Managing the Replaceability of Web Services Using Underlying Semantics

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ABSTRACT

In the context of web services, service replaceability refers to the ability of substituting one service for another. With the bloom of service-oriented computing, the effective management of service replaceability is important to make the applications unaffected once the requested service cannot work. This work studies the quantitative aspect of the replaceability of web services. FCA (Formal Concept Analysis) method is applied to reveal the pairwise replaceable relationship among web services. A novel structure, called RSLattice, is proposed to index web services on the basis of the underlying semantics, and the replaceability among services at the operation level is represented accurately. It ensures that the services having mutual replaceability are organized in the same path of RSLattice. Based on this property, we can greatly reduce the search space when retrieving the replaceable services in RSLattice. Experimental evaluation shows that RSLattice is an efficient and flexible structure for service replaceability management.

Keywords: Algorithms, Data Organization, Data Structure, Semantic Matching, Web-Based Applications, Web Services

1. INTRODUCTION

The replaceability of web services refers to the ability of using one service to substitute another in such a way that the change is transparent to service consumers’ applications. This issue is quite important to keep the stability of the service-oriented applications, especially in the case that the invoked service cannot work. Currently, if one service is unavailable, this exception will be propagated to its consumers’ applications and makes the consumers’ applications suspend or abort. To solve this problem, a straightforward solution is to find a service to replace the unavailable one. Intuitively, it seems that it is a simple job of checking whether the operations of one service contain those of the service being replaced based on WSDL (Brogi, Canal, & Pimental, 2004). However, the checking is quite time consuming if the number of services is large and the services are deployed by different companies or organizations. Thus,
to select the replaceable services at runtime is critical to reach the transparency of service applications. In this article, we study this problem and develop a novel data structure, which can be built on-line at the initialization phase, to represent the replaceability among services. We also verify the benefits of this approach from the theoretical and experimental aspects.

Currently, UDDI servers, as the brokers for advertising web services over the Internet, provide great support to find partners, products and services (Kleijnen & Raju, 2003). But its category-based service discovery method puts more human effort for consumers and providers. The providers need to publish their services in the appropriate UDDI categories, and the consumers are responsible for browsing the ‘right’ categories in order to find the potentially relevant services. Such an approach is very costly, and may produce low-precision results if the number and categories of web services are becoming very large (Bernstein & Klein, 2002). Moreover, it does not offer any support for the selection of the best services among many alternative services. The prioritization of the candidates is again the responsibility of consumers. Therefore, it can be concluded that the current service discovery approach is inapplicable to retrieve the replaceable services for a given service efficiently. This drawback is caused by the categorization of web service at the UDDI server, for it does not take into account the replaceable relationship among web services.

In this article, to represent the relationship among services, we present a novel structure, called \textit{RSLattice}, which is formed by applying FCA (Formal Concept Analysis) to a collection of web services. \textit{RSLattice} effectively indexes web services on the basis of the underlying semantics and accurately represents the replaceability among services at the operation level. This property ensures that once a \textit{RSLattice} has been built for a specific service collection, searching replaceable services for the given service contained in the collection through the \textit{RSLattice} will be very efficient. It is because the quantitative metrics of the replaceability can be pre-computed, and not necessary to compute the replaceability among services at query time. \textit{RSLattice} can be used in conjunction with current UDDI service discovery method to support more automatic replaceable service discovery by distinguishing the potential alternatives from the possibly irrelevant services and ranking the candidates according to their quantified replaceability. For the sake of conciseness, we use ‘service’ to stand for ‘web service’ in following sections.

The remained parts of this article are organized as follows. Section 2 reviews the related work in the literature. Section 3 gives the problem description and some basic definitions. In Section 4, we describe how to organize the replaceable services using FCA and propose a new structure, called \textit{RSLattice}, to reveal and represent the underlying semantics among services. Some algorithms which can retrieve the replaceable services for a specific service in a \textit{RSLattice} are presented in Section 5. Section 6 is experimental evaluation of the proposed approach. Finally, concluding remarks are given in Section 7.

2. RELATED WORK

One of the most important objectives of the replaceability management is to support the discovery of the replaceable services for a specific service. The most related work in this area is service discovery. In this section, we will offer a brief survey on this topic.

Service discovery is to find desired services according to the requirements of the consumers. Researchers have done much work on service discovery. As a very important approach for software reuse, signature matching could be used for the selection of services. However, signature matching itself is error-prone because it considers only data types but ignores the functions; furthermore, two services with the same signature may have completely different functions. Zaremski and Wing solved this problem by examining signature (data types of input/output messages) matching and specifi-
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