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Research Article

A Decade of Model Driven Web Services Composition Frameworks

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Abstract: Now a day, enterprises are implementing their Web Information Systems using Service Oriented Architecture. SOA applications are basically composition of services. To accomplish a business activity, these services are composed using services composition languages/standards, which define the execution order of services invocations and their interaction patterns. Services composition is a very complex process consist of several phases or steps and further subdivided into sub-process and sub-steps. Over the past decade, many researchers have come up with their proposed services composition frameworks consisting of different phases and steps and the whole life cycle is defined. Mostly these frameworks are using the Model Driven Software Development approach to develop Web Information Systems and UML is used as a modelling language for business process modelling. Later on system artefacts are automatically generated from these models. In this study, a survey is presented showing the progress made by these researchers in the area of service composition and discusses different services composition frameworks presented by the most prominent researchers for the development of Web Information Systems.

Keywords: Model driven architecture, service oriented architecture, software modelling languages, web services composition, web services composition standards

INTRODUCTION

Today's Information Technology (IT) environment is network/Internet centric such as Service Oriented Architecture (SOA), Cloud and Software as a Service (SaaS) which offer the IT agility demanded by business (Firesmith, 2003; Lang and Schreiner, 2009). The paradigm of SOA promises inter-operability and integration ensuring the availability of resources in the form of services over the network. SOA is an architectural style in which software applications are comprised of loosely coupled reusable services by integrating these services through their standard interface. Services are independent of language, platform and location and may be locally developed or requested from the provider. In an SOA environment, software applications are deployed over the Internet as a service. To support business ventures, these services are integrated/composed within and across organizations to form Internet-based systems and perform cross application transactions (Xie *et al*., 2006). A business process can be realized as a runtime orchestration of a set of services. Software applications are often comprised of numerous distributed components such as databases, web servers, computing nodes, storage nodes etc. and these components are distributed across different independent administrative domains. Services are used but not owned by the user and they reside on the provider side (Lewis *et al*., 2007; Bianco *et al*., 2007; Dan and Narasimhan, 2009). SOA is also called a "Find, bind and invoke paradigm" (Papazoglou, 2003; Xie *et al*., 2006).

Currently, most of the enterprises develop their Web Information Systems (WISs) using web service technology by composing web services which may be geographically located at different sites using the SOA paradigm (Menzel *et al*., 2009). Several terms are used in literature for web services composition e.g., web-services orchestration and choreography, business process modelling or workflow modelling etc., (Skogan *et al*., 2004). The area of web services composition has gained an interest in the web service community; however, most of the research work addresses implementation and execution issues. Therefore, many composition languages have been proposed in recent years such as Business Process Execution Language (BPEL), XLANG (X Language), Web Services Flow Language (WSFL) and Web Service Choreography Interface (WSCI) etc., to name few of them. However, these languages are not related to the early stages of the system development (Dumez *et al*., 2008a). Several Web services composition frameworks/methods are proposed for Web services composition; where emphasis is also given to the early phases of services composition and the whole life cycle is defined. In these methods/models/frameworks, software systems are models using general purpose modeling languages like UML and executable artifacts are generated by using Model Driven Software Development (MDSD) software engineering approach.

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This study presents a survey of these methods/models/frameworks of services compositions.

BACKGROUND MATERIALS AND RESEACH METHODS

Understanding the concepts of Model Driven Software Development (MDSD) and Web Services Composition are necessary for the whole discussion, which are presented in this section.

Model driven software development: Many software engineering approaches are used for the development of SOA systems; among them, the Model Driven Software Development (MDSD) is one of the most promising approaches. The Object Management Group (OMG, 2011) has presented a framework known as the Model Driven Architecture (MDA) (OMG), which is considered as an implementation of Model Driven Engineering (MDE). In the MDA framework, software systems are modelled using a general purpose modelling language like UML, as a Platform Independent Model (PIM) and then it is transformed into other PIM or Platform Specific Model (PSM). In the MDA framework, rather than just a visual aid, models are considered as essential parts of the software definition (Alam, 2007a; Rodríguez *et al*., 2007).

The Model Driven Security (MDS) is a specialization of the MDSD to the domain of security (Hafner and Breu, 2009). In the MDS, security requirements are defined as a model during the designing phase and concrete security configuration files can be generated by the model transformation e.g., security concepts are modelled side by side with the business process modelling at the PIM level of abstraction and step-wise refined to further levels of abstraction i.e., Platform Specific Model (PSM) and Implementation Specific Model (ISM) (Basin *et al*., 2006; Alam, 2007b; Fumiko Satoh *et al*., 2008; Wolter *et al*., 2009; Hafner and Breu, 2009).

