

E-Government Interoperability Enterprise Architecture: A Systematic Literature Review

Elton Sixpence

*Instituto Superior de Transportes e
Comunicações
Maputo, Mozambique*

elton.sixpence@isut.ac.mz

André Vasconcelos

*INESC-ID, Instituto Superior Técnico –
Universidade de Lisboa
Lisboa, Portugal*

andre.vasconcelos@tecnico.ulisboa.pt

Abstract

Public administrations have been introducing innovations such as digital initiatives and those initiatives are related to interoperability between systems managed by different government agencies. Despite those efforts citizens and businesses are still claiming for better digital public services. To understand interoperability challenges, this paper presents a systematic literature review addressing 1) the levels of interoperability that must be considered in government services, 2) the key motivation for interoperability, and 3) the challenges in the e-government ecosystem. From 680 papers we selected 28 to conduct a deep analysis. As a result, we have identified three core interoperability layers: technical, semantic, and organizational. We also present e-government interoperability project challenges related with strategic, policy, technological and barriers, and common modeling language. On the other hand, using ArchiMate, we have identified the elements of the e-Government interoperability motivation layer and used them to test how Enterprise Architecture can manage e-Government interoperability

Keywords: Government interoperability levels, government interoperability challenges, digital government interoperability frameworks, digital government interoperability reference architecture.

1. Introduction

Businesses such as banks, commerce, and telecommunication changed their business processes taking advantage of information and communications technology (ICT). Since the end of the nineties, the public administration sectors started to use ICT to provide better public services and increase the coverage areas of the public services.

During the last years, Public Administrations approved instruments to deal with digital government interoperability, for instance, Mozambique, the European Union, Australia, the United States of America, Canada, and others.

Electronic Government also referred to as digital government (e-Gov), consists of delivering public services using ICT, typically through Internet and Web Services [1, 2]. Within this work, digital government means the use of ICT to provide public services, excluding other ways such as radios, TVs, etc.

Despite all the mechanisms created to provide digital public services, those services are still not satisfying citizens and businesses [2, 3, 4]. Many challenges are posed when citizens or businesses have to provide the same information to all government agencies responsible for different public services [4]. According to [5, 6], interoperability plays an important role in e-

Gov solutions especially because all governments can exchange information and use it for different purposes. It is clear the advantages of e-Gov interoperability, but this feature remains a challenge for many public administrations in countries like India [1], for instance.

This paper aims to understand what level of interoperability exists, what is the motivation for e-Gov interoperability and what are the challenges on the e-Gov interoperability ecosystem. A systematic literature review (SLR) is conducted to address those three objectives and the motivation of e-Gov interoperability is modeled using an enterprise architecture modeling language.

This section introduces the work and in the next section the concepts of digital government are presented; Section 3 describes the methodology used to conduct the study; Section 4 presents the findings of the systematic literature review; Section 5 presents the threats to the SLR, and finally Section 6 presents the conclusion and future work.

2. Digital government concepts

Public administration is a complex system and digital government initiatives must be implemented wisely [7]. Layne and Lee [8] define four digital government stages, namely (i) catalog when the concern is to establish minimal online presence, for instance, web portals containing information, (ii) transition consists of integration of the informative portals with database using online interfaces, (iii) vertical integration when public services is been provided integrating from local to central government (inter-organizational integration), (iv) horizontal integration when public service is been provided by integrating different agencies (extra-organizational integration).

The digital government is a tool used by public administration to provide services to citizens (government to citizen), businesses (government to business) or other government (government to government) using different agencies and, most of the times, to fulfill one service the citizen must use more than a single agency. For instance, in Mozambique to formalize a business as a government supplier the company must provide more than five documents produced by different agencies making the process long and exhausting. The consensus among academics and practitioners for the simplification of this kind of process, is interoperability across digital government systems [9, 10].

According to the European Commission [11] interoperability is the ability of organizations to interact towards mutually beneficial goals, involving the sharing of information and knowledge between these organizations, through the business processes they support, by means of the exchange of data between their ICT systems. Meanwhile, Wayan Ordiyasa [12], considers that interoperability is a key to the success of digital government initiatives because it's only with an integrated system that is possible to provide better services due to the information sharing.

