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A NOVEL COMPOSITE WEB SERVICE SELECTION BASED ON QUALITY OF SERVICE

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ABSTRACT

Using the internet, as a dynamic environment thanks to its distributed characteristic, for web service deployment has become a crucial issue in QoS-driven service composition. An accurate adaption should be undertaken to provide a reliable service composition which enables the composited services are being executed appropriately. That is, the critical aspect of service composition is the proper execution of combination of web services while the appropriate service adaption performed with respect to predetermined functional and non-functional characteristics. In this paper, we attempts to deliberate the optimization approaches to devise the appropriate scheme for QoS-based composite web service selection.

Keywords: composite web service selection, web service composition, QoS-based web service selection.

INTRODUCTION

Using the internet, as a dynamic environment thanks to its distributed characteristic, for web service deployment has become a crucial issue in QoS-driven service composition. An accurate adaption should be undertaken to provide a reliable service composition which enables the composited services are being executed appropriately. That is, the critical aspect of service composition is the proper execution of combination of web services while the appropriate service adaption performed with respect to predetermined functional and non-functional characteristics. Specifically, the proper execution of composed services concerned with the selection of suitable services that satisfy the end-to-end QoS requirements and constrains of consumers. For this purpose, the optimization approaches should be deliberated to devise the appropriate scheme for service composition. The following issues should be handled with regards to optimized service composition. First of all, the service composition should be performed regarding maximizing and minimizing the variety of QoS attributes with different types; thereby, the multiple QoS attributes in terms of heterogeneous data should be minimized or maximized simultaneously for composite service selection. Secondly, the number of concrete service alternatives for each task and the number of tasks of business process are the important elements in composition process. That is, the huge number of tasks and available service alternatives for each task result in complex and wide range of composition plan dealing with discovering the feasible paths for service selection. Lastly, There are various constraints setting by the service consumers for each task regarding QoS attributes whereas aggregation of proposed QoS attributes constraints for entire composition plan should be satisfied with respect to dependencies and conflicts of services through selection process. The rest of this paper is organized as follows:

First of all, Quality of service, Quality attributes and Metrics for web services are described in Section 2. A review of the composite QoS-based web service selection approaches is provided in Section 3. The critical analysis of related works is introduced in Section 4. The proposed solution is described in section 5. Finally, Section 6 concludes the paper.

QUALITY OF SERVICE

In Service Oriented Architecture (SOA), Quality of service (QoS) refers to services characteristics which are supposed as relevant quality for available services. In this approach, each quality has its own associated attributes and values of these attributes are calculated by specific metrics [1]. Web Service Description Language (WSDL), as a formal service description language, is an XML-based language used to describe network services as a set of endpoint operation and messages [2, 3]. Web service description commonly cover the functional and non-functional attributes of web services used to trade-off web service candidates for a specific functionality [1]. In web service description, non-functional attributes refer to quality of service (QoS) related to quality attribute factors and metrics such as Execution Price, Performance, Availability, Reputation, etc. Some of the important quality attributes and their associated metrics may define as follows [1]:

Execution price: is the cost that would be paid by service consumers for the service invocation.

Performance (Response time): is a duration of moment that request is sent and moment that the result are available.

$$R(t) = \frac{\sum_{i=1}^{n} T_i}{n} \quad (1)$$

where: $T_i = T_{Process} + T_{transmision}$ and n=number of execution times

Availability: This QoS attribute refers11 to using service by user with possibility of measuring service availability and operational degree.

$$Av(s,t) = T(s)/t \quad (2)$$

where: *T(s)* equals to entirely amount of time in which the proposed service is available during a particular period of time (*t*).

