Developing E-Government Interoperability Driven Methodology

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***Abstract*— Developing e-Government interoperability in the government context is a complex task. As interoperability in government context is associated and hindered by many challenges and barriers connected to government nature of complexity. Interoperability is generally defined as the ability for two (or more) systems to exchange information and to use the information that has been exchanged. In this paper, we focus on computing systems interoperability across government ministries to achieve interoperable e-Government IT based solutions. In order to achieve e-Government interoperability in an organised and efficient way, this paper establishes a step-by-step e-Government Interoperability Driven Methodology. This contribution is motivated by the limitations of the traditional software engineering methodologies in terms of analysis, design and development frameworks to a point that they can hardly cope with the growing issues of e-Government services interoperability.**

***Index Terms*—E-Government, E-Government Interoperability, E-Government Services Interoperability, E-Government Interoperability Driven Methodology, Service Oriented Development Methodology.**

I. Introduction

E-Government interoperability is considered as significant if the interactions can take place at least at the three levels: data, services and process, with a semantics view defined in a given context [1], [2]. However, e-Government interoperability is not an easy task to achieve. It has been recognized as a key challenge and a crucial issue for e-Government at least since 2001 [3], [4]. This is because, realizing e-Government inteoperability is hindered by difficulties connected to implementation. These difficulties or challenges are faced because initially government ministries have built their computing systems independently with specifications and solutions relevant to their particular needs but without adequate attention to the need to connect, exchange and re-use data with other systems from different ministries. This resulted in a patchwork of heterogeneous computing solutions that have limited coherence and largely are uncoordinated [5].

The rapid development of e-Government services and the growing need for integrating these electronic services have pushed forward the limitations of the software engineering methodologies in terms of analysis, design and development frameworks. Therefore, the need for more research work in developing methodological approach to solve the interoperability problem is looking ever more serious. The new methodology could be coupled with an efficient implementation framework, generic enough to be used in any possible e-Government interoperability scenario.

Although some fragmented knowledge and solutions for interoperability have been accumulated since years, a complete interoperability methodology is still missing. Existing engineering methodologies such as GRAI methodology, CIMOSA, PERA, etc. were developed in the context of enterprise integration rather than interoperability [6]. In the context of enterprises, interoperability refers to the ability of interactions (exchange of information and services) between enterprise systems.

Ministries are not interoperable because there are barriers to interoperability between ministries systems. Barriers are incompatibilities of various kinds at the various ministry levels. There exist common barriers to all ministries. Consequently the methodology we propose aims at identifying the common barriers, measure the importance of the barriers using metrics and search solutions to remove barriers [7].

In this paper we will use a combination of literature review and observation research methodology to propose a methodological solution to achieve seamless and optimal interoperability in e-Government systems. The methodological solution proposed by this paper consists of a generic service interoperability engineering methodology, driven and based on generic Waterfall Software Engineering Methodology [8] and Service Oriented Development Methodology [9].

This paper is organized as follows. In section II we summarize the Service Oriented Driven Methodology to achieve e-Government Interoperability. Section III presents some related work. This is followed by providing a comparison framework in section IV. Section V proposes methodology benefits. Section VI covers the proposed methodology consideration. Finally, section VII concludes this work with our contribution and research perspectives.

II. Service Oriented Driven Methodology To Achieve e-Government Interoperability

Although the e-Government services are constantly increasing, the fact that the complexity of their

doi:10.4304/jetwi.6.3.318-323

interoperability is rapidly growing. This highlights the need for a formal methodological approach and design standards to ensure efficient and more importantly repeatable interoperability enabled services.

There is no federated systematic approach for all ministries to comply with. To help solving this challenge, this paper proposes an end-to-end framework to achieve interoperability in e-Government via methodological approach. Our vision is that all public ministries will need to share services of their respective domain in order to seamlessly exchange data and workflows. However, services sharing will not be possible if these services are not designed and implemented in a way that considers interoperability as a part of the services development process. Using service logic to only solve a single problem in a single ministry is not useful and does not leverage the logic's reuse and interoperable potential.

This section presents and describes the proposed Service-Oriented Driven Methodology to help achieving e-Government interoperability between heterogeneous, independent ministries' computing systems. This methodology is designed to be generic enough to allow automating any e-Government public service. Figure 1 is the graphical illustration of the main workflow in the proposed methodology.

