

RESEARCH TITLE

Service Oriented Architecture Methodology to improve reusability of e-Government Systems case study from Sinnar state, Sudan

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Abstract

Reusability, interoperability and integration are important factors in e-government systems since different governmental units collaborate to deliver a holistic service to a citizen. In the other hand building scalable software systems remains a complex undertaken, since such systems supposed to focus on processes and tools which support the concept that large systems can be assembled from independent, reusable collection of functionality to facilitate integrating disconnected systems. The main objective of this study is to propose service oriented architecture (SOA) development approach that can be implemented in Sudan e-government portals to improve reusability and interoperability throughout adopting a case study approach. The study presented a methodology for building e-government applications based on service-oriented architecture to promote reusability, interoperability of these applications since governmental agencies supposed to work in integrated manner to deliver a holistic service to a citizen. Besides, the model will contribute in dealing with heterogeneity of technologies and platforms used to realize e-government systems which resulted from the individual responsibility for each governmental unit to develop its own system with its own technological and platform choices, as the methodology defined set of guidelines and standards for e-government applications and e-services evaluated through case study step by step implementation.

Key Words: e-government, Reusability, Interoperability, Integration, Service Oriented Architecture, Web Services.

المستخلص

تعد إمكانية إعادة الاستخدام والتشغيل البيئي والتكامل عوامل مهمة في أنظمة الحكومة الإلكترونية حيث تتعاون الوحدات الحكومية المختلفة لتقديم خدمة شاملة للمواطن. من ناحية أخرى، يظل بناء أنظمة برمجية قابلة للتطوير أمراً معقداً، حيث من المفترض أن تركز هذه الأنظمة على العمليات والأدوات التي تدعم مفهوم إمكانية تجميع الأنظمة الكبيرة من مجموعة مستقلة وقابلة لإعادة الاستخدام من الوظائف لتسهيل دمج الأنظمة المنفصلة. الهدف الرئيسي من هذه الدراسة هو اقتراح نهج تطوير المعمارية الموجهة نحو الخدمة (SOA) الذي يمكن تنفيذه في بوابات الحكومة الإلكترونية في السودان لتحسين إمكانية إعادة الاستخدام والتشغيل البيئي من خلال تبني نهج دراسة الحالة. قدمت الدراسة منهجية لبناء تطبيقات الحكومة الإلكترونية القائمة على المعمارية الموجهة نحو الخدمة لتعزيز إمكانية إعادة الاستخدام والتشغيل البيئي لهذه التطبيقات حيث من المفترض أن تعمل الوكالات الحكومية بطريقة متكاملة لتقديم خدمة شاملة للمواطن. بالإضافة إلى ذلك، سيساهم النموذج في التعامل مع عدم تجانس التقنيات والمنصات المستخدمة لتحقيق أنظمة الحكومة الإلكترونية والتي نتجت عن المسؤولية الفردية لكل وحدة حكومية لتطوير نظامها الخاص مع خياراتها التكنولوجية والمنصات الخاصة بها، كما حددت المنهجية مجموعة من المبادئ التوجيهية والمعايير لتطبيقات الحكومة الإلكترونية والخدمات الإلكترونية التي تم تقييمها من خلال دراسة الحالة خطوة بخطوة.

الكلمات المفتاحية: الحكومة الإلكترونية، إمكانية إعادة الاستخدام، التشغيل البيئي، التكامل، المعمارية الموجهة نحو الخدمة، خدمات الويب

1. Introduction

Governments, businesses, communities and citizens recognized the value of information and communications technologies are being brought to their disposal. In the government situation, this has been described as electronic government or e-government. If e-Government properly designed and implemented, that will help the achievement of all governmental activities including policies and priorities.

E-governance is identified as the use of modern information and communication technologies e.g. internet, local area network, wide area network, mobiles, etc., by government to improve effectiveness, efficiency, and service delivery to citizens and promote transparency [1][2]. Now it's quite common to notice that governments are improving the public services and governmental activities making use of e-Government features. Almost countries all over the world are placing their critical information online and automating their processes so that the information would be fully available and reachable to their citizens and other stakeholders. However, there are many problems facing implementing and improving e-Government in Sudan in term of processes and methodologies used to realize such systems.

Throughout the last years interoperability has been in the focus of e-government practice and research [3]. The main objective of e-government is to enable the public sectors to provide citizens with information and services according to their need, hence to increase their effectiveness, efficiency and quality of service.

E-government applications require a reasonable degree of collaboration and interaction, since they may collaborate to deliver a comprehensive service to citizens. A Service Oriented Architecture (SOA) approach to e-government can improve reusability concept, hence it enables various government units to re-use developed assets [4]. The use of SOA architecture offering public services in reusable, interoperable and open way, and that could significantly contribute to move towards comprehensive e-government integration model in Sudan so as provisioning online services to all stakeholders.