Reputation: This QoS attribute is measured by last end user's experience in terms of trustworthiness assessment for a web service based on appropriate methods. The following formula is used to calculate the Reputation value for each web service:

$$\mathrm{Re}\ p_{w_{i,j}} = \frac{\sum_{i=1}^{n} W_i}{n} \tag{3}$$

COMPOSITE QoS-BASED WEB SERVICE SELECTION APPROACHES

Optimization is the vital aspect of web service selection that refers to select the best sequence of services based on user's requirements with respect to local and global constraints. Selecting the best sequence of services through using appropriate algorithms with low complexity can be supposed as an important problem in web service selection mechanism. Genetic-based Algorithm (GA) Approaches has been widely discussed regarding QoS-based composite service selection with end-to-end global constraints, although GA is not a constrain-based optimization method [4], and it is essential to integrate constraints into the search process.

Canfora *et al*. [5] as one of the first litterateurs uses GA for handling the service selection problem based on QoS-aware service composition. In their proposed solution, one-dimensional optimization has proposed in terms of coding schema. The "distance-based penalty function" was presented to satisfy the quality constraints.

Li *et al*. [6] proposed two different versions of Genetic-based approaches in service selection for QoS-based composition [6, 7]. In their first work, they applied the Strength Pareto Evolutionary Algorithm 2 (SPEA2), and in the later work, the Non-dominated Sorting Genetic Algorithm (NSGA) has been applied to deal with the optimization problem for multiple constraints. Claro et al. [8] utilized NSGA-II [9] to select services for service composition concerned with the scalability and the quality of the results.

In work of Liu *et al*. [10], to cope with the composite service selection modeled the problem as Multi-Constraint Multi-Objective Optimal Path (MMOP) which is the multi-objective Genetic-based Algorithm.

Sun and Zhao [11] applied Mixed integer programing (MIP) [12] for solving the service selection problem. In their approach, the Decomposed-based Composition Model has been offered as a suitable model to deal with the large compositional structure. By using the MIP, the large-scale structure decomposes into small-scale segment which can be handled with less effort in terms of time cost. In order to resolve the heterogeneity problem of quality value in their proposed method, the positive quality value has transformed into negative ones by multiplying -1. For satisfying the user requirements in terms of global constraints, each of global constraints decompose into local constrains with respect to decomposed large-scale structure of candidates and will be satisfied locally.

In Ma and Dong [13] approach, user preferences have been satisfied through preference function provided based on Linear Programming (LP). Briefly, they have two improvements for the LPP algorithm including initial value and simplification of preference function. Specifically, the simplification of preference function does not support any conditional statement; so that, they solve this problem through using genetic algorithm which is used to deal with the optimization problem.

Work of Pei *et al.* [14] proposed an optimal solution for service composition problem and the particle Ant Colony Algorithms (PACA) based on service quality was used to cope with the optimization problem. In this approach, the composition problem mapped to shortest path problem with respect to QoS through acyclic graph. The partial swarm optimization [15] has been used as an effective global search and easy implemented algorithm based on animal behaviours for determining the initial pheromones, which is the chemical produced by the ants for direct message medium when they are commuting from food source to nest [16].

Directed Acyclic Graph (DAG) may be used for modeling both the abstract service and concrete service composition for mapping a function graph of abstract service to graph of service candidate [17]. In particular, according to DAG, the QoS-aware service selection could be considered as a Multi-Constraint Optimal Path (MCOP) problem since each edge of graph is related to a collection of quality attributes and its associated utility value. In work of Li, Wang, *et al*. [18], invocation and execution graph is proposed in order for the service composition. They define a trust degree and employ the trust aggregation technique to obtain it. Besides, the Monte Carlo experiment has been adopted in their approach to discover the near optimal path for providing the trust-oriented QoS-based service composition through selection with respect to quality constraints.

Liu *et al*. [1] modeled the optimization problem with respect to user's global resource constraints. The problem is defined as how to select services from set of candidate for specific task whereas the quality of those services' combination is maximized and satisfied the user global resources constraints such as price and response time. In this case, the user may have one or more than one resource constraints for composition of service; therefore, they solve this problem by using "multi-dimensional multi-choice knapsack problem (with multiple resources mapped to multi-dimensional knapsack)" named as NP complete problem. In this approach, problem modeled as categorizing the element in different classes and just one element is selected from each class and contained in the knapsack.