To ensure interoperability, generally, the public administrations define national interoperability frameworks and make them mandatory for all digital government initiatives. The European Commission [11] released the European Interoperability Reference Architecture (EIRA) to be used by all the state members, at least the national interoperability frameworks must be aligned with EIRA [13]. The EIRA uses ArchiMate as a modeling language and encompasses five interoperability levels: legal, organizational, semantic, technical application, and technical infrastructure. The differences between EIRA and other reference architecture proposed by [6], [10], [14] rely on the usage of formal modeling language. Building blocks presented on EIRA [13] are useful to explain the complexity of digital government systems.

The concept of interoperability levels is still non-standardized in the digital government domain. As a result of this study, we presented in section 4 all levels of interoperability raised in selected papers for this SLR.

To get into in-depth regarding e-Gov interoperability we used ArchiMate, an enterprise architecture modeling language to show the motivation for e-Gov interoperability.

ArchiMate is a popular modeling language for enterprise architecture [15] It is a visual language with a set of default iconography for describing, analyzing, and communicating many concerns of Enterprise Architecture as they change over time [15]. This Architecture modeling language provides a uniform representation for diagrams that describe Enterprise Architecture.

The motivation layer used in this study as an enterprise architecture framework is important

to model the motivations, or reasons, that guide the design or change of an Enterprise Architecture [15].

3. Research Methodology

In this section there are presented the three phases of the systematic literature review. The first phase is related to the research protocol definition and the second to the execution of the selected research protocol and the third to summarize the extracted data from the selected studies and report the findings. This phase is presented in Section 4.

3.1. Planning

The planning represents the first step of the systematic literature review (SLR) methodology. This step is followed by the presentation of the motivation of this SLR, the research question, and finally the proposed research protocol.

3.2. Motivation

Among researchers and practitioners [3], [16, 17] there is a consensus that interoperability plays an important role within e-Gov solutions, but achieving interoperability is still challenging, for many countries. This SLR aims to understand what levels of interoperability exist for e-Gov solutions and to find out the motivations and challenges of the e-Gov ecosystem.

3.3. Research Questions

This SLR is based on two research questions, namely:

- **RQ1:** What levels of interoperability exist?
- **RQ2:** What is the motivation for e-Gov interoperability?
- **RQ3:** What are the challenges of e-Gov?

3.4. Research Protocol

Research protocol, according to [18, 19] is a plan aiming to describe how the SLR will be conducted, acting as a guide to answer the research questions.

In the other hand, the research protocol reduces the researcher bias and increases the reliability because the study can be conducted by another researcher [19].

The research protocol starts with selecting as many numbers as possible of the study materials using the defined keywords.

The keywords and databases used to find the study material were the following:

- **Keywords:** (e-Government OR e-Gov OR Digital Government) AND (interoperability layers OR interoperability levels OR interoperability types OR interoperability frameworks OR interoperability reference architecture).
- **Databases:** CiteSeerX, Google Scholar, ScienceDirect, IEEEXplore, Springer, B-on, Microsoft Academic and Scopus.

After keywords and database definition it is necessary to define inclusion and exclusion criteria to filter the obtained documents. Those criteria allow the selection of the materials related to the research questions and define the scope of the SLR. The criteria are defined in Table 1.

Table 1. Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Wrote in English or Portuguese	Wrote in a language different than English or Portuguese
Publications after 2010 included	Publication before 2010
Conference preceding or journal articles	White papers, master's or graduation thesis
Relevant title for e-Gov interoperability	Non-relevant title for e-Gov interoperability

The selection of study materials are from 2010 because the most digital government transformation initiatives started at around this period.

The first set of study materials was obtained by running the keyword and then the initial evaluation reading the abstract and keyword to find out the relevant materials for this study. Finally, it was performed the full reading of the study materials and after that, the relevant material for this SLR. The result of the research protocol is summarized in Table 2.

Table 2. Research Protocol Summary

Research Protocol	Number of articles
Research-based on keywords	680
Inclusion and exclusion criteria	100
Abstract reading	75
Full document reading	50
Selected papers	28

4. Literature review Levels, Motivation, and Challenges of e-Gov Interoperability

From the conducted SLR we managed to answer the three research questions. Regarding research question number one (RQ1) we find out essential six levels of interoperability, namely technically, semantic, organizational, legal, political, and cultural/social [7], [20, 21]. Some authors such as [3] argue that only the first three levels can be considered as digital government interoperability and another three levels must be seen as factors that affect the interoperability levels. Table 3 summarizes the levels of e-Gov interoperability identified on this SLR.