According to [5] e-government integration broadly defined as "An organizational arrangement whereby multiple organizational units collaborate in the concentration of providing accurate and timely services in a single access point to all users. This arrangement needs unified efforts from all stakeholders to overcome all obstacles faced on the way". Collaboration of organizational units to provide a comprehensive service to users or customers and the importance of coordination by stakeholder to resolve issues is a main idea behind e-government integration, and the definition captures it.

In Sudan e-government is an important objective in the strategy of ICT that approved, in 2001 a decision to get on e-government by the President of the Sudan has issued, when the government recognized the value and role of the e-government, and how it is can contribute in the sustainable development. The declaration point out that the country is ready to adopt e-government initiatives [6]. National Information Centre (NIC) is an official authority responsible for e-government projects in Sudan was formed in 2004, beside its responsibility to all projects related to ICT for the government (NIC 2019). [7] Conducted a research paper to evaluate the e-Services of the Sudanese Government Portal, considering 46 public e-Services. The results of the evaluation have shown that the level of the quality, interaction and completeness of these e-Services is unsatisfactory. Therefore, these e-Services at their current state cannot replace direct manual services within government offices. The paper concludes with recommendations for developing guidelines and standards for e-government websites and e-Services and legislation to enforce such standards.

A system development methodology refers to the basis that is used to

structure, plan, and control the process of developing an information system [8]. It is a sequential steps and procedures to carry out the development activities in different phases of a system development life cycle. Each methodology has its own assumptions about the reality, its own techniques to support working principles, and its own tools to generate the deliverables for activities. For maintenance and evolution purposes and to integrate new functionalities software building is moving towards the use of methodologies for controlling the software development process [9].

Service Oriented Architecture (SOA) is a current and interdisciplinary field of research. “SOA is defined as an architectural approach that utilizes services such as the basic constructs to support the development of rapid, low-cost and easy composition of distributed applications even in heterogeneous environments” [10]. The definition explains that the central idea of SOA is to provide the functionality of applications as a service, and then to allow a simple mechanism to access this service in a web infrastructure.

Web services are one of technologies used to implement SOA. A web service uses basic standards for messaging, describing web service interface and for implementing the service broker, which are Simple Object Access Protocol (SOAP), Web Service Description Language (WSDL) and Universal Description, Discovery, and Integration (UDDI) respectively. It is worth mentioning that UDDI is an optional technology [11]. The typical SOA architecture is shown in Figure (1)

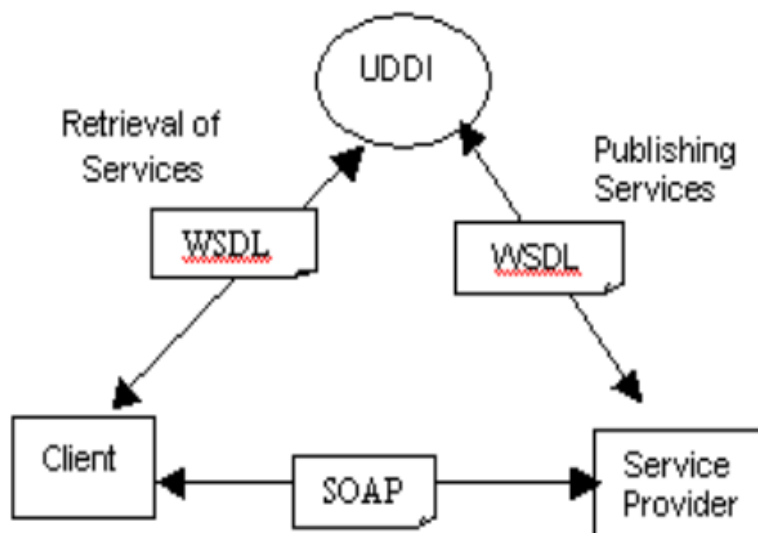


Figure 1: SOA Architecture. Adapted from [12]

Web services simplify business process without the involvement of human [13]. WSDL describes web service in two fundamental stages; one is abstract and the other is concrete [14].

Successful in business and organizations require information within the organization and Meta information. The existence of huge information repositories created by traditional applications prevents information flow between internal and external parts. However, SOA approaches can replace these huge resources by loose coupling services and satisfies the required information flow and increases speed in these organizations [15].

E-government systems in Sudan are in need to rely on flexible development architectures supporting the concepts of reusability and interoperability, because of changing governmental units’ structures, especially in Sudanese states governments which results in inevitable change in working systems. Besides, each government unit is responsible to

build its systems with their own choices, which results in heterogeneity and need to be considered since many government units supposed to interact with each other's to deliver a comprehensive service to citizens.

Building such systems need to focus on processes and tools which support the concept of assembling large systems from independent, reusable collection of functionality to facilitate integrating disconnected systems. E-government applications is one of most important applications that requires integrating variable software components from different governmental sections to deliver a holistic services to a citizens since their data might be used among these governmental agencies.