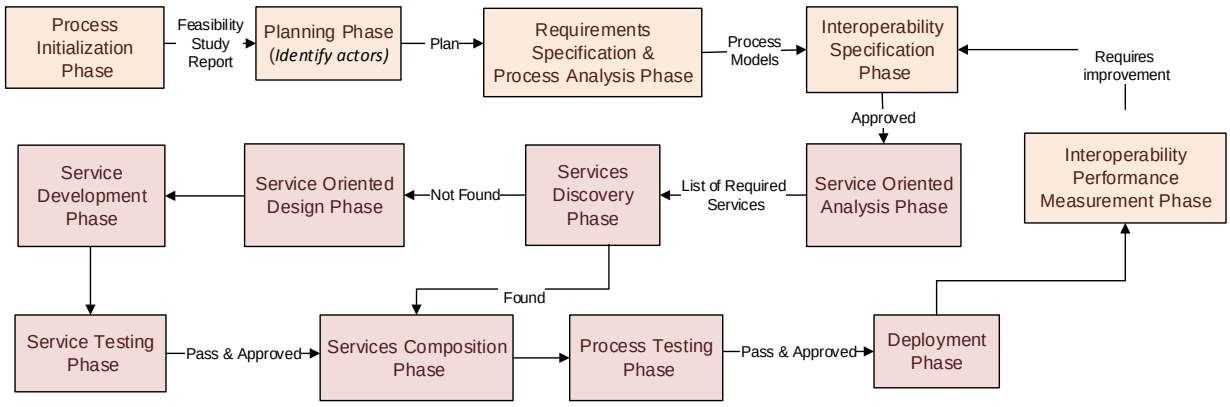

Figure 1: E-government interoperability driven methodology (abstract level)

This proposed methodology is considered as a structured approach that aims at defining the main phases to follow in a sequential way with possible iterations between the phases. Depending on whether the methodology is being applied to an individual ministry or a pair collaboration ministries. This methodology is influenced and driven by the advantages of the other software engineering models/approaches such as Waterfall [8], Agile [10] and Service Oriented Development Methodology by Thomas Erl [9].

The following are the main phases and activities that are carried out during the proposed methodology:

1: Process Initialization Phase: During this phase the project goal and the project feasibility will be determined.

2: Planning Phase: in this phase the **actors** (Ministries) that should take part in the business process are identified. Then, representative(s) of each involved actor shall be identified with enough authority to change and approve. Those representatives constitute the **project board group.** Then, business and technical experts from each involved ministry shall be identified as well. Those experts form the **project specialist group**. These two groups are responsible to set and execute the project plan.

3: Requirements Specification and Process Analysis Phase: Basically the main goal of this phase is to analyze the as-is situation, define the to-be situation and the gaps between them. Also to identify the involved applications and systems. Moreover, as the project specification and business process are clearly identified, further actors (ministries) may be involved as needed.

4: Interoperability Specification Phase: Practically the activities of this phase can be integrated with the activities of the previous phase. However, on papers it is shown as a separate phase to show its importance during the development of any e-Government project. During this phase the need for interoperability at each level of concern (Process, Service, and Data) associated with the "to-be" automated business process is identified. Then, the associated barriers with each level to interoperability are identified.

The Daclin interoperability compatibility measurement method will be used during this stage [7]. This measure is performed when the partner (ministries)/system of the interoperation is known. The measure is done with respect to the identified barriers to interoperability. Referring to each interoperability concern (level) and interoperability barrier, the objective is to check if there is incompatibility or not. With regards to the interoperability barriers.

If an incompatibility is detected, the coefficient 1 is assigned to the interoperating level and the barrier that are considered. Conversely, the coefficient 0 will be assigned when none incompatibility is detected. Following this rule, the compatibility measurement matrix proposed by Daclin and colleagues can be used as

presented in Table 1 below to represent the interoperability levels that must be achieved between concerned ministries and the barriers that must be removed to achieve each interoperability level.

