SERVICE ORIENTED ARCHITECTURE: A REVIEW AND EVALUATION OF REFERENCE MODELS

Mohsen Mohammadi

Department, Esfarayen University of Technology, Esafarayen, 9668195, Iran
e-mail: Mohsen@esfarayen.ac.ir
Iran

Abstract: Enterprises have embarked on the implementation of integrated information systems to support their business processes. To this effect, SOA, as a highly capable paradigm in IT, has been increasingly used in BPM using the Web service technologies; produce innovative patterns for the interpretability and integration of the processes and services. This has helped the attainment of required agility and flexibility for inter-organizational networks. As a result, many SOA reference models have been proposed for service modelling which facilitate the adoption of SOA for enterprise information systems including SOA Reference Model (SOA-RM), Service-oriented Modelling Framework (SOMF), Platform-independent Model for SOA (PIM4SOA), and Service-oriented Modelling and Architecture (SOMA). This paper concentrates on consolidating existing SOA modelling methods by utilizing the most commonly used evaluation method, namely the feature comparison. The purpose of this paper is to evaluate the aforementioned reference models for Service-oriented approach. The finding shows that SOMA is a more transparent, defining several key techniques and details of analysis, design, implementation, deployment, and policies in SOA project.

Key words: Service-oriented Architecture, Reference Model, Business Process, Evaluation Method

1. INTRODUCTION

In today's business environment, the uncertainties in Business Process management (BPM) increase the business requirement changes that have encouraged companies to make use of different technologies of IT systems. With the emergence of the Web Services, the possibility of integration of BPM with other systems has become less complicated.

Current research in the field of BPM focuses on business process integration [1-3]. Whenever integration is a matter of concern, it is crucial to share information. This requires coordinating the flow of the information and links their business processes [4-6]. In this regard, Service-oriented Architecture (SOA), as a fast growing paradigm in IT, has been widely applied in BPM and enterprise information systems [7, 8] which use Web service technologies and provide new pattern integration and interoperability in processes, services, and data in order to increase flexibility and agility in inter-organization network [9-11]. SOA as a fast growing paradigm in IS provides benefits as business applications are much better

aligned with business processes [12]. Consequently, many SOA reference models have been developed to support the requirement for modelling, development and implementation of information systems. The purpose of this paper is to evaluate the most widely used SOA reference models for Service-oriented approach and the applicability of the most widely used SOA reference model (SOMA) in scenario example.

1.1. Service-Oriented Architecture

The traditional way of providing new applications for organizations was to purchase them from software providers and then they customized or modified them in order to develop the applicability of the purchased applications. The adoption of the above approach is costly and it often results in the production of new applications which do not yield easily to further modifications [13, 14].

From the viewpoint of "business and technology", Markes and Bell in [11] defined SOA as follows:

"SOA is conceptual business architecture where business functionality, or application logic is made available to SOA users, or consumers, as shared, reusable services on an IT network"

In SOA, a service is described in a standardized style, published to service registry, discovered and invoked by a service consumer [12]. The service provider, service consumer, and service broker are three primary elements in SOA. The service provider publishes a service description and provides the implementation for the service, a service requester, consumer finds a service description in service registry, then binds and invokes the service, and the service broker provides the service registry. However, the service broker is optional and the service consumer can obtain service disruption directly from service provider [13]. Figure 1 shows the conceptual model of a SOA architectural style.

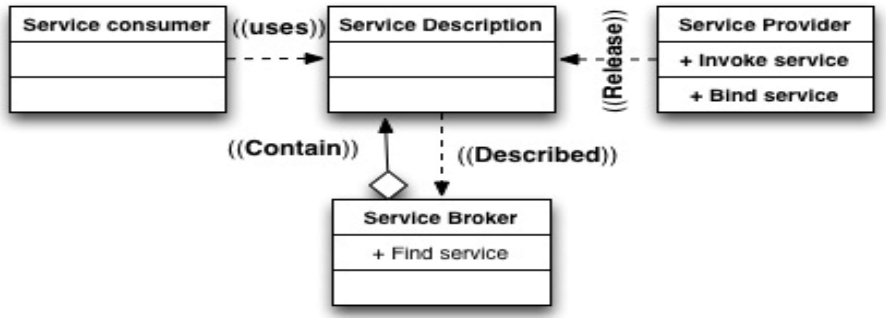

Figure 1. The conceptual model of SOA architectural style [13]