In order to full optimization its use, e-government services might benefit from innovative approaches such as Service Oriented Architecture to build flexible, open and collaborative services and lowering the costs of development. The aim of this research is to propose SOA development approach that can be implemented in Sudan e-government portals to improve reusability and interoperability.

2. Material and Methods

2.1 Sinnar case study

Sinnar is located in the south-eastern part of Sudan, bordered to the north by Gezira State, to the south by Blue Nile State, to the east by Gadaref State and the Sudanese-Ethiopian border, while to the west by the White Nile State and the borders of the State of South Sudan. The location results in Sinnar's unique characteristics, as it is the main passage between different states. Sinnar state oriented to making use of information technology since 2006, when established its official authority (Sinnar Information Center (SIC)) responsible of information technology in general and e-government initiatives in particular. SIC has its own regulations, issued since 2008, then modified in 2013, as a result SIC became under supervision of Information consultant. In 2017 the law modified again and clarified to make SIC under supervision of State Government General Secretariat directly, and the regulations has been approved from state ministers' council (Nesrein, A. 2017).

2.2 Data Analysis Procedure

Content analysis is consulted so as to be used in this study to identify. General themes through descriptive coding grounded around participants responses were defined taken from interview transcripts and documents, where code is defined as a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data, whereas descriptive coding also called "topic coding" summarizes in a word or short phrase, the topic is what is talked or written about [16]. The interview questions were framed and divided into main five dimensions to reflect several aspects that may affect implementing and improving e-government i.e. IT infrastructure, standards and software integration, organizational aspects including managerial problems and cultural issues etc. as the research followed several steps to analyze the data started with preparing data where transcribing interviews, translating them into English and organizing documents, then reading data, writing up ideas, information and farming respondents' thoughts. Identifying general themes and interpreting the meanings of data. The following are the results:

2.2.1 Information Technology infrastructure in Sinnar state

Figure (2) shows the percentage of respondents regarding to IT infrastructure in Sinnar state investigating the reality of network, websites, online services and corresponding evaluation of the existing websites. The sample participants taken form SIC staff member as well as IT technicians and managers from ministries, Sinnar and Singa localities, the original data came from interviews transcripts which has coded and transmitted into general themes to facilitate

content analysis. The answers of participants have grouped into four main categories of responses as shown in figure (2); this wide range of response categories arises because the respondents have different backgrounds and diverse technological knowledge. Most of interviewees (78%) agreed that there is an existence of good networks, but only at headquarters in different institutions as they need an extension to cover other parties. It is obvious that there is a responsible IT infrastructure, as there are many computer networks but needs to expand to cover all governmental units in the state. In the other hand there is a lack of websites and online services.

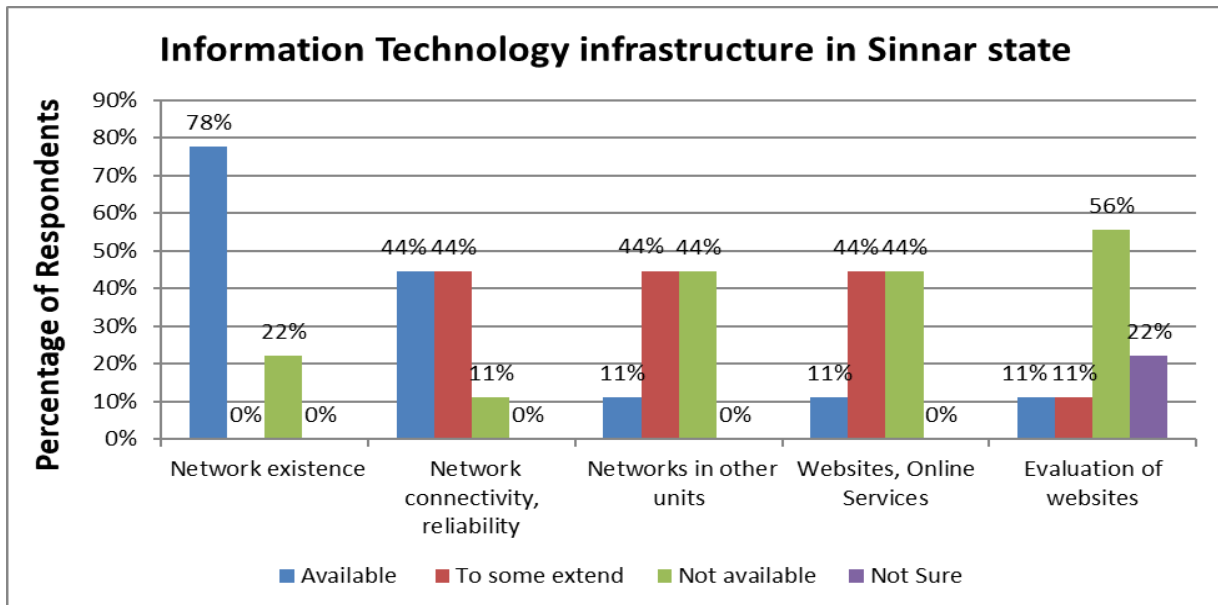


Figure 2: IT infrastructure in Sinnar.