Web services composition: The composition of Web services is a fundamental notion of a service-oriented system. There is plenty of work related to the composition of business services from atomic services (Henkel and Zdravkovic, 2004; Benatallah *et al*., 2005; Antonio and Stefania, 2006; Maurice *et al*., 2006; Xie *et al*., 2006; Ter Beek *et al*., 2007; Michael *et al*., 2007). Services are scattered across the Internet, rather then, each service invoking each other by using message exchange patterns, like Simple Object Access Protocol (SOAP), a mechanism is developed to compose more complex interactions among Web services. At the composition layer of the Web service specification stack, the execution order of a service invocation and their interaction patterns are defined. Services are composed using services composition languages/standards like Business Process Execution Language (BPEL). A composition consists of the invocation of Web services in the form of Choreography or Orchestration (Peltz, 2003). In Orchestration there is a central control which describes the execution order of Web services and the BPEL standard is used for services composition. While in Choreography, there is not a central control and web services interact with each other in a peer-to-peer fashion and the Web Services Choreography Language (WS-CDL) standard is used for services composition. To implement business collaborations, Web services provided by different vendors can be inter-connected, which leads to a composite web service. Composed services are provided by gluing together the Web Services Description Language (WSDL) services and corresponding operations (Antonio and Stefania, 2006; Hafner and Breu, 2009). Currently, the business logic of the composite Web service is expressed with the help of a business process modelling language like the UML or the BPMN (Van der Aalst *et al*., 2003; Skogan *et al*., 2004; Antonio and Stefania, 2006; Dumez *et al*., 2008b; Roy and Ida, 2004).

Web services composition languages/standards: Simple interaction among the Web services using standard messages and protocols is not sufficient in the case where business processes are integrated across enterprise boundaries (Van der Aalst *et al*., 2003; Antonio and Stefania, 2006). Real business scenarios involve long-running interactions, transaction management and state-full invocations; they are also often driven by a workflow engine (Antonio and Stefania, 2006). This raises the need for Web services composition languages that provides the mechanism to fulfill the complexity of business processes execution (Van der Aalst *et al*., 2003; Antonio and Stefania, 2006).

Web services composition languages are built directly on top of the WSDL (Van der Aalst *et al*., 2003). Two different communities are working for advancement in Web services compositions namely: the Business Process Management (BPM) community and workflow community (Skogan *et al*., 2004).

The BPM community: This community has mainly focused on Web service technology and has come up with a multitude of Web services composition standards (Skogan *et al*., 2004); the most popular three standards are discussed below:

- The most popular language for Web services composition is the BPEL4WS (Business Process Execution Language for Web Services) or simply called the BPEL (Business Process Execution Language). The BPEL is built by combining IBM's WSFL and Microsoft's XLANG (it is an XML based extension of the WSDL). The XLANG is a block-structured language while the WSFL is a graph-oriented language (Van der Aalst *et al*., 2003). The BPEL is presently a working draft by OASIS (Advancing Open Standards for the information Society). The BPEL is used for the

"Orchestration" of the Web services (Antonio and Stefania, 2006).

- The BPML (Business Process Markup Language) is the standard proposed by the BPMI (Business Process Management Initiative). The BPML was originally developed to enable the standard-based management of e-business processes used with the BPMS (Business Process Management System) technology. However it can be applied to a variety of scenarios, including the EAI (Enterprise Application Integration) and Web services composition. The BPML is a specification language committed to executable business processes (Antonio and Stefania, 2006). BPML and BPEL4WS are quite similar and are now being merged in OASIS (Skogan *et al*., 2004).
- The World Wide Web Consortium (W3C) presented the Web Services Choreography Description Language (WS-CDL). WS-CDL models the peer-to-peer collaboration among participants with different roles using "Choreography" (Antonio and Stefania, 2006). Other proposals are HP's Web Service Conversation Language (WSCL) and the SAP/Intalio/Sun/ BEA's Web Service Choreography Interface (WSCI) (Skogan *et al*., 2004).

The workflow community: This community is working outside the domain of Web services and is focused on established technologies which are now extended with Web service capabilities. They also support different forms of composition languages. The Workflow Management Coalition (WfMC) provides a specification for interchange of composition models called the XML Process Definition Language (XPDL) (Skogan *et al*., 2004).