TABLE 1.
THE COMPATIBILITY MEASUREMENT MATRIX [7]

Barriers / Levels	Conceptual		Ministerial	Legal	Technical
	Syntactic	semantic			
Process	1	0	1	1	1
Service	0	1	0	0	1
Data	1	1	1	1	1

To reach the highest degree of compatibility means that all the barriers to interoperability have been removed. The opposite situation means the poorest degree of interoperability. The compatibility measure allows ministries to know what kinds of barriers there are and what barriers have to be removed so that interoperability can be improved. In a similar way, the incompatibility measurement can allow ministry to prioritize the actions to be taken to improve interoperability. It is also necessary to work with interoperation ministries so that concerted and common actions to remove these barriers are taken at both sides.

After the compatibility measurement matrix is filled, the legal barrier is removed (if exist) by the project board members and they escalate it to other parties if required. As it is always not possible to proceed with the project unless it is aligned with the country's laws and regulations.

Meanwhile, the ministry barrier is removed as well by removing any process conflicts and authorities/responsibilities clearly defined between involved ministries. If for any reason the process activities not agreed upon or legal or ministerial barriers are not aligned with the proposed "to-be" business process, then, the proposed "to-be" business process is sent back to the previous phase for further analysis or adjustment. Otherwise, if the process activities are approved by all involved parties and the legal and ministerial barriers are removed then the "to-be" business process is sent to the project board for approval and moved to the next phase.

5: Service Oriented Analysis Phase: This phase is driven by service orientation principles associated with Service Oriented Development Lifecycle. The primary objective of this phase is the analysis of individual services in relation to business process automation. This phase's activities are carried out by collaboration between both business analysts/experts and technology architects/experts (project specialist members). During this phase an analysis of two interoperability levels (data and service) is carried out, with the assocaited interoperability barriers with these two levels. The deliverables of this phase are agnostic service candidates which are an input for the next phase.

6: Service Discovery Phase: During this phase, the development team will search for the list of agnostic servcies identifiyed in the previous phase. The main goal of this phase is to search for existing reusable services that match the desired criteria from the Services Repository using the discovery system.
The disovering process will end up with a result of one of the following cases:

- The service match is found → (move to servcies compositon phase).
- The service is found but it requires some customization → (move to service oriented design phase).
- The service is not found → (move to service oriented design phase).

7: Service Oriented Design Phase: The typical starting point for the service-oriented design process is a service candidate that was produced as a result of completing all required activities of the service-oriented analysis phase. Every candidate definition (logical service) can be used as input for a service-oriented design process. All service candidates are shaped and structured around the application of service-orientation design principles. "All eight principles are fully applied during service design" [9].

8: Service Development Phase: During this phase the actual programming of the required services can begin by the concerned technical team in each ministry with supervision of e-Government development team. Because the service architecture will have been already well-defined as a result of the previous stages and the involvement of service orientation design principles. During this phase the development of any required interoperability solution takes place as well.

9: Service Testing Phase: Services need to undergo the same types of testing and quality assurance cycles as traditional custom-developed applications. However, in addition, there are new requirements that introduce the need for additional testing methods and effort. For

example, to support the realization of the Service Composability principle, newly delivered services need to be tested individually and as part of service compositions. Agnostic services that provide reusable logic especially require rigorous testing to ensure that they are ready for repeated usage.

If any service fails during testing, then it will be sent back to the development phase for further enhancement. Otherwise, if it passes all test cases successfully, then it is sent for approval.

10: Approval Phase: If the developed services passed the testing phase then they are sent to the e-Government excellence committee for approval. The e-Government excellence committee will test the services against the e-Government standards and guidelines. A quality is assured as well by ensuring services adherence to norms and guidelines

11: Services Composition Phase (Process Construction): During this phase the "to-be" automated business process is realized through the services composition. These services are approved by the e-Government Excellence Committee make it possible to achieve interoperability ministry to ministry from interconnection services offered by multiple ministry partners based on business process. This interconnection of services to meet a certain business process is called service composition.

12: Process Testing Phase: The purpose of this phase is to test the process as whole after the related services are composed to realize the process automation. The process now needs to undergo the same types of testing and quality assurance cycles to make sure that the process functionality is realized and the norms are met.

13: Process Approval Phase: After the developed process passed the process testing phase, then it is sent to the e-Government Excellence Committee for approval. The whole process shall be tested and audited to assure that it fulfills the required functional and nonfunctional requirements, and best practices.

If the process is not approved, it is sent back to the development phase for further improvement.Otherwise, if it is approved then it is added to the Business Process Repository and sent to the next phase to be deployed.

