Towards an Interoperability e-Government Framework for Uganda

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Abstract. In the absence of a single entity that develops all systems for government, there is need to support a common understanding of the development environments such that new products can easily be integrated within existing services. Owing to the size of governments, different departments tend to conceive and develop services independently and yet they serve the same citizens. These services should be consistent regardless of which entity is providing the service. This paper proposes a National Enterprise Architecture (NEA) to support the implementation of an e-government interoperability framework (e-GIF). The architecture is driven by a Service Oriented Architecture (SOA) model and uses ontologies to provide semantic interoperability.

Keywords: Interoperability · e-government · Enterprise architecture

1 Introduction

Most government services are being delivered through the use of Information and Communication Technology (ICT). The Government of Uganda through the National IT Authority Uganda (NITA-U)[1] is supporting several e-government systems which include: systems for registration of persons (e.g. national identity cards, passport and driving permit), business registration systems, Integrated Financial Management System, Integrated Personnel and Payroll System (IPPS), e-Tax System, and the e-Visa Application System. However, most of these systems are decentralized and interoperability between them is not achieved.

As a result, there are numerous failed initiatives of adoption of e-government frameworks especially in developing countries. This can be attributed to the fact that the development process is mainly inclined to technology while eliminating the non-technical issues which affect the main goal of interoperability [16]. As [12] asserts, an important step in achieving seamless delivery of public services across government entities is ensuring that the systems used are compatible and

[1] http://www.nita.go.ug.

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interface coherently. This requires a holistic approach that defines standards and structures for any e-government system to be able to share information and processes.

In this paper, we propose an e-government interoperability framework (e-GIF) that is based on an ontology enabled National Enterprise Architecture (NEA) driven by a Service Oriented Architecture (SOA) model and interoperability standards developed for use as a reference for implementing e-government systems in Uganda. The developed e-GIF was evaluated by users, application developers and public service officials who used their knowledge of software engineering and public service delivery to validate the framework for appropriateness, completeness and accuracy.

The rest of this paper is organized as follows. First, we provide an overview of related work in Sect. 2. Section 3 discusses the methodology used in this paper. Section 4 discusses the interoperability framework introduced in this paper. We discuss the evaluation carried out based on the framework in Sect. 5. Finally, Sect. 6 concludes the paper.

2 Related Work

E-government interoperability is the ability for government agencies to use ICTs to meaningfully and seamlessly exchange and use information [23]. As stated in [16], interoperability can be defined at three levels of operation: organizational, semantic and technical [1,13]. These dimensions also form the capabilities of an e-GIF required to improve interoperability [13]. Interoperability improvement can be achieved through the right mix of policy, structure, standards, process, management and technology across all these three constructs. Consequently improving the ability of government organizations to deliver coordinated public services [13,16].

Review of Existing e-GIFs: There have been several initiatives to develop e-GIFs and here we analyze some existing e-GIFs drawn from different countries at different levels of economic development and e-government maturity. This analysis was based on their scope, design principles and conceptual frameworks.

Scope of the Framework: This covers the interoperability dimensions and categories of the e-services offered. The e-GIF's in Estonia [8], Nepal [21] and Mozambique [19] provided detailed organizational interoperability. All these e-GIF's offered the common e-government services. The UK [22] and Estonia e-GIFs provide for Government to other Government e-services, while Estonia also provided for the private sector to implement the e-GIF in their own Business to Business services.

Design Principles: This parameter covers the guiding principles on which the e-GIFs are based. All the e-GIFs recommended the e-government applications to be Internet based and the use of open standards. Other common design principles included resource sharing and reuse, collaboration, scalability and confidentiality.

For example, Estonia and Australia [3] use federated identity management where the users can use various identities for authentication and authorization to access the e-government systems.

Conceptual Framework: This identifies which components of the e-GIFs that semantic and technical interoperability used. The European Interoperability Framework (EIF) [14] provides conceptual guidance for the creation of an European Interoperability Reference Architecture (EIRA). In general, all the e-GIFs identify interoperability standards for implementing (i) interconnection; (ii) data integration; (iii) content management and metadata; (iv) information access and presentation; and (v) security. All the e-GIFs recommend the use of SOA and XML standards. With the exception of Nepal and Estonia who used ontologies. All the e-GIFs recommend and adopt metadata standards for semantic interoperability.