Alrifai *et al.* [19] proposed a new mechanism for extracting quality levels, which results in a feasible solution for decomposing of end-to-end constraints. In fact, the optimization problem of QoS-based service selection has been addressed with respect to specified end-

to-end user constraints by identifying skyline services. In selection process for service composition the non-dominated services called skyline are considered as a set of qualified candidate for composition.

Zeng *et al.* [20, 21] concentrates on dynamic and QoS-based service selection and uses global planning to discover the most suitable sequence of services for the proposed composition. In their proposed approach, the MIP techniques were used to solve Multiple Attribute Decision Making (MADM) by discovering the optimal solution for selection problem in terms of service composition. In their work, satisfying the global constraints was not guaranteed, although they evaluate overall service quality to obtain better QoS. Similarly, Ardagna and Pernici [22, 23] applied the linear programming (LP) approach and extend it with local constraints. In this approach, service consumer as an end user of services set the global constraints in regards to use in composition phase, whereas local constraints can be determined in design phase of component services where specification of service composition has been specified by the designer. In spite of these approaches, in work of Alrifai et al. [24] global constraints specified by end users were decomposed into local constraints to facilitate handling local constraints specified by the designer for composite service selection. Besides, in this approach MIP is used for decomposition of the global constraints and selection mechanism would be performed by different hybrid approaches.

CRITICAL ANALYSIS

As the various approaches of QoS-based web service composition discussed in previous section, it is generally done to combine desired features of each, so that the overall algorithm is better than the individual components which may called Hybrid algorithm. "Hybrid algorithm" does not refer to simply combining multiple algorithms to solve a different problem, many algorithms can be considered as combinations of simpler pieces, but only to combining algorithms that solve the same problem, but differ in other characteristics, notably performance. In constraint satisfaction, a hybrid algorithm solves a constraint satisfaction problem by the combination of two different methods, for example variable conditioning (backtracking, backjumping, etc.) and constraint inference (arc consistency, variable elimination, etc.).

Hybrid algorithms exploit the good properties of different methods by applying them to problems they can efficiently solve. For example, search is efficient when the problem has many solutions, while inference is efficient in proving unsatisfiability of overconstrained problems [25].

To address the above mentioned issues to select the appropriate services for service composition, the variety of approaches have been discussed in terms of combinatorial approaches rather than exhaustive solutions. For evaluation performance of proposed solution in the existing research, accuracy and complexity considered as evaluation elements to tell between the proposed approaches of existing models. In the following table (Table-1), we analyze the benchmark approaches in QoS-based web service selection for proposed methods and applied QoS evaluation approaches.

Table-1. The analysis of existing works of QoS-bsed composite web service selection.

Authors & publication year	Methods	QoS Evaluation	Drawbacks
Zeng et al. [20, 21]	Local & Global Planning (Multi-objective with Simple Additive Weighted (SAW))/(MIP) approach	Simple Aggregation Function based on unfolded state-based process specification	Complexity & Accuracy
Ardagna and Pernic [22, 23]	MIP, Multi-objective with SAW	Simple Aggregation Function based on unfolded BEPL4WS specifications	Complexity
Liu et al. [1]	Rank based algorithm with SAW/ Convex hull	Simple Aggregation Function	Accuracy
Doshi et al. [26]	Markov Decision Process (MDP),MIP, Bayesian Method	Simple Aggregation Function based on reward function	Complexity
Ma and Don [13]	Linear Physical Programing, Genetic Algorithm, SAW	Aggregate Preference Function using linear physical programming	Complexity & Accuracy
Pei et al. [14]	Partial Swarm Optimization (Ant Colony); Acyclic Graph	Simple Aggregation Function	Accuracy
Pop et al. [28]	Graph Model & Ant Colony	Simple Aggregation Function	Accuracy
Canfora et al. [5]	Genetic Algorithm	Simple Aggregation Function based on unfolded state-based process & BEPL4WS specification	Accuracy
Li, Wang, et al. [18]	Monte Carlo method based algorithm, Bayesian , Invocation Graph	Aggregation Function with Trust Value and Trust weights	Complexity
Alrifai et al. [24]	Hybrid approach (Local selection), MIP, Iterative Method	Simple Aggregation Function based on unfolded state-based process specification	Accuracy
Menascé et al. [29, 30]	Exact Method and hill climbing (2008); use of quality function for the quality dimensions (2010)	Aggregation function based on BPTree of a BEPL specifications	Complexity
Li, Cheng, et al. [7]	SPEA2	Simple Aggregation Function	Complexity & Accuracy
Li, Yang, et al. [6]	NSGA-II	Simple Aggregation Function	Complexity & Accuracy