14: Deployment Phase: Service deployment represents the actual implementation of a service into the production environment. This stage can involve numerous inter-dependent parts of the underlying service architecture and supporting infrastructure.

15: Interoperability Performance Measurement Phase: After the new automated business process is deployed in production to be used by ministries end-users either citizens or employees, the performance measurement has to be performed during the operational phase, *i.e.* run time, to evaluate the ability of interoperation between the cooperating ministries. This measurement criteria may include for example cost, delay (performance), quality and others can be used to measure the performance with respect to barriers and concerns during a basic interoperation cycle (exchange and use of information).

Figure 2 below illustrates all phases described above of the e-Government Interoperability Driven Methodology in **a detailed level** showing all possible iterations between phases. This figure is considered as a second level of the proposed methodology.

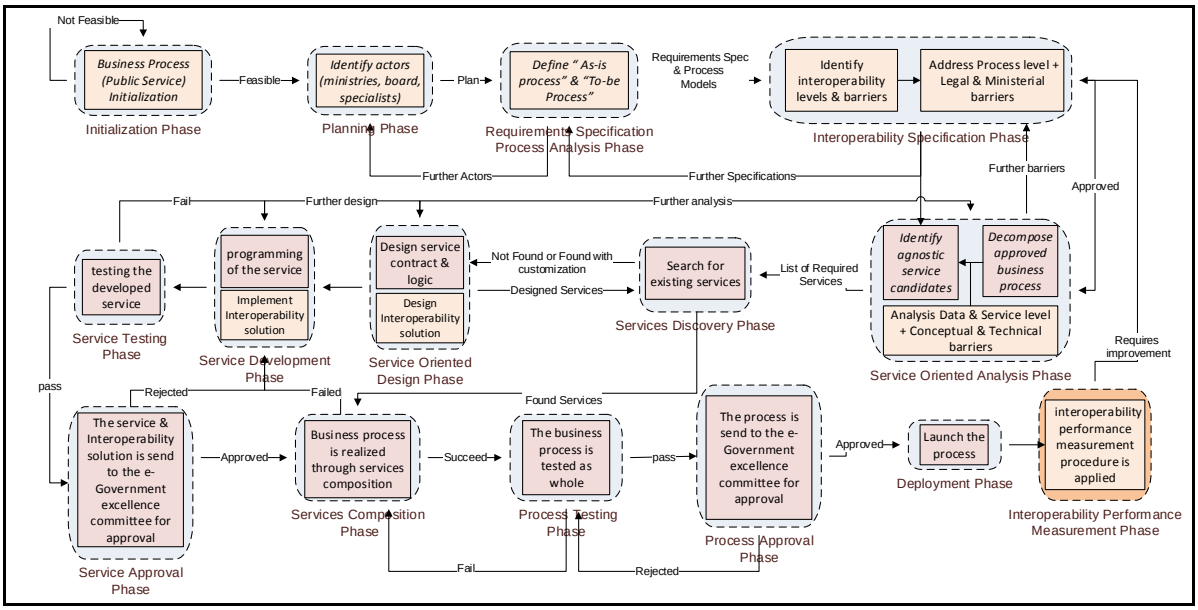

Figure 2**:** E-government interoperability driven methodology (detailed level)

III. Related Work

There are always alternatives when working on information systems generally and interoperability in particular. Therefore, some individual researchers tried to tackle the interoperability challenge by developing some methodologies that provides a guide on how to implement an interoperability solutions between enterprises (ministries) systems. This approach aims at defining the main steps to follow in a sequential way.

In 2005, Daclin proposed a methodology following federated approach [11]. This methodology establishes interoperability at the business level only. Moreover, it is very generic and lacks detailed steps to be followed by interoperability solution implementer. However, it can help in drawing guidelines for detailed methodologies.

In 2007, Sanati and colleagues proposed a new methodology called "E-Service Integration Methodology" by which the interoperability is considered as part of software development phases [12]. This methodology doesn't address interoperability barriers in details. Moreover, it lacks the implementation details which requires further research that focuses on detailing the integration specific tasks of E-SIM to clarify such tasks in their depth.

In 2008, Daclin and colleagues proposed another methodology for enterprise interoperability. It aims "to provide a generic methodology allowing enterprises identifying their problems in terms of interoperability and selecting solutions adapted to their needs" [7].