Review of Enterprise Architecture Development Frameworks: Numerous authors have carried out a comprehensive survey to provide comparisons between the leading enterprise architecture frameworks and modeling tools [2,4,9,10,20,24]. The work carried out in [2] affirms that a large number of organizations apply one of these three enterprise architecture frameworks because of their level of maturity: the Zachman framework [25], the Open Group Architecture Framework (TOGAF) [11], and the Federal Enterprise Architecture (FEA) [6]. The Zachman's Framework focuses on constructing views of an enterprise rather than on providing a process for the creation of an architectural description [4,25].

The TOGAF has an Architecture Development Method which is used as a process to describe how to create an enterprise architecture [4,11]. The Federal Enterprise Architecture Framework (FEAF) extends the Zachman Architecture Framework. It comprises a set of models, principles, and methods that are used to implement an enterprise architecture. The framework provides a means to communicate information about architectural artifacts, their relationships to each other, and to their stakeholders using a common vocabulary [4,20]. Another prominent framework is the new European Interoperability Framework [14] that provides specific guidance on how to improve governance of interoperability activities, establish cross-organizational relationships, streamline processes supporting end-to-end digital services, and ensure that both existing and new legislation do not compromise interoperability efforts. Although, these are the most popular frameworks, there is not a single framework that addresses all the needs of a particular organization. This is one of the leading reasons as to why organizations are taking a hybrid framework approach in developing an Enterprise Architecture Framework [9,24].

In this paper we extend the TOGAF framework as it provides a holistic and systemic view of all Enterprise Architecture components, and their business, organizational and environmental contexts. We further adopt a Service Oriented Architecture and an e-government ontology which provides for a classification methodology that can be used by a government to create a common understanding of concepts based on the country's laws policies and procedures

[15]. The uniqueness of this approach is that the interoperability requirements are elicited from the actual practitioners and are analyzed to derive the design principles and specifications the proposed e-GIF.

3 Methodology

The requirements elicitation phase commenced with the selection of the repondents. A purposive sample selection method was used where 20 Ministries and 10 Agencies were selected. A questionnaire guide was designed for eliciting the interoperability requirements from officials in the selected Ministries and Agencies. Data collection was carried out using interviews and observations. Interviews were held with the key informants using the questionnaire guide. The key informants for this study were domain experts who included heads of IT departments, heads of user departments and industry experts such as Application Developers.

In order to acclimatize ourselves with the finer intricacies of the existing systems in use, we carried out observations of some of these systems while in use and also got to interview some of the actual users. Our interactions with the users focused on analyzing the systems' interfaces in relation to (i) the application boundaries; (ii) stakeholder satisfaction; and (iii) inputs/outputs processing. Lastly, we also studied some of the systems' manuals so as to understand further the interoperability requirements in relation to the existing systems.

3.1 Analysis and Design Phase

During this phase, the requirements collected from the field were edited and categorized into main themes and sub themes for analysis. The major themes were namely (i) current state, (ii) desired state and (iii) adoption factors for interoperability. The responses under each theme were further sub-divided into sub-missions according to the earlier identified dimensions of interoperability. Lastly, the categorization of the findings and the subsequent data analysis were aligned to the research objective. The results from this analysis were then used to develop the interoperability Framework design principles and the aggregated interoperability requirements.

3.2 Framework Design and Evaluation

Overall, the development of the e-GIF was guided by the interoperability design principles and the aggregated interoperability requirements developed from the analysis and design phase. Two comparative studies, one on existing e-GIFs and the other on Enterprise Architectures were carried. Some of the lessons learned from these studies were later adopted into the proposed interoperability framework. In addition, we propose standards guidelines that are based on industry best practice and the interoperability design principles and aggregated requirements developed from the analysis and design phase. A case study on the registration of a natural person was also carried out to demonstration e-government interoperability. The interoperability Framework thus developed was presented to a focus group for validation and the feedback obtained was then used to fine tune the e-GIF. The evaluation employed the Enterprise Architecture (EA) Scorecard [18] which provides a qualitative measure of EA quality and completeness.

4 The Framework

Our architectural framework follows the TOGAF version 9 architecture development methodology [11]. Unlike TOGAF which has four major domains, the proposed architecture has five major domains namely (i) the services architecture; (ii) the business processes architecture, (iii) the data architecture; (iv) the organizational architecture; and (v) the technology architecture as illustrated in Fig. 1.

