Web Service Quality Composition Modelling

Ganna Frankova

DIT - University of Trento, Via Sommarive, 14, 38050 Povo-Trento, Italy
email: ganna.frankova@dit.unitn.it

Abstract. The critical issue of web services success is the ability to compose web services in order to build complex added-value services. In web service compositions both functional and non functional properties, i.e. quality of service, should be taken into account. The quality of service in web service compositions plays a vital role and has opened a wide spectrum of challenges. We survey and analyze various approaches for modelling web service quality composition. Also we overview some ideas of service selection according to the surveyed models. From the analysis it turns out that there are many open issues in the web service quality composition area.

1 Introduction

One of the most thought provoking issues in web services (WS) is that of automatic composing services in order to build complex added-value services. In particular, the quality of service (QoS) compositions plays a vital role and has opened a wide spectrum of challenges.

Nowadays the attention is on quality driven web service discovery [19] and efficient composing [5]. The research is well under way, and most of the focus is on "higher level" issues, i.e., selection and composition. On the one hand, it is important, on the other hand, there is not enough "background", i.e., models for QoS of WS composition are far from ideal ones.

In this paper, we survey and analyze various approaches for modelling web service quality composition. Some ideas of service selection according to the models are presented. From the analysis it turns out that there are many open issues in the quality of web service composition area.

The reminder of the paper is organized as follows. Section 2 discusses related work. Section 3 is devoted to the comparison of the various approaches to WS quality composition modelling with respect to the proposed requirements. Some open issues and concluding remarks are presented in Section 4.

2 Approaches for WS Quality Composition Modelling

Web service QoS issues are gaining attention and have been addressed in a number of recent works. Some approaches are based on the extension of the Web Service Description Language (WSDL) [7] to define not only functional, but also non-functional properties of the service, e.g., [11]. The problem with this kind of approach is that the QoS definition is tied to the individual operation, rather than to the service as a whole; furthermore, there issue of run-time support is not addressed.

In [20], the authors define QoS for WS by using XML schemas that both service consumers and providers apply to define the agreed QoS parameters. The approach allows for the dynamic selection of WS depending on various QoS requirements. On the negative side, the life-cycle of agreements is not taken into account, and it is not possible to define an expiration for a negotiation.

In [8], the Agreement-Based Open Grid Service Management (OGSI-A) model is presented. Its aim is to integrate Grid technologies with Web Service mechanisms and to dynamically manage negotiable applications and services using WS-Agreement. Recently proposed Web Services Agreement Specification [4] defines the interaction between a service provider and a consumer, and a protocol for creating an agreement using agreement templates. A formal definition of what the semantics of a QoS negotiation is and an extension to make agreements more robust and long-lived are proposed in [2].

The feasibility of using constraint programming to improve the automation of web services procurement is shown in [15]. A predictive QoS model for workflows involving QoS properties is proposed in [6]. In [9], the authors propose a model and architecture to let the consumer rate the qualities of a service. Various approaches and contemporary standards for managing web services can be found in [17]. In addition, the industry has proposed a number of standards to address the issue of QoS: IBM Web Service Level Agreement (WSLA) and HP's Web Service Management Language (WSML) are examples of languages used to describe quality metrics of services [13].

An overview of several of the proposals for web service quality composition modelling follows. For all these approaches we present a realistic car loan example that involves getting a loan and buying a car. We assume that standardized web services interfaces for getting a loan and buying a car already exist. Some ideas of service selection according to the models are also presented.

Continuous-time Markov chains solution. The approach of estimation execution time and cost of a workflow based on continuous-time Markov chains is proposed in [12]. Applying the approach to the running example we take execution cost into account. In order to introduce a simple QoS model, each activity whose start and end is signaled by a service is assigned an execution cost. The cost incurs when the activity is started. Therefore, each transition is labeled with the sum of the costs of all activities which are active in the destination node but not in the source node.

Quality Vector solution. Description of elementary service quality as a quality vector is proposed in [21], a similar solution can be found in [1]. Each component of the vector is a quality criterion for the service. The authors propose to compute quality criteria for composite services by using special aggregation functions.

Applying the approach to the car loan example, a quality vector can be defined as q(s)=($q_{price}(s), q_{duration}(s)$), where $q_{price}(s)$ is price of the service execution; $q_{duration}(s)$ is the expected delay in seconds between the request to the service s sending and the result receiving. The quality vector of a composite service's execution plan p is the following: Q(p)=($Q_{price}(p), Q_{duration}(p)$), where $Q_{price}(p) = \sum_{i=1}^{N} q_{price}(s_i)$; $Q_{duration}(p)$=CPA[1]($q_{duration}(s_1), ..., q_{duration}(s_N)$); N is a number of states in the execution path.

Selection of optimal component services of a composite service can be done with a global planning approach. Furthermore service selection can be formulated as an optimization problem which is solved using linear programming.

Agent-oriented solution. The use of the agent-oriented methodology Tropos to model a wide spectrum of quality of web services properties is proposed in [3]. To model a quality composition of our running example web services, the whole set of interacting services is represented as a multi-agent system.