The term "service-oriented" and SOA came into existence before the arrival of Web service [14]. Web services are the most suitable technology for successful SOA, although it is not limited to web services [14]. For instance, Common Object Request Broker Architecture, CORBA and Message-oriented Middleware systems such as the IBM Message Queue Series and Java Messaging Service, JMS can be applied, but web services in comparison with others have more loosely coupled interfaces [12, 15]. Web services provide the underpinning technology for SOA including the standard invocation mechanism defined by Web Service Definition Language, WSDL, the standard communication protocols provided by Simple Object Access Protocol, SOAP as a mechanism for exchanging XML-

based message in web applications, and Universal Description, Discovery and Integration, UDDI for supporting web services location management [12, 15]. Figure 2 shows service collaboration based on SOA.

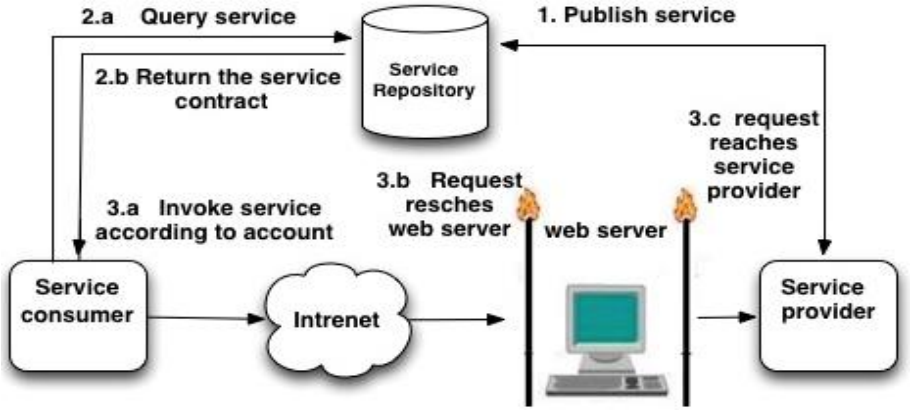

Figure 2. The service collaboration based on SOA [16]

The second section includes the evaluation of the SOA reference models. Section 3 highlights how to adopt SOA in business processes for the example scenario. Finally, the last section terminates with discussion and concluding remarks on the scope of this study. Herefore, in the representation of business processes in service-oriented approach, modelling relationship between processes and services' view must be clear. As a result, many SOA reference models have been proposed for service modelling which facilitate the adoption of SOA for enterprise information systems including SOA Reference Model (SOA-RM) [16], Service-oriented Modelling Framework (SOMF) [17], Platform-independent Model for SOA (PIM4SOA) [18], and Service-oriented Modelling and Architecture (SOMA) [19].

2. RESEARCH METHOD

This section concentrates on consolidating existing SOA modelling methods by utilizing the most commonly used evaluation method, namely the feature comparison.

2.1. Evaluation method

The ever-increasing need for today's organizations to model their business processes has led to the introduction of numerous methods. However, the problem is not the huge number of methods and techniques. There is a scarcity of standardized methods for evaluating them [20]. Evaluation methods are used for different purposes, for example, to understand the capability of different modelling techniques, to model the real business environment [21], to have better grasp of the characteristics, strength and weakness of methods for classifying modelling techniques and improving them, to compare different modelling techniques and gather information for using specific techniques, and to enhance the information system development process [20, 22]. Previous comparative researches have sometimes provided a crystal clear evaluation methodology; for example, [20] conducted a survey on method evaluation. They presented a holistic comparison on evaluation methods and classified them in three categories: the feature comparison, the theoretical and conceptual investigation, and

the empirical evaluation method. Table 1 illustrates the classified scheme of evaluation methods.

