

Chapter VI

Adaptive Search- and Learning-Based Approaches for Automatic Web Service Composition

Nikola Milanovic, Technical University Berlin, Germany

Miroslaw Malek, Humboldt University Berlin, Germany

Abstract

We investigate architectural properties required for supporting automatic service composition. First, composable service architecture will be described, based on modeling Web services as abstract machines supported by formally defined composition operators. Based on the proposed infrastructure, we introduce and analyze several options for achieving automatic service composition by treating it as a search problem. Namely, basic heuristic search, probabilistic, learning-based, decomposition, and bidirectional automatic composition mechanisms will be presented and compared. Finally, we discuss the impact and outlook for automatic composition.

Introduction

Service-oriented architectures (SOAs) and Web services (WS) are present in the mainstream scientific and industrial focus for many years. SOA promised advances in enterprise integration, B2B interactions, and novel ways to process business workflows. However, industry is still using SOA mainly *inside* an enterprise as a helper for integration of different systems. Native WS capabilities are standardized: communication (SOAP), description (WSDL), and discovery (UDDI) (Papazoglu, 2003). Apart from that, the WS architecture stack is mainly empty, meaning not standardized.

There are many additional WS frameworks and specifications aspiring to become standards (e.g., WS-Addressing, WS-Transactions, and WS-Coordination). What is not clear, however, is how they can or will cooperate with one another. Each solution targets a specific problem, not taking into account other requirements. What is currently missing is a unification effort towards WS architecture (Vinoski, 2004). Our goal is to identify key SOA elements and constraints required to support service composition, and to verify composition correctness and automatic composition. In this chapter, we briefly present our previous work on architectural concepts and requirements, and focus on the problem of automatic service composition. Although the remaining part of the chapter is based on Web services as the most prominent SOA available today, proposed methods are not limited to solving WS-specific issues only, since they offer an architectural approach for designing SOA to support automatic service composition property.

The need for automatic service composition is justified by the ubiquity of the Internet which is forcing enterprises to abandon their heritage business models and legacy systems and organize themselves into virtual enterprises (Heuvel & Maamar, 2003). On-demand creation of virtual enterprises can shorten delivery times, increase product quality, deliver personalized services, decrease transaction costs, and accommodate short-term cooperating relationships, which can be as brief as a single business transaction. This paradigm requires a shift from tightly coupled business components to more flexible and loosely coupled ones (Webber & Parastatidis, 2003) that now dynamically interact with each other through automatic composition in ways that were not predefined and/or predicted at deployment time. The two major attributes required for such an environment are *extensibility* and *adaptivity*. It is clear that in open environment like this, where services dynamically interact with each other on demand, being able to ensure correctness (dependability, security, timeliness), plays a crucial role. Web service architecture is considered a solution that can support extensibility and adaptivity required for dynamic composition (Yang & Papazoglou, 2000).

The rest of the chapter is organized as follows: First, our previous work in the area of the composable service architecture and modeling services as abstract machines

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