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Fuzzy Logic Control for Web Service Selection

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Abstract: This study proposes a fast service selection approach by using fuzzy logic control. The approach adopts fuzzy logic control to support fast and dynamic service selection and mixed integer programming to assist users in obtaining most suitable services. Experimental results show that our proposed approach can perform web service selection quickly.

Key words: QoS, web service selection, fuzzy logic control

INTRODUCTION

Service computing is emerging as a powerful vehicle for organizations which enables business applications and daily life running on distinct platforms and exchanging data regardless of platforms or locations. It has created unprecedented opportunities for organizations to shorten software development time by composing existing services across Internet. In service-oriented environments, multiple web services may provide similar functionalities with different non-functional attribute values (i.e., QoS). Duplicated and similar functional features existing among services require service consumers to include additional aspects (e.g., global QoS constraints) to evaluate services. How to select the most suitable composite service among available service candidates for consumers is an interesting practical issue.

Although tremendous efforts and results (Ardagna and Pernici, 2007; Yu *et al.*, 2007; Zeng *et al.*, 2004) have been made and obtained in web service composition area, the technology is still not mature yet and requires significant efforts. Some existing service selection approaches excessively considered global optimization while they concerned too little about computation time or time complexity. Hence, a quick service selection approach should be designed.

In this study, we propose a fast service selection approach based fuzzy logic control. The approach uses fuzzy logic control to adaptively decompose global QoS constraints to local constraints. Then upon the receipt of local constraints, mixed integer programming can find the best web service candidate by local optimization quickly. To evaluate our approach, simulation comparisons are illustrated. The results show that our proposed approach can find most suitable services for service customers quickly. Moreover, it significantly improves QoS-aware web service selection process.

OUR APPROACH

The main idea of our approach is to model global QoS constraints into local constraints by Adaptive Quality Level (AQL). As shown in Fig. 1, our approach contains four phases.

Phase 1. AQL initialization: First of all, quality levels are initialized for each service class S_j by dividing the value ranges of each QoS attribute q_k into a set of $p(p\in N)$ discrete quality values as follows:

$$Q_{j,k}^{min} \leq q_{jk}^{1} \leq \cdots \leq q_{jk}^{p} \leq Q_{j,k}^{max} \quad (1)$$

The quality levels determined represent the data collection of each service class. Here, AQL uses FLC to adaptively adjust the number of the quality level p by monitoring the relationship between the QoS utility function and the computation time. In this way, p

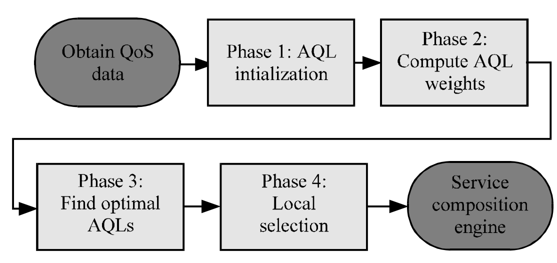

Fig. 1: Procedure of our proposed approach

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is adaptively adjusted according to different service compositions by Eq. 2. The adjustment of AQL consists of three steps.

Firstly, let Dm denote the current performance of AQL. To present Dm and p universally, we normalize them in the range of [0, 1] by the following equations:

$$Dm = (Fp_{max}-Fp)/(Fp_{max}-Fp_{min}) \quad (2)$$

where, Fp is the current value of the AQL, Fp_{max} is the maximum value, Fp_{min} is the minimum value.

Secondly, let cp denote the appropriate change of the AQL. By using fuzzy logic control, we translate Dm and p into a set of linguistic values and assign a membership degree to each linguistic value. The inference engine makes decisions based on fuzzy logic inference rules. Each rule is an IF-THEN clause in nature which determines the linguistic value of cp according to Dm and p. Then we adopt the centre of gravity (Van Broekhoven and De Baets, 2009) to get crisp cp.

Finally, having obtained the crisp value cp, the new number of AQL can be adaptively adjusted as follows:

$$p.new = p.old^* (1 + cp) \quad (3)$$

where, p.new$\in$ N, 1$\leq$p.new$\leq$l/m, l is the number of service candidates and m is the number of global QoS constraints.