Table 1. Evaluation Methods [20]

Evaluation Methods	**Sub Categories (Source)**
Feature Comparison	Check List [23]
Theoretical and Conceptual Investigation	Conceptual Framework: Curtis's framework [24] Workflow pattern framework [25] Semiotic quality framework [26]
Empirical Evaluation	Survey [27] Laboratory Experiments [28] Field Experiments [29] Case Studies [30] Action Research [31] Verbal Protocol [32]

In the evaluation method category, the empirical evaluations have some disadvantages, for example, they decrease the level of efficiency. Further, the survey method and the verbal protocol method need to access human subject, and the model created in laboratory experiments may not be suitable in the real word [20]. The field experiment method is difficult to apply in an information system context [33]. The feature comparison technique is used by developing a checklist of ideal method features across which methods or modelling techniques are evaluated. A clear understanding of the ordinary methods indicate that theoretical and conceptual investigation methods are less subjective and do not require empirical data [20]

In the category of theoretical and conceptual methods, many frameworks for the evaluation and assessment of methods and modelling techniques have been proposed. Some of the highly utilized frameworks, which have been applied by other researchers, include the workflow pattern framework [25], the semiotic quality framework [34], and the Curtis framework [24]. Workflow pattern analysis provides taxonomy as a benchmark for analyzing the methods and modelling languages for process-aware information systems [25, 35]. However, it cannot access the Quality of Services (QoS) in a business process [36]. The semiotic quality framework (SEQUAL) is based on linguistic and semiotic concepts for the evaluation of the conceptual models' quality [26, 37]. However, this framework is too static, and its definition of programmatic quality is considerably narrow [26].

In light of the above, the feature comparison is relatively easy to evaluate the SOA reference models provided that the criteria are well defined in the checklist [20]. With regard to the evaluation of SOA reference models, the most important features are identified based on the main concepts of SOA. Then, a checklist is designed in order to analyze the extent to which the SOA reference models meet the requirements for supporting Enterprise Architecture in terms of Business Architecture, Information Architecture, Technology Architecture, and Application Architecture. Finally, a case study is adopted from the DELL's order fulfillment, online Order processing in computer industry to show the applicability of the most widely used SOA reference model.

3. RESULT AND DISCUSSION

3.1. SOA evaluation

This sub-section reviews and examines the selection of proper SOA reference for SCP modelling. These reference models include SOA Reference Model (SOA-RM) [16], Service-oriented Modelling Framework (SOMF) [17], Platform-independent Model for SOA (PIM4SOA) [18], SOA Modelling Language (SoaML)[38], and Service-oriented Modelling and Architecture (SOMA) [19], which have been widely applied in industrial and academic contexts. In the following each of these reference models are elaborated.

- The SOA-RM is an OASIS standard that intends to provide a common vocabulary for capturing the essence of SOA [16]. It is designed explicitly not to be implementable directly but to provide a common conceptual and terminological framework for everyone working in service-oriented modelling [16, 39]. Moreover, this reference model defines meta-model aspects of services related to service description and policies [16].
- SOA-RFA is currently an OASIS committee specification that is an abstract foundation reference architecture which addresses the business via service view [39-41]. SOA-RFA early draft was initially presented as the SOA Reference Architecture, yet throughout time it developed in varied forms, reflecting the domains of implementation paradigm. Consequently, it was renamed by adding the word Foundation that provides a common vocabulary to understand the importance of the ecosystem view within the SOA paradigm and demonstrates how SOA-based system can be realized in an abstract way [39, 40].
- The SOMF is a model-driven methodology with specialized modelling notation to help model, analyze, and identify services that are proposed by [17]. It provides a formal method of service identification at different levels of abstraction including meta-model concept and specific notation [42, 43].
- PIM4SOA is developed based on a meta-model for SOA, consisting of a set of crucial aspects such as services (description of services including access, operation and types), process (logic order in terms of action, control flows and service interaction), information (message or structure of service exchange), and the quality of services (extra-functional qualities regarding to service, information and processes)[18]. The main goal of PIM4SOA meta-model is to define a language for describing SOA as an independent level platform [18, 44].
- The Object Management Group (OMG) proposed SoaML for representing SOA artifacts, using Unified Modelling Language (UML) as a core-modelling standard [45, 46]. Moreover, a meta-model and a UML profile are provided in SoaML for the specification and the design of service to SOA [38].
- SOMA is a modelling method for developing and building SOA-based systems proposed by IBM. SOMA activities focus on service identification (discovering candidate service and interaction between them), service specification (making decision for exposing services), and service realization [19, 47]. The primary focus of SOMA method is on the service and service components and flows with emphasis on reusing services [48].