Table 3. Levels of interoperability

Interoperability	Description	article
Technical	The ability of one or more systems to exchange data	
	Relayed on ICT technologies	[3], [6, 7], [10],
	Considered as the root of all communication	[14], [16], [20], [21], [22, 23, 24, 25, 26]
Semantic	Allow the exchange of data	
	Refer to the meaning of exchange	
	The data exchanged must be seamless among the system	[1], [3], [6, 7], [12], [16], [21, 22,23], [25, 26, 27]
Organizational	All the systems have a common understand of the data	
	Data standardization	
	Process agreements	
	The exchanged data must be used accordingly	[1], [3], [6, 7], [14], [16], [21, 22, 23, 24, 25, 26, 27, 28]
Legal	Ensure the alignment of processes among agencies	
	Systems can participate in multi-organization business process	
	Legal power assigned to system capabilities	
	Data and privacy protection	
Political	Accommodate manual process from manual to digital	[3], [7], [16], [20], [23], [28]
	Facilitate the data usage	
	A clear structure for digital government initiatives	
	Avoid agencies contradiction	[3], [7], [16], [23]
	Better funding policies	
	Stakeholders involvement	
	Strong human resource capacity strategy	

Social/Cultural	Adjust solutions according to the local demands	[3], [23]
	Multi-channel public services adoption	
	Social inclusion	
	Change management strategy	

The second research question (RQ2) aims to give answer about what is the motivation for e-Gov interoperability. Using ArchiMate motivation layer [15] it was possible to highlight the elements that are normally used as motivation within e-Gov projects. Table 4 illustrates the motivation elements identified in selected papers.

Table 4. e-Gov Interoperability Motivation Layer

ArchiMate Concept	Interoperability element	Mentioned article
Stakeholders	Government agencies	[2, 3, 4], [10], [23, 24]
	Citizens	
	Business	
	Donors	
Drivers	Incensement of public service demand	[2], [4], [10], [24, 25]
	Process simplification	
	ITC advances	
	Transparency in public services	
Assessment	Funding	[2] [4] [28] [13] [25]
	Citizens or Businesses complain	
	Number of public services	
	Increase of public services coverage areas	
Goals	Improve the user experience on digital public services	[2], [6], [8], [29], [30]
	Access to the public services from anywhere	
	Secure and reliable digital public services	
	Reduce operation costs with public services	
Outcomes	Quality digital public services	[2], [4], [10], [24, 25]
	Increase user's satisfaction	
	Reducing time on public service fulfillment	
	Reduce bureaucracy	
Principles	Increase of public services coverage areas	[2], [4], [23], [28], [31]
	Ensure technological uniformization	
	Infrastructure and information sharing	
Requirements	Citizens or Business oriented solution	[1], [6], [9], [12], [17], [31]
	Increase of public services coverage areas	
	Ensure security and data protection	
	Allow transparency within the public service providers	
Constraints	Funding	[12], [16], [25], [32]
	Seamless of data exchanged	
	Data quality	
	ICT Infrastructure	
	Human Capital	

The last research question (RQ3) was seeking to get answers about the challenges within the e-Gov interoperability ecosystem. The e-Gov interoperability challenges were grouped within four barrier sets namely strategic, technological, policy, and organizational. Table 5 presents details related to the challenges in the e-Gov interoperability ecosystem.

Table 5. Digital government interoperability challenges

Challenges	Description	Mentioned article
Strategic barriers	Lack of shared goals and governance, and overambitious milestones	[4], [7], [10], [16], [21]
Technological	Incompatibility across standards, security	[5], [8], [16], [22], [29]

barriers	models, and legacy systems Vendor locks and lack of legacy systems documentation	
Policy barriers	Privacy and data ownership	[6], [7], [25], [28], [31]
Organizational barriers	Lack of readiness, absence of government champion and stakeholder commitment, and legacy processes	[14], [20], [24], [26], [31]

5. Threats to validate the SLR

Some threats to the validation of the systematic literature review were identified, namely the synonyms for the search terms may have excluded relevant studies on interoperability in e-Gov. This threat was mitigated by evaluating the citations of the included articles to determine if any relevant studies were missing. Additionally, the quality of the selection and evaluation of the articles may not accurately represent their importance. This threat was mitigated by grouping the chosen attributes into subsets to facilitate classification and improve selection. Finally, the evaluation of the articles was based on the authors' experience. This threat was mitigated by establishing an analysis protocol and systematically reaching agreements.