Phase 2. Compute AQL weights: After dividing the range of attribute values into p sub-ranges, we randomly select one sample value from each sub-range. The more frequent a given value is, the higher the probability is. This means the sub-range of highest probability is selected as a quality level in each service class. We then assign each quality level q^z_{jk} a weight vale b^z_{jk} between 0 and 1 which estimates the benefit of using this quality level as a local constraint. This weight value is determined as follows:

$$b^z_{jk} = U(q^z_{jk}).\ G(q^z_{jk})/(U_{max}.l),\ 1\leq z\leq p \quad (4)$$

where, U (q^z_{jk}) is the highest utility value that can be obtained with consideration of these qualified services by calculating the utility value of each service candidate in the service class using the utility function, U_{max} is the highest utility value that can be obtained for this class by considering all service candidates, g (q^z_{jk}) is the number of service candidates that would be qualified if this level was used as local constraint, l is the total number of service candidates of service class S_j.

Phase 3. Find optimal AQLs: In this study, we use mixed integer programming to find the best decomposition of global constraints into local constraints. The Mixed Integer Programming (MIP) has been recently used to solve the service composition problem by Wang *et al.* (2010).

The fitness function of MIP is to maximize the b value (e.g., b^z_{jk}) of selected quality levels to minimize the number of discarded feasible selections. Therefore, the fitness function can be expressed as follows:

$$f = \max \sum_{j=1}^{n}\sum_{k=1}^{m}\sum_{z=1}^{d} \ln(p^z_{jk})x^z_{jk} \quad (5)$$

In order to ensure QoS constraints, we also add some constraints (Ardagna and Pernici, 2007) to Eq. 5. Finally, by solving Eq. 5 using any mixed integer programming solver methods, a list of AQLs are obtained and go to Phase 4 for service selection.

Phase 4. Local selection: Having decomposed global QoS constraints into local ones, our approach can perform local selection based on the already gained AQL as local constraints for each service class independently. The received local constraints are used as upper bounds for the QoS values of component services. Web services that violate these upper bounds are excluded. A list of qualified services is made and the services are sorted out by their utility values.

PERFORMANCE EVALUATION

In experiment, some simulation comparisons are used to compare the computation time and the optimum degree with other studies.

To evaluate our approach, numerous simulation comparisons have been performed on QoS-aware web service selection. In the experiments, The capital letters GOA represent the global optimization approach by Ardagna and Pernici (2007). The capital letters HGO represent the hybrid global optimization approach by Alrifai and Risse (2009). All results were collected in average after each approach running for 10 times.

Here, we achieve three simulation comparisons: Our approach, GOA and HGO. Table 1 show the computation time of our approach, GOA and HGO.

From Table 1, the computation time of our approach is obviously the shortest with respect to the number of service classes. The reason why our approach is superior to GOA is that global QoS constraints is decomposed into local constraints with AQL by fuzzy logic control which is almost equivalent to that the service components are selected by local optimization. Hence, our approach avoids a large number of redundant search.

Table 1: Computation time

	Computation time (ms)		
Service classes	Our approach	HGO	GOA
25	339	1334	7605
30	341	2189	11002
35	358	3021	12246
40	367	3653	14949
45	393	4051	21783
50	445	7038	46959

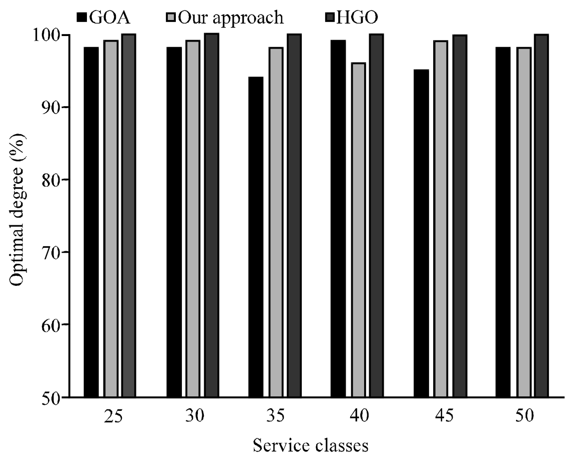

Fig. 2: Optimal degree

In this experiment, we evaluate the quality of the results obtained by comparing them with the optimal results obtained from GOA and the selected results from HGO. Figure 2 shows the optimal degree of our approach, GOA and HGO.

From the simulation results, the optimal degree of our approach is 98.2% in average which is higher than that of HGO that is 97% and almost close to the optimal solution of GOA. Because this gap (1.7%) is very little, it is acceptable for the service composition based on global QoS constraints.

CONCLUSION

In this study, we propose a fast service selection approach. our approach makes good use of fuzzy logic control to adaptively decompose global QoS constraints to local ones with adaptive quality level and select the most suitable service candidate from each service class by local optimization with optimal adaptive quality levels obtained by mixed integer programming. Experimental results show that our approach can effectively perform web service selection than other approaches.

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