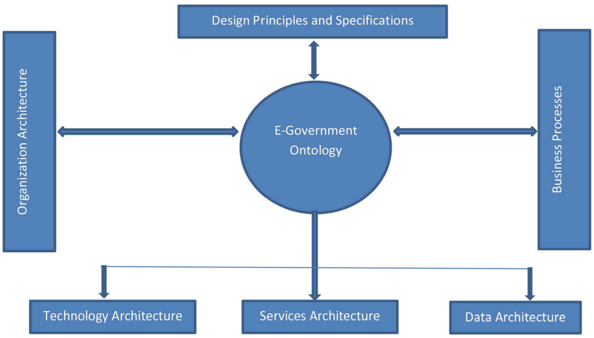

Fig. 1. Enterprise Architecture of the framework that consists of organizational architecture, technology architecture, services architecture, business process architecture and the data architecture.

A central aspect to this architectural framework is an e-Government ontology which is the main engine for driving interoperability. The interactions between architectural components are guided by the concepts, relationships and rules defined in the e-government ontology. Overall, the architecture is premised on a SOA model [24] that is realized using Web Services [17]. The section that follows briefly explains the different architecture components.

4.1 e-Government Ontology

The e-Government ontology concepts, attributes, relationships and axioms form the basis upon which the XML Schemas of the exchanged messages are built. All the messages exchanged by the Web services must comply with the terminology, semantics, business rules, data structures, coding and naming schemes agreed upon in the ontology in order for such messages to be processed and exchanged in a meaningful manner. The e-government ontology is decomposed into modules that form the e-government domain. The modules are based on the major government services.

Typical modules include the Registration, Financial, Health Services and Support Service Modules. Each module contains the following artifacts: (i) Concepts which are the objects under each module (ii) Properties: for each concept, e.g. a concept Person may have attributes such as identification number, surname, etc. (iii) Relationships: identify and define the relationships between concepts and properties, e.g., the relationship between the concepts Person and Voter may be depicted as Voter *is-a* Person and (iv) Constraints - determine the rules that bind the concepts, attributes and the relations, e.g., a person must have only one national identification number.

Figure 2 shows an example of ontological relationships between the various registration documents for registration of persons. Due to space limitations we include only small part of the ontology. Under the Uganda Registration of Persons Act of 2015, all persons resident in Uganda should be registered except for refugees and visitors whose stay in the country does not exceed a period of 90 days. The officially recognized registration documents include: (i) birth certificate; (ii) baptism card; (iii) immunization card; (iv) voters identification card; (v) immigration document; (vi) National identity card; (vii) valid Ugandan or foreign Passport; (viii) valid driving permit; (ix) valid residence permit; (x) certificate of acquired citizenship.

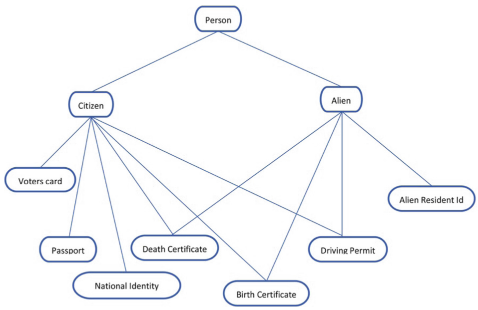

Fig. 2. Part of ontology for Registration of Persons.

4.2 Services Architecture

In order to achieve high levels of interoperability, the e-Government services must be defined from a global perspective and not separately for each entity. The choice is to use web services implementation of SOA. The individual services provided by Government entities are loosely coupled with little dependence. Due to the scalability requirements of National Enterprise Architecture, the services are provided over the Internet using web services. The following characteristics are provided by web services: (i) communicate via open Internet protocols (such as HTTP, SMTP); (ii) process XML messages framed using SOAP; (iii) use XML schemas to describe messages; (iv) WSDL [5] will be used to provide an endpoint description of the web service; (v) web services can be discovered by use of the UDDI registry [7]. The web services metadata must be stored in a globally accessible services repository. Further, these services should be loosely coupled such that it is easy to add or modify the services so as to enable the building of new business processes thus supporting the evolution and sustainable maintenance of the systems which is one of the core design principles for the overall proposed architecture framework.

4.3 Business Process Architecture

The business process architecture is a segmentation of logically related tasks performed to achieve a defined business outcome. As shown in Fig. 3 the business process architecture is comprised of sub-components namely: process categories, activities and tasks. *Major Process Categories* are based on the purpose and outcome of the business process, e.g., registration. The *Sub-categories* are complete sets of related activities which transform inputs into outputs under a given major category, e.g., Human Resources Management System. The *Activities* are sets of actions carried out in each sub category, e.g., under the Human Resources Management System the activities can include recruitment, leave roster management, and staff deployment. The *Tasks* are the individual actions that are carried out under each activity.

