, Mohd Adib Omar, and Shahida Sulaiman. 2013. A hybrid and distributed architecture for an interoperable One-Stop e-government portal. Paper presented at the 2013 Third World Congress on Information and Communication Technologies (WICT 2013), Hanoi, Vietnam, December 15–18; pp. 325–30. doi:10.1109/WICT.2013.7113156. [CrossRef]

Sedek, Khairul Anwar, Mohd Adib Omar, and Shahida Sulaiman. 2014. A hybrid architecture for one-stop e-government portal integration and interoperability. Paper presented at the 2014 8th Malaysian Software Engineering Conference (MySEC), Langkawi, Malaysia, September 23–24pp. 96–101. doi:10.1109/MySec.2014.6985996.

Sedek, Khairul Anwar, Shahida Sulaiman, and Mohd Adib Omar. 2011. A systematic literature review of interoperable architecture for e-government portals. Paper presented at the 2011 Malaysian Conference in Software Engineering, Johor Bahru, Malaysia, December 13–14; pp. 82–87. doi:10.1109/MySEC.2011.6140648. [CrossRef]

Shaw, Mary, and David Garlan. 1995. Formulations and formalisms in software architecture. In *Computer Science Today*. Berlin and Heidelberg: Springer, pp. 307–23.

Sourouni, Aikaterini-Maria, Fenareti Lampathaki, Spiros Mouzakitis, Yannis Charalabidis, and Dimitris Askounis. 2008. Paving the Way to eGovernment Transformation: Interoperability Registry Infrastructure Development. Paper presented at the International Conference on Electronic Government, August 31–September 5. Berlin and Heidelberg: Springer, vol. 5184 LNCS, pp. 340–51. doi:10.1007/978-3-540-85204-9_29. [CrossRef]

Tambouris, Efthimios, Eleni Kaliva, Michail Liaros, and Konstantinos Tarabanis. 2014. A reference requirements set for public service provision enterprise architectures. *Software & Systems Modeling* 13: 991–1013. doi:10.1007/s10270-012-0303-7. [CrossRef]

Tebib, Assia, and Mahmoud Boufaida. 2015. An architecture using formal interaction protocols for business process integration in e-government. *Electronic Government, an International Journal* 11: 154. doi:10.1504/EG.2015.070118. [CrossRef]

Tepandi, Jaak, Eric Grandry, Sander Fieten, Carmen Rotuna, Giovanni Paolo Sellitto, Dimitris Zeginis, Dirk Draheim, Gunnar Piho, Efthimios Tambouris, and Konstantinos Tarabanis. 2019. Towards a cross-border reference architecture for the once-only principle in europe: An enterprise modelling approach. Paper presented at the IFIP Working Conference on The Practice of Enterprise Modeling, November 27–29; pp. 103–17.

Usman, Muhammad, Muhammad Nadeem, M. Ali Ansari, and Sajjad Raza. 2006. Multi-agent Based Semantic e-government Web Service Architecture Using Extended WSDL. Paper presented at the 2006 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology Workshops, Hong Kong, China, December 18–22; pp. 599–604. doi:10.1109/WI-IATW.2006.92. [CrossRef]

Wang, Jingxia, Renchu Gan, and Yanbing Ju. 2009. A study on adaptive architecture of e-government network for small and medium cities. Paper presented at the 2009 IEEE International Conference on Grey Systems and Intelligent Services (GSIS 2009), Nanjing, China, November 10–12; pp. 1316–20. doi:10.1109/GSIS.2009.5408116. [CrossRef]

Webster, Jane, and Richard T. Watson. 2002. Analyzing the past to prepare for the future: Writing a literature review. *MIS Quarterly* xiii–xxiii.

Wei, Zhiguang and Ting Yan . 2010. A security e-government model based on service-oriented architecture. Paper presented at the 2010 International Conference on e-Health Networking Digital Ecosystems and Technologies (EDT), Shenzhen, China, April 17–18; vol. 1, pp. 280–83. doi:10.1109/EDT.2010.5496582. [CrossRef]

Wisniewski, François, D. G. Katehakis, Massimiliano Masi, and Soeren Bittins. 2016. Improving cross-border european eprescription and patient summary services through e-sens cross-sectorial building blocks. *Global Telemedicine and eHealth Updates: Knowledge Resources* 9: 234–38.

Yan, Pei, and Jiao Guo. 2010. Researching and Designing the Architecture of e-government Based on SOA. Paper presented at the 2010 International Conference on e-Business and e-Government, Guangzhou, China, May 7–9; pp. 512–15. doi:10.1109/ICEE.2010.137. [CrossRef]

Ye, Xin, Zhao Li, and Shange Fu. 2013. RNM based decentralized architecture of cross-organizational workflow management system for e-government. Paper presented at the 2013 IEEE 4th International Conference on Software Engineering and Service Science, Beijing, China, May 23–25; pp. 60–63. doi:10.1109/ICSESS.2013.6615255. [CrossRef]

Yu, Chien-chih. 2008. Building a Value-Centric e-Government Service Framework Based on a Business Model Perspective. Paper presented at the International Conference on Electronic Government, Turin, Italy, August 31–September 5; Berlin and Heidelberg: Springer, pp. 160–71. doi:10.1007/978-3-540-85204-9_14. [CrossRef]

Yusuf, Muhammad, Carl Adams, and Kate Dingley. 2016. A review of e-government research as a mature discipline: Trends, themes, philosophies, methodologies, and methods. *The Electronic Journal of e-Government* 14: 18–35.

Zeeshan Ali Ansari, M., and M. Imran Khan. 2008. Utilizing Owl-S in multi-agent based architecture for semantic e-Government services. Paper presented at the 2008 International Symposium on Information Technology, Kuala Lumpur, Malaysia, August 26–28; pp. 1–7. doi:10.1109/ITSIM.2008.4631710. [CrossRef]

Zhang, Xiaoyuan, Guoqiang Han, Bin Li, Kun Zou, and Wen Li. 2008. An e-Government Platform Based on Multi-Tier Architecture. Paper presented at the Fifth International Conference on Information Technology: New Generations (itng 2008), Las Vegas, NV, USA, April 7–9; pp. 1170–72. doi:10.1109/ITNG.2008.42. [CrossRef]

Zheng, Tuo, and Lei Zheng. 2011. e-government enterprise architecture research in China. Paper presented at the 5th International Conference on Theory and Practice of Electronic Governance—ICEGOV '11, Tallinn, Estonia, September 26–28; p. 167. doi:10.1145/2072069.2072097.

© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).