In general, there are many more standards for Web services composition that one can find in literature. The abundance of these overlapping standards is overwhelming. "In fact, the collection of competing Web services standards without a clear added value has been termed the Web Services Acronym Hell" (Van der Aalst *et al*., 2003).

Research method used during this study: During this study, qualitative methods are used to collect and analyze the qualitative data. Qualitative data is normally in the form of pictures, words, statements, description and diagrams. The process followed to collect them are ethnographies, case studies and interviews (Abbas and Charles, 1998). In qualitative methods the focus is more towards the collecting and analyzing the non-numeric data and information are explored in depth rather than in breath (Loraine *et al*., 2001). Qualitative data is analyzed using categorization and sorting (Runeson and Höst, 2009). Qualitative research explores attitudes, behavior and experiences and the research methodologies used are: Phenomenology, Ethnography, Case studies, Interviews, Action Research, Grounded Theory (Dawson, 2002; Cresswell, 2009).

During this study, an explanation building technique (Yin, 2003) is adopted that support in comparative analysis of existing research work. In explanation building, many different kinds of evidence, figures, statements, documents etc., are linked together to support a strong and relevant conclusion (Runeson and Höst, 2009). During this research work, figures (security annotated business process diagrams) and statements are used as an evidence to support the conclusion. In order to analyze the results, a comparative study has been conducted. The outcome of the comparative study is represented in the form of statements as well as table.

WEB SERVICES COMPOSITION FRAMEWORKS

In this section, related work is presented about the different methods/models/frameworks presented by different researchers for web services composition. There are several terms used in literature for web services composition e.g., web-services orchestration and choreography, business process modelling or workflow modelling etc., (Skogan *et al*., 2004):

- Orriëns *et al*. (2003) have presented a phased approach for services composition and named it the "Services Composition Life cycle". Four broad phases are described for services composition namely the definition, scheduling, construction and execution. In this approach, the UML is used for modelling the services composition; it will enable the development of technology independent composition definitions, which can subsequently be mapped to a specific services composition standard e.g., the BPEL. To our understanding it is a general framework just describing the process of services composition.
- Roy and Ida (2004) have described the whole process of web services composition by naming it as "Actions to build a composite web service". The four actions they have identified for the web services composition are: discover Web services, model a composite Web service, implement the composite Web service and publish the composite Web service. They emphasized, for the services composition modelling, one should perform two kinds of modelling; service modelling and workflow modelling. Service modelling identifies services to be exposed with their interfaces and operations (UML class diagram); while, the workflow modelling identifies the control and data

flows from one service to the next service (UML activity diagram). The focus of their work is workflow modelling of the composite Web service using the UML Activity diagram. In our framework, we are also working along the same direction, i.e., for service modelling, the UML class diagram is used and for workflow modelling the UML activity diagram is used.

- The "UML-S" (UML for Service) is presented by Dumez *et al*. (2008a). They defined the static aspects of the composition i.e., the interface of the services composition by the UML-Class diagram (WSDL interface and data types involved) and used the UML-activity diagram to model the dynamic aspects (the composition scenario itself, i.e., the interaction among the existing services). Dumez *et al*. (2008b) presented the different steps under the titled of "Composite Web Service Development Process" which should be performed for the Web services composition. Dumez (2010) in his PhD dissertation presented a framework for services composition based on these steps. In our framework, we are also working along the same direction, i.e., for services composition modelling a UML class diagram is used and for composition scenario modelling a UML activity diagram is used.
- Skogan *et al*. (2004) have presented an approach where services composition is modelled using a UML activity diagram. They proposed "a method, a UML profile and transformation rules" that can be used to produce UML models of Web services compositions. They have provided a way to model the coordination and the sequencing of the interactions among Web services. However, in this approach, methods, input/output and data transformation are modelled as notes (i.e., comments) on the side of the workflow, which can get quite confusing when the composition flow gets complex.

All of the above Frameworks do not treat security as a separate activity; the following are a few frameworks which also include security.