Ontology-based solution. E.M. Maximilien and M.P. Singh proposed an ontology-based framework for dynamic web services selection [16].

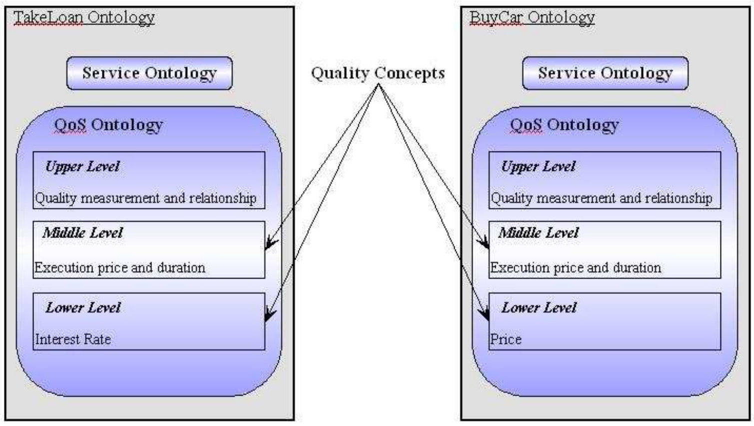

Fig. 1. Ontology-based solution of the loan receiving and a car buying example

The model consists of two-layers: service ontology and QoS ontology. The services ontology relates services to QoS whereas the QoS ontology leads to the quality concepts. The QoS ontology is divided into three ontologies: upper, middle, and lower. QoS upper ontology includes the basic characteristics of all qualities and the main concepts associated with them, e.g., quality measurement and relationships. QoS middle ontology specifies domain-independent quality concepts, e.g., availability, performance, reliability, security. QoS lower ontology is a domain-specific ontology that typically completes the middle one.

Figure 1 shows the application of the approach to the running example. Both for TakeLoan and for BuyCar services service and QoS ontology are presented.

[1] Critical Path Algorithm [18]

The TakeLoan QoS ontology contains the concepts of `Interest Rate`, similarly the BuyCar QoS ontology includes the domain specific concept `Price`. Both domains use concepts of execution price and execution duration depicted in the middle ontology section.

Dynamic service selection calls for an agent-based solution. Using QoS ontology, service agents match advertised quality levels for the consumers with specific QoS preferences.

3 Discussion

Now we can compare the various approaches for WS quality composition modelling with respect to the requirements derived from our exploration of the approaches we surveyed. The table in Figure 2 summarizes the results. The approaches are presented in the columns while the rows show the requirements.

	Markov Chains	Quality Vector	Agent-oriented	Ontology-based
Objective QoS	√	√	√	√
Subjective QoS				√
Run-time support	√		√	
QoS assignment		√	√	
Requirements considering level	Low	Average	High	High

Fig. 2. Comparing approaches for WS quality composition modelling

Objective and Subjective QoS. QoS can be objective, such as reliability, availability, and request-to-response time, or subjective, i.e., focusing on user experience [16]. Objective qualities are taken into account in all approaches, while only ontology-based systems focuses on both types of QoS.

Run-time support. According to the fact that some QoS metrics such as response time can change at run-time and a single value is not appropriate, approaches for WS quality composition modelling should have a run-time support infrastructure. Markov chains- and agents-based approaches provide run-time support.

QoS assignment to composite service. When quality constraints and preferences are assigned to composite services rather than to component services it is easy to reuse the composed service, i.e., use it in another quality driven composition. The table in Figure 2 shows that quality vector-based and agent-oriented solutions allow to assign QoS to composite service.

Quality Requirements. QoS Requirements for Web Services [10, 14] include performance, reliability, scalability, capacity, robustness, exception handling, accuracy, integrity, accessibility, availability, interoperability, security, regulatory, and network-related QoS requirements. Analyzing the approaches one notes that not all of the requirements are met. Specifically, execution price and time are estimated in [12]. While [21] considers execution price, execution duration, reliability, availability and reputation, and [1] focuses on four quality dimensions, i.e., execution cost, execution time, reliability, and availability. Ontology- and agent-based solutions theoretically deal with on all QoS requirements.

Summarizing, an analysis of the table shows that current QoS models of WS composition are far from ideal, and a number of open challenges exists.

4 Concluding Remarks and Future Directions

In this paper we have presented a survey and analysis of various approaches for modelling web service quality composition. Web service quality composition approaches range from industry standards to more abstract models. An ideal approach should satisfy the identified requirements, but so far there is not an approach fulfilling all requirements.

The survey has highlighted that there is a lot of space for further investigation and innovative research. In particular, web services are widely-used in e-commerce, an area required achieving high level of security. But there is no solution to model security properties of composed services. Further investigation should be devoted to solving security quality integration, as well as run-time support issues. Mathematical modelling approaches, and graph-based solutions are promising fields to look for solutions to this problem, as well as optimization techniques. The author will focus on solving the web service security composition problem by applying optimization techniques.

Acknowledgments

The author thanks Marco Aiello and Fabio Massacci for discussions and assistance in the presented work.

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