Effective Service Composition in Large Scale Service Market:
An Empirical Evidence Enhanced Approach

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ABSTRACT

The web has undergone a tremendous shift from information repository to the provisioning capacity of services. As an effective means of constructing coarse-grained solutions by dynamically aggregating a set of services to satisfy complex requirements, traditional service composition suffers from dramatic decrease on the efficiency of determining the optimal solution when large scale services are available in the Internet based service market. Most current approaches look for the optimal composition solution by real-time computation, and the composition efficiency greatly depends on the adopted algorithms. To eliminate such deficiency, this paper proposes a semi-empirical composition approach which incorporates the extraction of empirical evidence from historical experiences to provide guidance to solution space reduction to real-time service selection. Service communities and historical requirements are further organized into clusters based on similarity measurement, and then the probabilistic correspondences between the two types of clusters are identified by statistical analysis. For each new request, its hosting requirement cluster would be identified and corresponding service clusters would be determined by leveraging Bayesian inference. Concrete services would be selected from the reduced solution space to constitute the final composition. Timing strategies for re-clustering and consideration to special cases in clustering ensures continual adaption of the approach to changing environment. Instead of relying solely on pure real-time computation, the approach distinguishes from traditional methods by combining the two perspectives together.

Keywords: *Bayesian Inference, Quality of Service (QoS), Service Colonies, Service Oriented Architecture (SOA), Web Service Composition*

INTRODUCTION

Service Oriented Architecture (SOA) has become a significant paradigm to facilitate distributed application integration and interoperability in the domain of service computing in recent years (Jeong, Cho, & Lee, 2009). Applications following the SOA paradigm conceptually have three-party architecture, i.e., service provider, service consumer, and a broker which either belongs to a specific service provider or an independent agency. The broker mediates between service providers and service consumers, and provides information for the consumers to find

DOI: 10.4018/jwsr.2012010104

their desired services. Further enhancement to brokers can give recommendations to service consumers on the services to be utilized for satisfying some specific pieces of requirement. Since the requests from the consumers are raised to discover appropriate services and the recommendation such services is performed upon consumers' requests, such process is called "*on demand*" service.

A crucial feature of the *on demand* service composition is that the underlying requirement contained by the *demand* (or requests) may vary among different consumers. On the one hand, for the complex requirements raised by consumers that cannot be satisfied by existing services, instead of developing new services with coarser-grained granularities by the consumers themselves, in SOA, service composition (Zeng, Benatallah, Ngu, Dumas, Kalagnanam, & Chang, 2004; Milanovic & Malek, 2004) is leveraged in prevalence to maximize the usage of existing services by aggregating individual services into coarse-grained integrated functionalities, which may cross both organizational and network boarders. Service composition achieves higher-level value than that exposed by the original services, and is undoubtedly the most active area of research in the domain of service computing; on the other hand, as a bridge between service consumers and service providers, the broker should not only properly select and compose a subset of services together to functionally satisfy the requirement raised by consumers, the quality requirement should also to taken in to account in the service discovery and selection process, especially in real-time applications where dynamic composition and re-composition of services might be frequently triggered to adapt to the volatile environment, how to determine a "the optimal the better" subset of services in term of quality from existing available services within limited time becomes a critical issue. To satisfy customer requirements on demand, it is necessary to search and determine the optimized composition solution at real-time, and the participating services should be evaluated in term of both functionality and quality to derive qualified composite ones.

While industrial practice has witnessed a dramatically growing number of web services published on the Internet in recent years (Al-Masri & Mahmoud, 2008a), it has already come to emerge a huge market or community of abundant services to be shared and reused by venders all around the world. The flourish of available services leads to more and more services with similar functionalities yet differentiated quality. While the chance of obtaining better composition solutions is elevated by such situation, at the meantime, as an inevitable consequence, the real-time determination of an optimized and satisfactory solution for service composition become even tougher in terms of both the optimality of the composite results and the efficiency of the determining process.

Due to the reasons given, we argue that the current solution for service composition shows significant reluctance in its adoption to the Internet-based huge service market. More efficient determination of the participating services for service composition is required for the on-demand situation in market with huge their quality attributes of services, in order to improve the online performance of service composition.

To satisfy the requirements, we first review to fundamental basis of SOA, where service providers deploy their services and publish them onto the service registry, where service consumers can retrieve and find appropriate services for their direct consumption or constructing new applications. As the service registries are widely enhanced nowadays to have the ability of recommending and composing services for personalized requirements, such ability shows a potential of further processing to the data available to the registry. Moreover, as the discovery for desired service for specific requirement is frequently performed by keyword matching approach in practice, which suffers from low recall and precision, and meanwhile, the semantic web services are not extensively adopted and available from the Internet for practical usage, both industrial and academic focuses are turned onto summarizing or deriving functional informa-