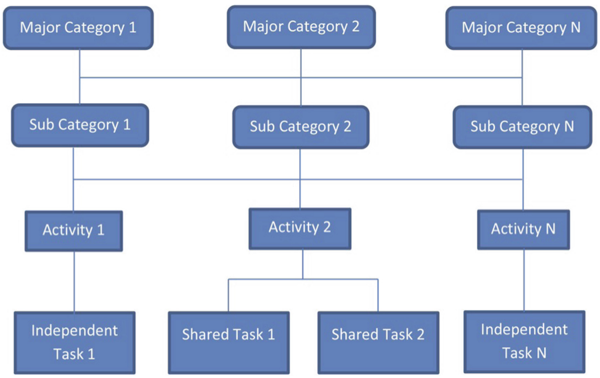

Fig. 3. Business Process Architecture comprises of the major process categories based on the purpose and outcome of the business process.

The business process architecture identifies the relationships between the tasks. This information provides key input for the development of the both atomic and compound services. Functionality for reusable tasks are built into common Web services. In our running example, the personal registration and verification is a common task that is shared across different services.

4.4 Data Architecture

The data architecture promotes the common identification, use and sharing of data across the Government entities through the standardization of the data. As illustrated in Fig. 4, the major components of the data architecture include: (i) metadata standards, (ii) data integration standards, and (iii) information access and presentation standards.

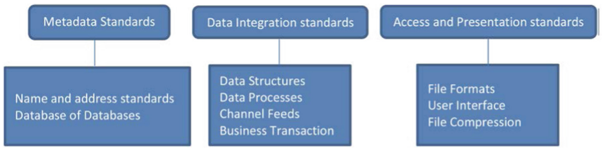

Fig. 4. Data Architecture that consists of three major components: metadata standards, data integration standards, and information access and presentation standards.

The aim of the metadata standards is to provide a means to uniformly describe data, thereby supporting its discoverability and shareability. The metadata standards are comprised of two sub-elements namely: (a) Naming and addressing data standards: which follow a predefined set of rules for choosing the character sequences to be used for identifiers. They denote objects such as variables, types, web services in the source code and documentation; and (b) Database of databases: this is a repository of metadata and statistics about all databases used by the e-government applications.

4.5 Organization Architecture

This provides mechanisms for implementing and managing the entities while facilitating inter-agency collaboration. The processes carried out while implementing the organizational architecture include: (i) Aligning the business goals and organizational resources with the e-government infrastructure; (ii) Implementing business process re-engineering; (iii) Planning and executing migration plans from the legacy systems to the new e-government applications; (iv) Carrying out quality assurance of the e-government applications and products; and (v) Ensuring compliance to the interoperability framework. Due to scope constraints, the organizational architecture was not developed further in this study.

The main benefits to be derived from the use of the developed architecture include: (a) Alignment of the business goals to the IT infrastructure through the various architecture artifacts, like the Business Process Architecture, the Technology architecture, the data architecture and the services architecture; (b) Development of the e-government ontology which provides a common vocabulary for sharing information across multiple software agents; (c) Provision of a governance mechanism to conform compliance with the interoperability requirements; (d) Provision of a mechanism through which entities can collaborate while managing changes to facilitate manageable growth of large scale government systems; (e) Provision of a database of databases which functions as a central control registry of e-government databases where no database will be allowed to operate without being registered in this central database. This helps to address the problem of data redundancy where entities re-register information already registered in the databases of other institutions.

5 Framework Evaluation

In this section, we present an evaluation of the e-GIF framework in order to determine its suitability for implementing interoperability of e-government services. The analysis of the evaluation results was done for each of the six levels of abstraction: contextual, environmental, conceptual, logical, physical and transformational levels. At each level the analysis was done with respect to each aspect area: *business*, *information*, *information systems* and *technical infrastructure*.

In accordance with the EA Scorecard methodology, a score of two was awarded for each clear rating, one for each partially clear rating and zero for each unclear rating. The detailed scores for each evaluator were aggregated for each abstract level and aspect area. Given that a question that produced a clear response was awarded two (2) points, then the possible maximum points per level were equivalent to 2 points $*$ total number of questions in that level. The individual points at each level and aspect area where then summed up using Microsoft Visual Fox Pro database management software.

5.1 Results from the Evaluation

Table 1 provides a summary of the results from the evaluation of the architecture. The results shown here are presented based on the Enterprise Architecture Scorecard [18] which summarizes the rating for each aspect areas and abstract level. In the following, we discuss the results shown in Table 1 in more detail.