As a consequence of the relationship between Enterprise Architecture and SOA, a proper SOA reference model is supposed to support four sub-architectures including Business Architecture (BA), Information Architecture (IA), Technology Architecture (TA),

and Application Architecture (AA) which will be elaborated in the following discussions [49-51].

According to the instructions of the SOA governance council, the whole business landscape has to be deconstructed into a series of business compartments so as to support diverse business functions [51]. Moreover, the Information Architecture layer guarantees an appropriate manifestation of data and information that is to be obtained in an SOA [52]. Thus, a proper Service-oriented modelling method has, at least, to define service message whereupon service message specification influences Information Architecture. Further, the orchestration of services and IT components have to be supported by the representation of the information flow [48]. The infrastructure capabilities which are required in SOA are provided by Technology Architecture [51]. The requirements of the data storage, operation system, and application layer in SOA and its infrastructural technologies are expected to be met by Technology Architecture perspectives [53]. Hence, a qualified Service-oriented modelling method is to support not only Technology Architecture's major concepts and perspectives but also SOA maturity. Such requirements often begin with the identification of a series of atomic service where the final services are exposed by encapsulation of the Information Architecture functions [19, 49, 50]. In light of above discussion, Table 2 is an illustration of the specific features for SOA reference models, in terms of Enterprise sub-architectures, demonstrating the extent to which reference models support the sub-architectures.

Table 2. SOA reference models in Enterprise Architecture view

Reference models	**Business Architecture**	**Information Architecture**	**Technology Architecture**	**Application Architecture**
SOA-RM	Not support	Partly support	Partly support	Not support
SOA-RF	Partly support	Completely support	Completely support	Not support
SOMF	Completely support	Completely support	Completely support	Partly support
PIM4SOA	Completely support	Completely support	Completely support	Partly support
SoaML	Completely support	Completely support	Partly support	Not support
SOMA	Completely support	Completely support	Completely support	Completely support

With regard to the important features of the aforementioned SOA reference models, Table 2 shows that SOA reference models have dealt, to some extent, with the core concepts and essence of SOA. All abovementioned SOA reference models, in a certain way, support Technology Architecture except for SoaML, for in this method there is more focus on services' representation [54]. Almost all SOA reference models support Information Architecture and Business Architecture except for SOA-RM, for this method uses neither modelling language for representing business process, nor can it represent the transactions between services [16, 55]. One of the most conspicuous features of modelling service, however, pertains to Application Architecture, which is concerned with exposing atomic services [50]. Moreover, the exposure of atomic services require techniques for service

identification [19]. Since there is no service identification in SOA-RF, SOA-RM, and SoaML, these methods are not capable of providing any support for Application Architecture. SOMF utilizes its own specified notification and PIM4SOA makes use of UML [17, 44], but there are no specification techniques in both these methods for service identification. Thus whereas both these methods can provide a partial support for Application Architecture, SOMA, providing service identification techniques, properly supports Application Architecture.

Regarding Table 2 and the content of the previous discussions, one can find that SOMF, PIM4SOA and SOMA method have a broader sphere that covers the aforementioned architectures. But SOMA is more detailed and is systematically capable of inspiring rapid design and having more flexibility in service modelling for SOA solution.

3.2. Adoption of SOA for business process

Traditionally, enterprises customize their applications to meet specific requirements, but this approach is costly and it is quite difficult to keep pace with changes that occur as business's needs evolve [41]. In the SOA approach, such applications are created or developed by recomposing the enterprise's services [41]. Figure 3 shows a business application, which is structured as set of reusable business services; and the orchestrated services by business processes [41].