2.2.2 Organization (human capabilities, change management and top management)

Figure (3) shows the organizations nature and its related factors which may influence implementing e-government in a proper manner such as culture, human capabilities, change management and top management. The results shows low percentage of IT competences of staff as well as the extent of top management awareness and commitment to e-government initiatives at (22%), (33%) respectively, as the organizations suffering from losing skilled staff with prorata of 89%. All this negatively affects the stability of organizations in general and their e-government initiatives in particular.

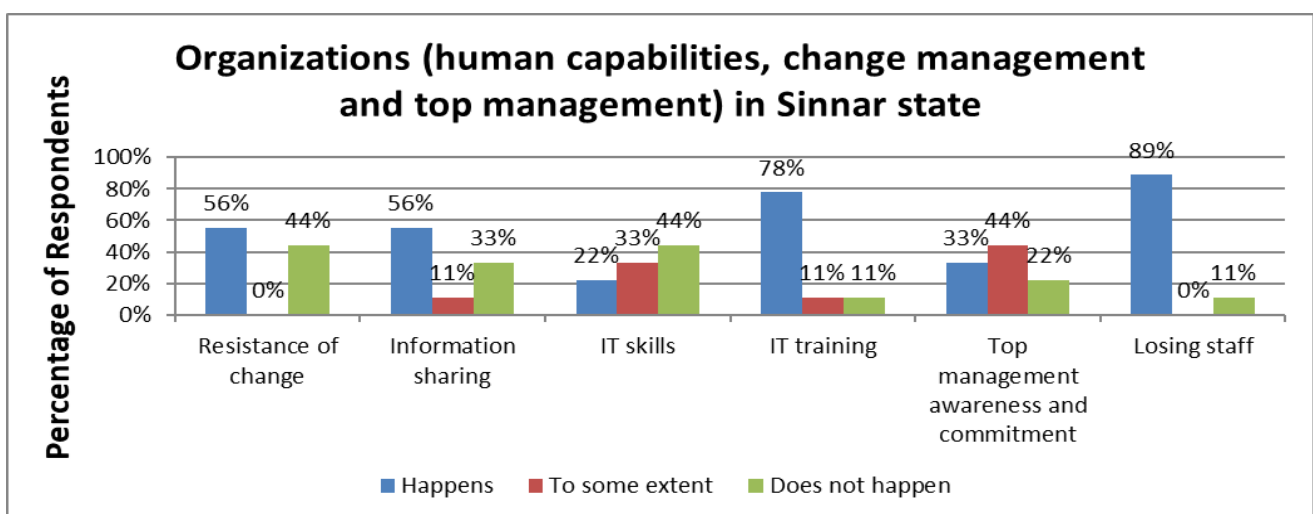


Figure 3: Organizational factors influencing e-government.

2.2.3 Challenges and barriers faces adopting e-government initiatives in Sinar state institutions

Figure (4) illustrates the respondents' views regarding to challenges that barriers implementing e-government effectively in Sinar state, its noticed that funding is a key challenge that barriers e-government implementation. As interviewees mentioned very important points which maybe a key factors and main challenges that needs to be highlighted such as security issues, E-participation issues, Illiteracy, customs and traditions, resistance of IT innovations by old employees and politicians negative opinions about IT innovations.