Table 1. Summary of the evaluation framework scores (%) based on the Enterprise Architecture scorecard which highlights the different abstract levels and aspect areas of the framework.

Abstract Levels	Aspect areas			
	Business	Information	Information systems	Technical infrastructure
Contextual	75	68.8	56.3	54.7
Environmental	62.5	45	55	67.5
Conceptual	50	42.5	50	62.5
Logical	54.2	43.8	58.3	64.6
Physical	54.2	58.3	70.8	68.8
Transformational	35	22.5	52.5	47.5

In provide a summary of the aspect areas that were scored well and the ones that were scored poorly under each abstract level as shown in Table 1.

Contextual Level: Was used to measure the extent to which the architecture meet the scope, mission and vision of the organization. The *Business* aspect area had an average score of 75% which indicates that the proposed architecture satisfies the business goals of the client who is the Government of Uganda (GOU) and that the architecture is based on appropriate business drivers and concepts. The technical infrastructure aspect area had an average score of 54.7% which implies that the architecture satisfies the technical infrastructure requirements in respect to the technical goals, drivers and concepts.

Environmental Level: Measured the business relationships and information flows. The *Business* aspect area had an average score of 62.5% which implied that the architecture meets the requirements for business collaborations between the various MDAs. The *Information* aspect area had a low score of 45% and the framework does not model all the possible information exchanges that are required in a fully automated e-government environment.

Conceptual Level: Explored the architectural functional and non-functional requirements, goals and objectives. The *Information* aspect area had an average score of 42.5% which implied that the architecture does not sufficiently meet the required level of information interaction. This result is attributed to the lack of enough detailed functional requirements for the GOU since the proposed solution put more emphasis on specifying requirements for a few selected priority areas. The *Technical infrastructure* aspect area had an average score of 62.5% which implies that the provision for inter-connection at the conceptual level is sufficiently high.

Logical Level: Measured the logical solutions and sub-functions within each aspect area. The *Information* aspect area had an average score of 43.8% which implies that the architecture did not sufficiently provide for all the possible types of information interaction since the focus here was on only a few subfunctions that the architecture performs. The *Technical infrastructure* aspect area had an average score of 64.6% which showed that the type of interconnection proposed in the architecture has sufficient interconnection layers.

Physical Level: Was concerned with assessing the physical solutions, concrete products and techniques proposed in the architecture. The *Business* aspect area had an average score of 54.2% which indicated that the proposed architecture has sufficient business solutions for the MDAs to collaborate at the physical business level. The *Information systems* aspect area had an average score of 70.8% which implied that the proposed architecture has excellent provisions for interoperability at the physical level.

Transformational Level: Was concerned with assessing the impact of the architecture on the enterprise after its implementation. The *Information* aspect had an average score of 22.5% which showed that the proposed architecture does not have adequate provisions for changes in information interaction. The focus was not on all the possible information exchanges that are required in a fully automated e-government environment. The *Information systems* aspect area had an average score of 52.5% which indicated that the provisions for change in the information systems are adequate.

5.2 Discussion

It is pertinent to note that four aspect areas do not have an equal impact on the enterprise architecture. However, in this study all the aspect areas were considered to be of equal importance. The results show that the information aspect area received the least scores compared to all the other aspect areas across four of the five abstract levels. This could be attributed to the fact that not all the possible information exchanges are mot modeled and the architecture focused on few priority areas.

Furthermore, the transformational abstract areas has received the least scores across the four aspect areas. This could be due to the fact that the abstract level focused on good design, cost savings and organizational change yet these were not mainly highlighted in the implementation of the architecture, for example, the cost sequences and all the possible information exchanges that are required in a fully automated e-government environment. Overall, the results indicate that the proposed architecture is acceptable as presented.

6 Conclusion

This paper presents an e-government interoperability framework that is driven by a Service Oriented Architecture (SOA) model and interoperability standards developed for use as a reference for implementing e-government systems in Uganda. The interoperability is achieved through a set of related ontologies. Lessons from the study of existing country e-GIFs and enterprise architectures were enjoined to complement the proposed architecture.

The developed e-GIF was evaluated by a focus group comprised of users, application developers and public service officials who used their knowledge of software engineering and public service delivery to validate the framework for appropriateness, completeness and accuracy. It is therefore, our conviction therefore, that the proposed architectural Framework and interoperability standards selection procedures are best suited for resolving the e-government interoperability challenge in Uganda. Future studies will consider further development of the organizational architecture and prototype implementation in partnership with the Government of Uganda and NITA-U.

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