This methodology is more detailed than Daclin's methodology and provides the compatibility measurement matrix (Table 1) to identify the barriers over all concerns before implementing the interoperability solution. However, this methodology considers interoperability only between two partners [7]. Therefore, it is not applicable to be used for e-Government solution where the interoperability must be considered between many partners sometimes.

In 2009, Saekow and Boonmee proposed a Pragmatic Approach to Interoperability Practical Implementation Support (IPIS) [13] to approach e-Government interoperability. They described an overall methodology for IPIS approach in order to fully engage the e-Government interoperability.

Eventhough this methodology is detailed enough in terms of combining existing solutions, this methodology is dedicated with IPIS tools with a main purpose to help adapting standards to only achieve technical interoperability. Still, this methodology does not address the other levels and barriers of the Interoperability.

IV. Comparison Framework

By comparing our proposed methodology with other approaches discussed above. We found out the following result as presented in Table 2 below.

TABLE 2:
COMPARISON BETWEEN THE PROPOSED APPROACH AND OTHER APPROACHES

Approaches → / **Interoperability***	Daclin, 2005 [11]	Sanati et al., 2007 [12]	Daclin et al., 2008 [7]	Saekow and Boonmee, 2009 [13]	Al-Hosni, 2013 [14]
*Levels and Barriers are addressed	Levels only	Levels only	YES	NO	YES
*addressed in parallel with methodology phases	N/A	YES	YES	NO	YES
* Measurement is applied	NO	NO	YES	NO	YES (Technique is future work)
Reusability is supported	N/A	YES	YES	YES	YES
Driven by (SE) methodology	-	Waterfall	-	-	S.O.LC
Validated	NO	NO	YES	NO	YES (Requires further validation)
Driven by e-Government	NO	YES	NO	YES	YES

The result of this comparison study highlights the contribution value of the proposed methodology and architecture in the body of knowledge. This study's contribution linked between many concepts in software engineering discipline. It linked between Service Oriented Architecture (SOA), Service Oriented Development Life Cycle (SODLC), e-Government and Interoperability.

V. Proposed Methodology Benefits

Using a methodology will avoid hazardous approaches. Therefore, reduce the time needed to develop interoperability and avoid the implementation of non-adapted solutions. Here are some benefits of the proposed methodology.

- This methodology will be generic enough to be used to automate any e-Government public service.
- It allows ministries to identify their problems in terms of interoperability and select solutions adapted to their needs.
- Unified methodological approach to e-Government projects allows following a structured approach in a step-by-step manner in order to guide ministries during the interoperability implementation of solutions.
- Evaluating interoperability degree between ministries to know their strengths and weaknesses.
- Dynamically composing available interoperability solution services according to identified requirements.
- Focused on identifying and involving various actors and stakeholders of the ministries concerned.

VI. Proposed Methodology Considerations

The development of this methodology is taking into consideration the following points:

- First: it considered the existing independent software systems deployments and technical implementation rather than trying to replace them. Ministries have already invested heavily in building their running systems and it would be impractical to suggest a big bang approach that induces fundamental changes on existing infrastructures.
- Second: it is interoperability focused. So it considered the interoperability identification and elimination as one of the main phases in the proposed generic methodology.
- This proposed methodology is considered as a first version. So, further research and practical validations shall be conducted in the future.

VII. Conclusions and Future Work

The main objective of this paper is to propose a methodology to help in establishing interoperability between ministries systems. The propsed methodology is called "e-Government Interoperability Driven Methodology". It is considered as a step-by-step approach to realize the proposed architecture.

We recognize that integrating existing e-Government services to a unified Service Oriented driven methodology is an important engineering task that is relatively different than developing e-Government solutions following hazardous approaches. Therefore, reduce the time needed to develop interoperability and avoid the implementation of non-adapted solutions.

Interoperability complexity has convinced us that the traditional software development methodologies are ill equipped for efficiently dealing with service interoperability engineering projects that in turn may increase the risk of complete or partial project failures.

Therefore, we are encouraged to take this study one step further and research the requirements of a new methodology that will be capable of carrying out a successful and efficient service interoperability engineering project for e-Government. The proposed methodology in this paper is designed to guide the development team to correctly follow a series of steps in creating software's to meet business needs. This paper's contribution has evolved as a new methodology and new research that have addressed weaknesses of older models. Ideas have been borrowed and adapted between the various models as explained in related work section.

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