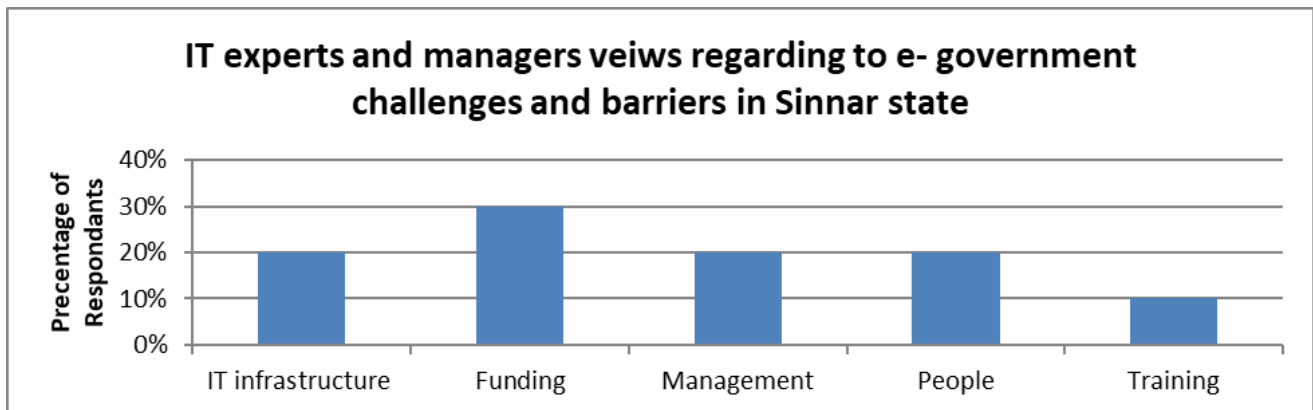


Figure 4: IT experts view

It is worth mentioning that before conducting interviews in Sinar state, NIC was included to take a general view at national level because it is an official authority responsible for e-government all over the country and serves as a policy maker and advisor for states information centers. Some valuable information gained from NIC, regarding to reusability the respondents agreed that there is no methodology used to reuse these systems or software, and the evidence for this is that there are many similar systems in government units which lead to wasting state money. While the main challenges of integration process could be: Lack of regulations, security issues, data sharing, heterogeneity, as different government units use different types of technologies and management issues, as there is a resistance from other organization related to integration.

2.3 SOA Methodology for e-government Applications

This section introduces the methodological steps that form the SOA approach for e-government, which can address most of the requirements of the current E-government system development in Sinar state. The focus is to propose organized steps which leads to a set of well-defined web services that would adapt to the way in which government services are provided in general, and services that common to government unit in particular. Also the proposed methodology takes into consideration the good practices from industry experience to create integrated and coherent web services.

2.3.1 Implementation and Design

The following is the sequential steps of the methodology for web services development to integrate e-government systems as well as to enhance software components reusability.

2.3.1.1 Web Services Development Steps

The figure (5) shows the empirical steps used to develop web services form selected business process domain, it is similar to waterfall model with more activities e.g. deployment and publish as it represent a development workflow.

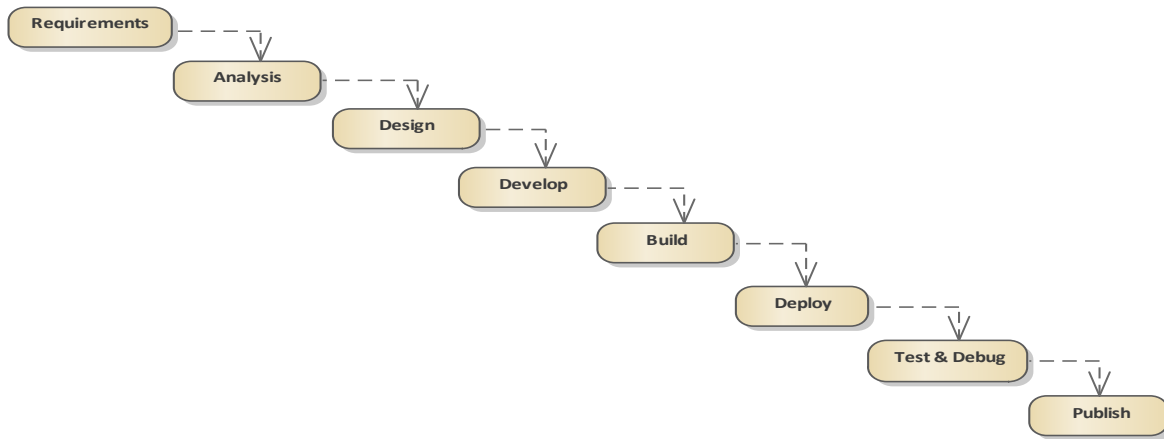


Figure 5: Web Services Development Workflows

Consequently, the phases identified to be suitable for web services lifecycle phases are: requirement, analysis, design, implementation, test and deployment.

2.3.2 Design Scope

In this step business process scope defining carefully for analysis purposes, the analysis affords the basis for verification of completeness of the design [17]. This step identifies relevant business process and participants. Figure (6) illustrates the general design framework.

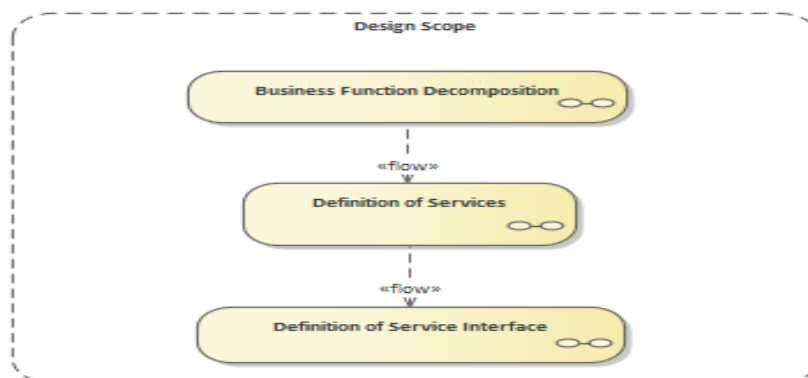


Figure 6: Services Design Framework

Figure (6) shows sequential steps begins with business function decomposition and the goal of this step is to decompose the business process into elementary business functions, identifying sub-functions, activities and actions. This method will maximize the cohesion as basic business functions typically realize a single concrete task. Next step is to define group of services corresponding to the basic business functions identified in a previous step, Services should allocate in a separate manner according to their specific functionality to ensure reusability. Then define group of operation for each service according to the business logic with their input and output messages to form the service interface. In this step, the services are designed and named; typically the service consists of the service name, message type where there are two types of message (input and output) and then message name must be specified to determine whether the operation status is request or response.