PROPOSED SOLUTION

In our proposed solution, we provide a mechanism to satisfy the local and global constraints determined by the service user that reduces the complexity for web service composition. For this purpose, the Execution price (EP) is considered as a non-technical QoS attribute which serves as a particular criterion that reduces the complexity. In fact, we choose Execution price because it refers to non-technical aspect of QoS attributes. Undoubtedly, the service users prefer to select a service with low cost and for this reason, the service usxers allocate a high value of weight to this attribute; therefore technical quality attributes such as availability or response time may be interfered. In our approach, the technical and non- technical aspects are used for selection and optimization separately. That is, each service user has different constraints for Execution Price for each task. In this approach, local constraint for Execution Price is found by decomposing global constraint based on average Execution price for each task and Preference regions is defined based on average of Execution price ($AvEP_{T_j}$) for each task; hence, the number of web service candidates will be pruned. The complexity is reduced by considering just high qualitative scored web services. For this purpose, the following new rule (4), proposing in this work, should be satisfied where i is the number of web service, j is the number of task, n is the total number of web service alternatives for each task and m is the total number of proposed tasks for composition. For each task $W_{i,j}$ is selected where:

$$EP_{w_{i,j}} \le EP_{Lv_j} : i \in \{1,2,...,n\}, j \in \{1,2,...,m\} \quad (4)$$

As EP_{Lv_j} is calculated by following formula for each task:

$$AvEP_{T_j} = \frac{\sum_{i=1}^{n} EP_{w_i}}{n} \quad (5)$$

$$EP_{Lv_j} = \frac{AvEP_{T_j}}{\sum_{m}^{j=1} AvEP_{T_j}} * G_{EP} \quad (6)$$

where: G_{EP} is Global Execution Price constraint and $AvEP_{T_j}$ is Average Execution Price for task *j*.

We proposed a hybrid approach for solving the QoS-based composite service selection problem based on genetic algorithms and Lagrangian Relaxation (Geoffrion, 1974)27 method for solving the mentioned problem of genetic algorithm. The Lagrangian Relaxation (7) method is applied as an appropriate method which is used for relaxing the global constraints in our proposed methods. Fitness function for genetic algorithms should be provided using Lagrangian Relaxation method in order to cope with multiple constraints.

$$Z = \left(\sum_{n}^{i=1} P_i \sum_{m}^{j=1} X_{i,j} \right) - \lambda \left(G_c - \sum_{n}^{i=1} F_i \sum_{m}^{j=1} X_{i,j} \right) \quad (7)$$

$P_i = q_{\max} - q_i$; where: $q_{\max}$ is the maximum value of quality among all available services.

CONCLUSIONS

In this paper, we analyze the existing approaches of QoS-based composite web service selection in terms of complexity and accuracy described in Table-1. As the table shows, most of the existing works used the simple aggregation function for QoS evaluation that interfering the accuracy and increasing the complexity. To cope with this problem, in our proposed solution, the Execution price is excluded from technical attributes and would be satisfied separately as described in section 5. Besides, we proposed a hybrid approach for solving the QoS-based composite service selection problem based on genetic algorithms and Lagrangian Relaxation method [27, 31] for solving the mentioned problem of genetic algorithm.

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