- Jun Han and Khan (2006) have presented a framework named the "Framework for security-oriented system composition and evolution". In this framework, they have defined security at two different levels i.e., System-level, which defines the security requirements of the overall system and Service-level, which defines the security requirements for a particular service. They did not discuss anything about the business process modelling and which modelling language would be used, what essential security objectives of the SOA environments are to be modelled, how these security objectives would be incorporated in the business process model, or how these security objectives would be transformed into implementations. According to our understanding, their focus is service security and they just provide general guidelines for secure services composition having no discussion concerning the technologies and standards used to achieve them.
- Baresi *et al*. (2009) have incorporated security along the services composition and presented a methodology called the "Sec-MoSC" (Security for Model-oriented Services Composition). In this methodology a total of thirteen steps are performed in three different levels, namely the Business-level, Design-level and Execution-level. Security requirements are represented in different views corresponding to these levels. A business process model is enriched with security by adding three thing; NF-Attributes, NF-Statements and NF-Actions. They have identified security requirements and presented general guidelines for the corresponding implementation methods. They have used the BPMN as a modelling language and the BPEL for services composition. To our understanding, a business process expert is not a security expert, it cannot be expect from him to incorporate too many security details. Furthermore, the beauty of a model is its simplicity, if too many details e.g., NF-Attributes, NF-Statements and NF-Actions; are added for just one non-functional attribute "security", then the whole model will become unreadable.
- Saleem *et al*. (2012b) have presented a framework for secure web services composition. In this framework, four broad phases are performed namely: UML Modeling of Service Composition, Transforming of WSDL of discovered Web Services into UML Class Diagram, Refining UML Activity Diagram of Composite Web Service and Transforming of UML Models into WSDL and BPEL. They have used the UML as a modelling language and the BPEL for services composition. In their framework, security is defined at two different stages. Firstly, at step-1, the overall modelling of the services composition is performed using the UML activity diagram. This is the concept building stage about services composition i.e., what functionality this services composition has to perform and which services are required to accomplish this functionality. Secondly, at step-3, all required services are either discovered or developed; now all the required services are available and security will be refined/redefined for modelling of the services composition using the UML activity diagram. They used "UML-SOA-Sec" (Saleem *et al*., 2012a) for security modelling.

Table 1: Characteristic of MD web services composition frameworks presented by the most prominent researcher

	Characteristics of the MD web services composition frameworks				
Researchers	Title	Phases	Modeling language	Focused system aspect	Incorporated security modeling
Orri¨ens *et al*. (2003)	Service composition life cycle	Four phases naming: definition, scheduling, construction and execution	UML	Business process	No
Roy and Ida (2004)	Actions to build composite web services	Four phases naming: discover web services, model composite web service, implement composite web service in a workflow engine, publish composite web service	UML class diagram, UML activity diagram	Business process	No
Dumez *et al*. (2010)	Composite web service development process	Five phases naming: import WSDLs of web services, UML class diagram generation, generation of the interface for composite web service, composite web service method definition, composite web service code generation	UML class diagram, activity diagram	Business process, business-to-business	No
Skogan *et al*. (2004)	A method	Four steps naming: UML modeling and searching of web services in the repository, transformation of WSDL into UML models for composite web service, transformation of UML models into XML document and into some execution engine, publish the composite web service	UML activity diagram	Business process, modeling,	No
Jun Han and Khan (2006)	A framework for security oriented system composition and evaluation	They defined three stages for service composition and evaluation naming: system architecture design, system instantiation and composition and system execution and evaluation	No	No	Define security at system level and service level
Baresi *et al*. (2009)	A methodology named Sec-MoSC (Security for Model-oriented Service Composition)	They defined thirteen steps for service composition development and grouped them in three abstraction levels, business, design and execution	BPMN	Business process modeling	Incorporate security at business process model which will propagate during the remaining steps
Saleem *et al*. (2012a, b)	MDS services composition framework	Four steps naming UML modeling of service composition, transforming of WSDL of discovered web services into UML class diagram, refining UML activity diagram of composite web service and transforming of UML models into WSDL and BPEL	UML	Business process modeling	Incorporate security at step 1 and 3 during business process modeling

To our understanding this framework facilitates the secure web services composition by providing necessary steps/phases for web services composition. It also facilitate a common business process expert to define security along the business process modeling using UML Activity diagram and "UML-SOA-Sec". Afterwards these security enhanced business process models are transformed into executable artifacts using MDA approach.

The whole discussion regarding the Web services composition frameworks is summarized in Table 1.

CONCLUSION

This study tried to compile the work of different researchers which are working in the area of Web services composition and have presented different Model Driven Web services composition frameworks. We believe our efforts will facilitate the practitioners in selecting the most suitable MDS services composition framework. We believe our efforts also facilitate the beginners in this area to get a picture of already presented work which will serve him/her as a basis for understanding the area of web service composition and provide basis for further improvements in the said areas.

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