While the definition of service interface is the specification of services operations and assigning input and output parameters to individual operations are performed in this step to form service interfaces. So interface definition specifies operation name, message type, message name to determine whether the message is for request or response and finally the message content which is typically contains attributes in case of request status or return value in case of response message.

2.3.3 Implementation Architecture

An enterprise service bus (ESB) is one of middleware that used as implementation architecture, also it is used to route a mange messages between service provider and service consumer. ESB provides different virtualization patterns; one of them is an interface The ESB pattern can be either hardware or software middleware products [18].

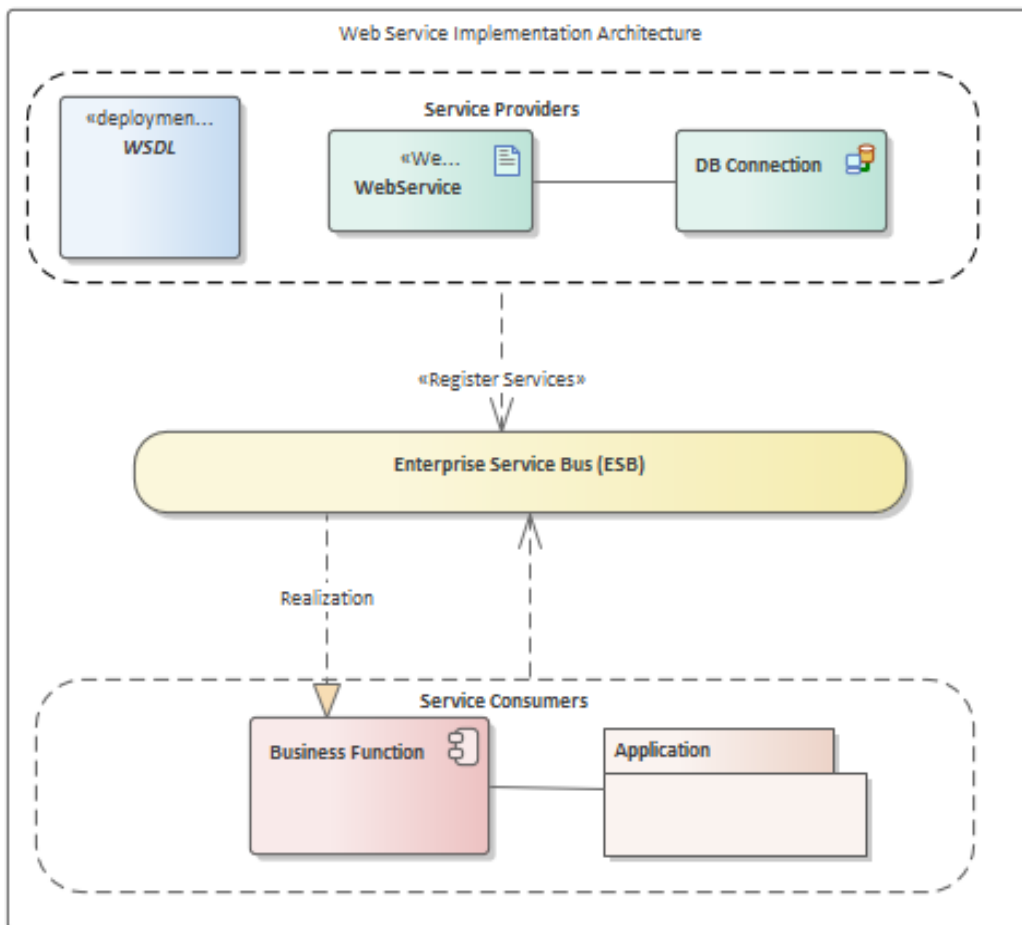


Figure 7: Web Service Implementation Architecture

Figure (7) describes the logic of the implementation architecture which using publish-subscribe strategy, as services can be published via bus engine and registered to ESB, so it provide alternatives to service consumers in case of the target endpoint is not available. The implementation architecture scenario in the context of this research, SIC the service provider deploying available web services which symbolizes common shared services among deferent governmental units into main servers (ESB). Using description and specification of the web services the governmental services expose and use suitable ones to their business functions to realize certain functionality in their systems. This way the governmental units are able to build their systems through assembling functionalities offered by these reusable web services, and it does not need to worry about technological details used to define and realize these web services, since its lay on open standards which makes them interoperable components.