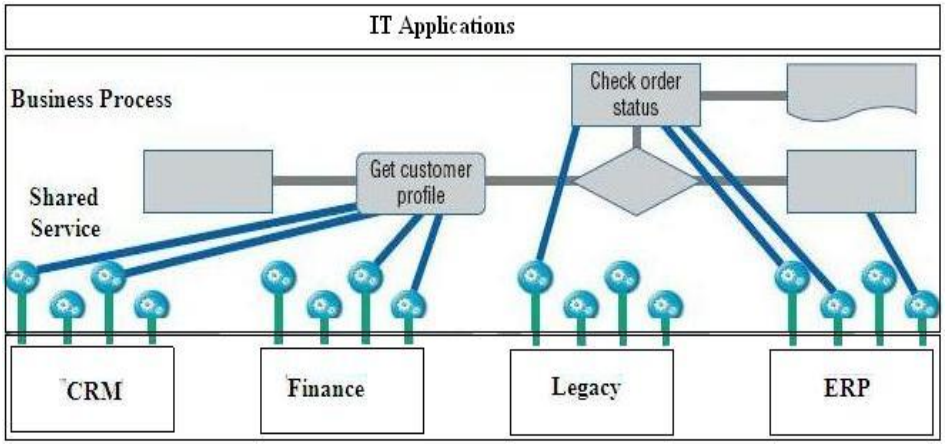

Figure 3. The business application with business services [41]

Regarding the application in Figure 3, a case study is adopted from the DELL's order fulfillment, online Order processing in computer industry. The process is represented using BPMN as business process modeling language, which has been widely used in enterprise modeling [44, 46]. The order fulfillment process model is represented in general and does not expect more details to show the applicability of reusable services in SOA Paradigm. Figure 4 shows the related business service to order processing. When applying SOA to business process, service components are formed into business services, which are orchestrated by business process and some service are moved to service repository for reuse and shared as part of other services [12, 56]. For example " get customer profile" and "check credit" are requested by "CRM" and " banking service" on any platform respectively.

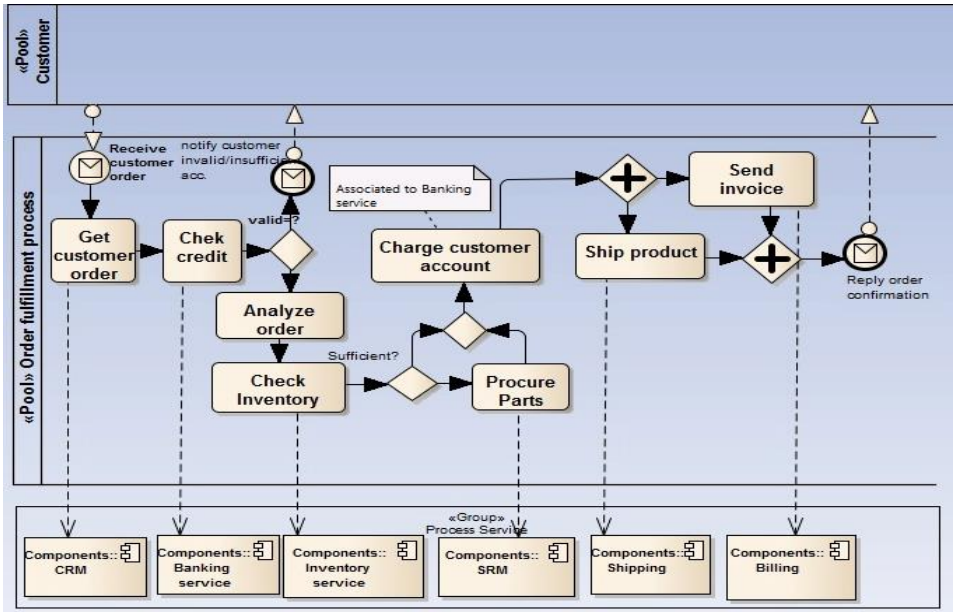

Figure 4. Business logic and business services.