6. Conclusion and future work

The core levels of e-Gov interoperability among the selected papers are technical, semantic, and organizational. Interchangeably, it was possible to find out other levels of e-Gov interoperability such as legal, political, social, and cultural. The complexity of e-Gov interoperability led us to the first conclusion; to succeed in e-Gov interoperability all levels must be addressed holistically due to the relationship between them. Enterprise Architecture seems to be a good ally to improve the existing Interoperability Frameworks. For instance, if two systems can interchange data, we can say that they are interoperating, but if those systems are unable to deal with the data with a common understanding is not possible to get leverage of technical interoperability and the same happens with other types of interoperability.

Through the motivational layer of ArchiMate, it was possible to identify the main motivations for interoperability in e-Gov (RQ2). Interoperability alone does not solve the issue of digital public service quality demanded by citizens and businesses. The operationalization of interoperability must be carried out with the perspective of enhancing the efficiency of the various systems used in the provision of digital public services. Among the eight motivational elements of the ArchiMate layer, the primary motivations for interoperability in e-Gov include the need to increase and improve the quality of digital public services, which should consider reducing operating costs of public administration through the adoption of uniform practices in processes and technologies. At the motivational layer, constraints were identified, such as limited human capacity to handle e-Gov projects, data quality of legacy systems, and funding for e-Gov initiatives, among others.

Regarding challenges in the e-Gov interoperability ecosystem (RQ3), these can be categorized into four main areas: strategic, technological, political, and organizational. Key challenges include inadequate readiness of public administrations to deal with interoperability, lack of human capacity to lead projects of this nature, legacy processes not adjusted for interoperability, data ownership, and privacy concerns, incompatibility among various systems, and lack of alignment on common objectives, among others.

In a preliminary result, we are convinced that Enterprise Architecture can be used to improve the implementation outcomes of interoperability in e-Gov, as it provides tools that facilitate smoother communication between the stakeholders.

As future work, we suggest the use of the findings of this paper to evaluate practical projects, that combine the utilization of the e-Gov interoperability framework and Enterprise Architecture modeling languages, such as ArchiMate.

Acknowledgements

A special thank you goes to ISUTC and INESC-ID for their support to the realization of this work.

References

1. Paul, A., Paul, V.: The e-Government Interoperability through Enterprise Architecture in Indian Perspective. In 2012 World Congress on Information and Communication Technologies, pp. 645–650 (2012)
2. Alshehri, M., Drew, S.: E-Government Fundamentals. In Proceedings of the IADIS International Conference on ICT, Society and Human Beings, pp. 35–42 (2010)
3. Novakouski M., Lewis, G.: Interoperability in the e-Government Context. SEI, Carnegie Mellon University (2012)
4. Grafika, S., Yogyakarta, N., Sumur, B., Mada, U.G.: Review: Interoperability Model of e-Government Services. pp. 177–182 (2015)
5. Jamoussi, Y., Al-Khanjari, Z., Kraiem, N.: A guidance based approach for enhancing the e-Government interoperability. Journal of Information and Organizational Sciences 41 (1), 35–56 (2017) doi: 10.31341/jios.41.1.3.
6. Kalogirou, V., Stasis, A., Charalabidis, Y.: Adapting national interoperability frameworks beyond EIF 3.0: The case of Greece. ACM International Conference Proceeding Series, pp. 234–243 (2020) doi: 10.1145/3428502.3428536.
7. Othman, M.H.B., Razali, R.: Key contributing factors towards successful Electronic Government systems interoperability. International Conference on Research and Innovation in Information Systems, ICRIIS, vol. 2013, pp. 302–307 (2013) doi: 10.1109/ICRIIS.2013.6716726.
8. Layne, K., Lee, J.: Developing a fully functional e-government: a four stage model. Government Information Quarterly 18, 122–136 (2001)
9. Omar, E.L.B.: SOA Based E-Government Interoperability BPEL Orchestration Approach. 12th International Conference of Computer Systems and Applications (AICCSA), pp. 2–3, (2015)
10. Setiawan, A., Yulianto, E.: E-Government Interoperability and Integration Architecture Modeling Using TOGAF Framework Based On Service Oriented Architecture. Asian Journal of Technology Management 11 (1), 26–45 (2018) doi: 10.12695/ajtm.2018.11.1.3.
11. European Commission: European Interoperability Framework (EIF) for European public services. pp. 1–40 (2010) doi: 10.2799/17759.
12. Ordiyasa, I.W., Nugroho, L.E., Santosa, P. I., Kumorotomo, W: Enhancing Quality of Service for eGovernment interoperability based on adaptive ontology. Proceedings - 2016 2nd International Conference on Science and Technology-Computer, ICST 2016, pp. 102–107 (2017) doi: 10.1109/ICSTC.2016.7877356.
13. Chou, B.C.C.H., Chou, Archive, F.D., Goethals, A.: European Interoperability Reference Architecture (eIRA), Ec, pp. 1–13, (2009)
14. Hongbo, L.: Model and architecture of one-stop government system: A solution of systemic interoperability. Proceedings of 2013 6th International Conference on Information Management, Innovation Management and Industrial Engineering, ICIII 2013, vol. 1, pp. 75–79 (2013) doi: 10.1109/ICIII.2013.6702879.
15. The Open Group, ArchiMate 2.1 Specification (2013)
16. Putri, M.E., Sensuse, D.I., Mishbah, M., Prima, P.: E-government inter-organizational integration: Types and success factors. ACM International Conference Proceeding Series, pp. 216–221 (2020) doi: 10.1145/3378936.3378955.
17. Lisboa, U.D.E.: Analysis of Enterprise Architecture Models : An Application of Ontologies to the Enterprise Architecture Domain e Branquinho Antunes. (2015)
18. Kitchenham, B.: Procedures for Performing Systematic Reviews. Keele, UK, Keele Univ., vol. 33 (2004)
19. Writing-a-Systematic-Literature-Review.pdf.
20. Agarwal, R., Thakur, V., Chauhan, R.: Enterprise architecture for e-Government' ACM International Conference Proceeding Series, vol. Part F1280, pp. 47–55 (2017) doi: 10.1145/3047273.3047330.
21. Pamungkas, Y., Santoso, A.B., Ashari, B., Sensuse, D.I., Mishbah, M., Meiyanti, R.:

- Evaluation of interoperability maturity level: Case study Indonesian directorate general of tax', *Procedia Computer Science*, vol. 157, pp. 543–551 (2019) doi: 10.1016/j.procs.2019.09.012.
22. Gascó, M.: Approaching E-Government Interoperability. *Social Science Computer Review* 30 (1), 3–6 (2012) doi: 10.1177/0894439310392181.
 23. Suchaiya, S., Keretho, S.: Analyzing national e-Government interoperability frameworks: A case of Thailand. 2014 9th International Conference on Digital Information Management, ICDIM 2014, pp. 51–56 (2014) doi: 10.1109/ICDIM.2014.6991416.
 24. Gacitua, R., Astudillo, H., Hitpass, B., Osorio-Sanabria, M., Taramasco, C.: Recent Models for Collaborative E-Government Processes: A Survey. *IEEE Access* 9, 19602–19618 (2021) doi: 10.1109/ACCESS.2021.3050151.
 25. Pardo, T.A., Nam, T., Burke, G.B.: E-Government Interoperability: Interaction of Policy, Management, and Technology Dimensions. *Social Science Computer Review* 30 (1), 7–23 (2012) doi: 10.1177/0894439310392184.
 26. Al-Khanjari, Z., Al-Hosni, N., Kraiem, N.: Developing a service oriented E-government architecture towards achieving E-government interoperability. *International Journal of Software Engineering and its Applications* 8 (5), 29–42 (2014) doi: 10.14257/ijseia.2014.8.5.04.
 27. Mondorf, A., Wimmer, M.A.: Requirements for an architecture framework for Pan-European E-government services. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 9820 LNCS, pp. 135–150 (2016) doi: 10.1007/978-3-319-44421-5_11.
 28. El Benany M.M., El Beqqali, O.: Cross-organizational orchestrator for e-government interoperability. *Proceedings of IEEE/ACS International Conference on Computer Systems and Applications, AICCSA*, pp. 0–5 (2017) doi: 10.1109/AICCSA.2016.7945750.
 29. Apleni, A., Smuts, H.: An e-Government Implementation Framework: A Developing Country Case Study. vol. 12067 LNCS. Springer International Publishing (2020) doi: 10.1007/978-3-030-45002-1_2.
 30. Gide, A.: Choreography for Interoperability in the e-Government Applications. *Angewandte Chemie International Edition* 6 (11), 5–24 (2018)
 31. Mondorf, A., Wimmer, M.A., Reiser, D.: A framework for interoperability testing in pan-european public service provision. *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 8074 LNCS, pp. 188–199 (2013) doi: 10.1007/978-3-642-40358-3_16.
 32. Abu-Shanab, E., Harb, Y.: E-government research insights: Text mining analysis. *Electronic Commerce Research and Applications* 38, 100892 (2019) doi: 10.1016/j.elerap.2019.100892.