To sum up all: the proposed methodology is comprised of three main stages with different activities as shown in table (1).

Table 1: SOA methodology stages

Stage	Elements (activities)
Service Identification	Web service development steps.
	Web service development lifecycle.
Service Specification	Principles and guidelines.
	Design scope.
	Business function decomposition.
	Defining services.
Realization	Defining service interface.
	Implementation architecture.

Table (1) shows the three stages of SOA methodology and its associated activities, it begins with service identification where standard web service development steps followed and its lifecycle considered then specifying web services by decomposing business function to facilitate the definition of services and their interfaces considering industry experience and best practices. The last stage concerns with the realization step, where decision taken about certain implementation architecture.

Although the proposed methodology, didn't addressed managerial aspects. However, it remains a very important aspect to take into account when intending to develop e-government applications, as it may affect the process as whole positively or negatively. Managerial aspects need to be implicitly considered in working in e-government projects e.g. preparing budgets and top management support as well as IT infrastructure.

3. Results

3.1 Evaluation of the Case Study and Implementation

Technically all ministries, localities and its administrative units in the state which is referred to in this research as government agent affiliated to SIC. Figure (8) illustrates the current business process adopted between SIC and the government agents in order to realize e-government initiatives in the state.

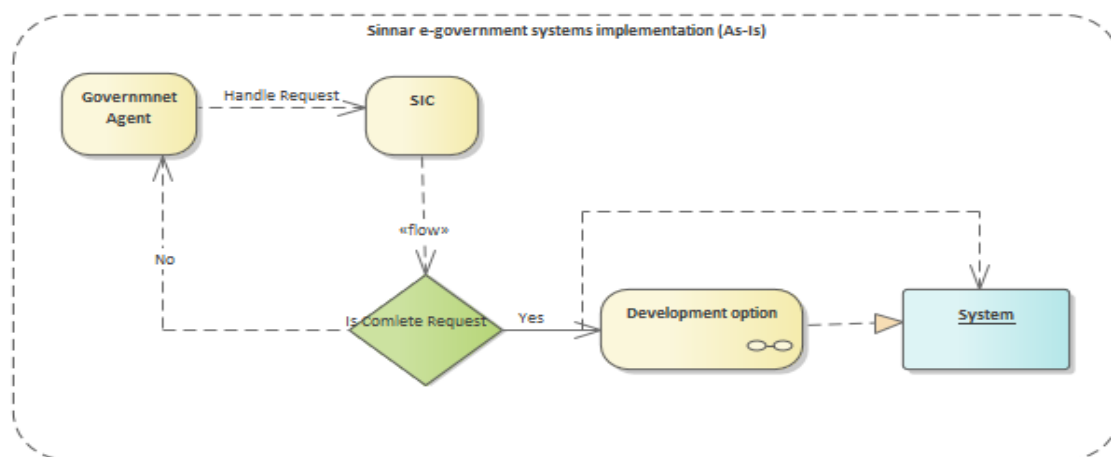


Figure (8): Sinner e-government systems implementation (As-Is)

Figure (8) shows the current business process adopted to implement systems within Sinner State e-government, the process starts by request from certain government agent to SIC to computerize its business functions. SIC staff checks the request and ask for requirements, when they receive requirement, they decide whether to develop the required system internally or to contract a company for the implementation process. This process results in various types

of systems with different architectures, varied technologies and programming languages which causes difficulties in merging and integrating different systems in the e-government to interact and collaborate as it is an investable process in governmental work to deliver a comprehensive service to citizens. It is worth to mention here, that this research deals with this kind of obstacles, and seeks to tackle them through the proposed methodology.

To promote interaction and collaboration of different information systems within Sinnar state e-government project, this research introduces new business process which leads to flexible information systems architecture. Figure (9) presents (To-Be) architecture for Sinnar e-government project information systems. According to the proposed methodology, the planned architecture mainly depends on conducting a comprehensive analysis for the institutions to decompose the business processes to their elementary business functions identifying sub functions, activities and actions which can be wrap together as services, and then to provide the services where needed, that enables Sinnar state institutions to build their systems by assembling independent, reusable collection of services hence to facilitate integrating disconnected systems. The proposed architecture considers interoperability as critical factor, so open standard such as XML and SOAP are used, this architecture introduces reusable and interoperable web services that can be published and exposed where needed.