In the context of SOA, each of the supply chain partners such as Customer, Sales order entry, Billing, Manufacturing and shipping in the order fulfilment process plays an important role in service-oriented application. In fact, executing business process by services in the SOA platform facilitates information sharing throughout the supply chain. Moreover, dependency between business function and application can be reduced by using reusable and shared services [42]. Considering study in [43] and [45] Figure 5 and Figure 6 show the dependency business function and application before and after applying SOA for the case study "order fulfilment processing". Therefore, adoption of SOA increase the collaboration among different partners with lower cost and more flexibility entire the supply chain.

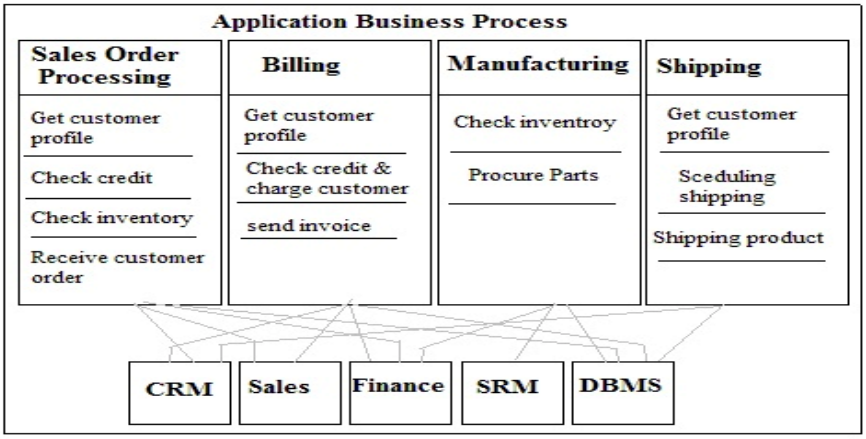

Figure 5. Dependency between business function and application.

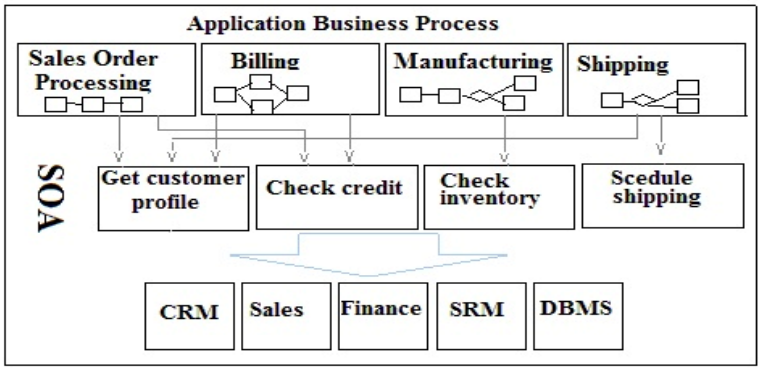

Figure 6. The reusable and shared services in SOA approach.

4. CONCLUSION AND FUTURE WORK

Enterprises have embarked on the implementation of integrated information systems to support their business processes. To this effect, SOA, as a highly capable paradigm in IT, has been increasingly used in BPM using the Web service technologies, produce innovative patterns for the interpretability and integration of the processes and services. This has helped the attainment of required agility and flexibility for inter-organizational networks. The SOA-RM contains a common vocabulary for capturing the essence of SOA, providing a terminological and common conceptual framework in service-oriented modeling, though it does not cover service identification and service composition. The SOMF is a formal method, covering analysis, design and identification services, using its specific notation; however, it does not support transformation of existing assets into SOA. PIM4SOA is developed based on a meta-model for SOA and covers the essential aspects of SOA, including service, process, information, and quality of service. SOMA is a more transparent and detailed method, defining several key techniques and details of analysis, design, implementation, deployment, information flows, components, and policies in SOA project. Due to the importance of business rules for business analysts and managers, the business processes need to follow and then integrate with business rules. Therefore, in field of supply chain process modeling, future researchers should consider the integration of business logic with business rules, which improves the performance of supply chain process.

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Information about the authors:

Dr. Mohsen Mohammadi is assistant prof. at Esfarayen University of Technology, Iran. His research area is Information systems and BPM.

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