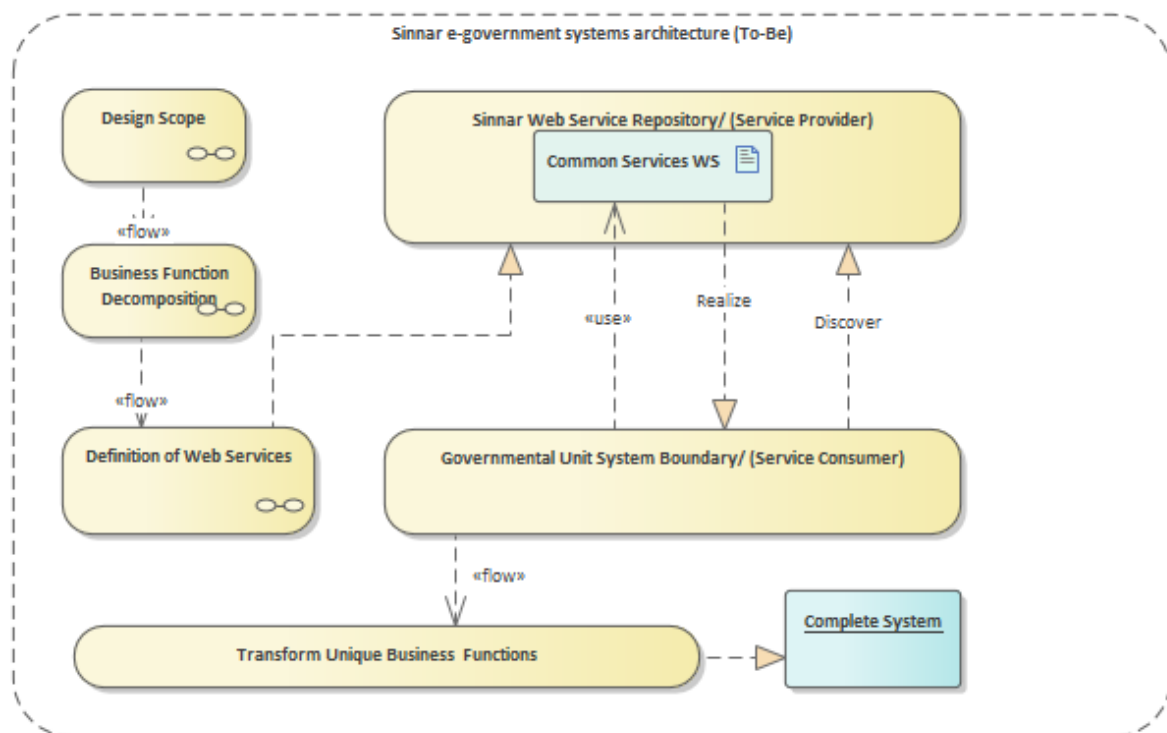


Figure (9): Sinnar e-government systems implementation (To-Be)

For the purposes of this study the author decided to develop a set of web services represent most common, shared services among different government units in whole state to be a base for building e-government applications in the state based on enabling the process of reusing software components and interoperability.

Since the concept of SOA includes a service provider who provides a web services and a beneficiary of these services, called a consumer. So, in the context of the proposed methodology in this study, Sinnar Information Center (SIC) represents the service provider, while the rest of government institutions, including ministries and their lower units, and localities and administrative units represent the consumer.

In general the proposed methodology agrees with SIC transformation plan which prepared to

adopt e-government initiatives in several, thus much support the assumption that the proposed methodology supports the transformation of the state government to e-government, taking into account the construction of systems with a flexible architecture capable of expansion and integration.

4.1.1 Case Study Analysis Summary

This section introduces the findings that obtained from the case study real context conducted in section (3.2) and its findings that described the factors that affect e-government initiatives in Sinner state, so as the proposed SOA methodology used as a solution, table (2) shows the results.

Table (2): Features brought to case study

No.	Feature	Description
1	Using open standards	Web service depends on open standards e.g. HTTP, XML and SOAP
2	Reusability	Web services can be exposed by different parties to do the same function in variable application contexts.
3	Interoperability	Can be exposed form different environments.
4	Integration mechanisms	Enabling reusability and interoperability enables integration mechanism.
5	Assembling systems from different collection of reusable functionalities	Any government unit can expose set of web services to resemble an entire system.

5. Conclusion

Reusability and interoperability are most important features in e-government applications; this study has highlighted and emphasized the significance of these elements. As the research presented applicable SOA methodology for e-government to promote afore mentioned features.

Case study strategy was used to emphasize applicability of the proposed solution, and then interview method used to produce detailed descriptions and to evaluate e-government initiatives accordingly to understand how e-government established in Sudan and its progress, so as to identify key criteria followed in development process, also to identify software standards, integration methods and their challenges.

The proposed methodology depends on Web services technology to facilitate integration, reusability and interoperability in e-government applications in Sudan. Besides, the model will contribute in dealing with heterogeneity of technologies and platforms used to realize e-government systems which resulted from the individual responsibility for each governmental unit to develop its own system with its own technological and platform choices.

5.1 Recommendations

For future work, we suggest to test the proposed approach in different government situations and carefully consider the security aspects of using Service Oriented Architectures.

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