Chapter 7
Adaptive Hybrid Semantic Selection of SAWSDL Services with SAWSDL-MX2

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ABSTRACT
In this paper, the authors present an adaptive, hybrid semantic matchmaker for SAWSDL services, called SAWSDL-MX2. It determines three types of semantic matching of an advertised service with a requested one, which are described in standard SAWSDL: logic-based, text-similarity-based and XML-tree edit-based structural similarity. Before selection, SAWSDL-MX2 learns the optimal aggregation of these different matching degrees off-line over a random subset of a given SAWSDL service retrieval test collection by exploiting a binary support vector machine-based classifier with ranking. The authors present a comparative evaluation of the retrieval performance of SAWSDL-MX2.

INTRODUCTION
Semantic service selection is commonly considered key to the discovery of relevant services in the semantic Web, and there are already quite a few matchmakers available for this purpose and different formats like OWL-S, WSML and SAWSDL (Klusch, 2008). As a W3C recommendation dated August 28, 2007, the SAWSDL¹ (Semantic Annotations for WSDL) specification proposes mechanisms to enrich Web services described in WSDL² (Web Service Description Language) with semantic annotations. Among others, one goal of these additional descriptions is to support intelligent agents in automated service selection, a task which is hard to accomplish using pure syntactic information of service profiles based mainly on XML Schema definitions. Typical application
scenarios that require or benefit from a service matchmaking component include, for example, negotiation and coalition forming among agents and automated or assisted service composition. The first hybrid semantic service matchmaker SAWSDL-MX1 for semantic services in SAWSDL (Klusch & Kapahnke, 2008) adopted the ideas of our hybrid matchmakers OWLS-MX and WSMO-MX (see Klusch, Fries, & Sycara, 2009; Kaufer & Klusch, 2006) for semantic services in OWL-S, respectively, WSML.

However, SAWSDL-MX1 focuses on semantic annotations of the signature but not on the XML structure of the Web service as a whole. This is taken into account by the WSDL-Analyzer tool presented in (Zinnikus et al., 2006) by means of measuring the XML tree edit distances between given pairs of services through XML type compatibility, token-based text and lexical similarity measurements. Besides, SAWSDL-MX1 combines logic-based and text-similarity-based matching in a fixed manner: It applies five logical matching filters and ranks service offers that share the same logical matching degree with respect to a given request according to their text similarity value. The hybrid variant SAWSDL-M0+WA does the same as SAWSDL-MX1 except that its ranking of services with the same logical matching degree is according to their structural similarity value as computed by the WSDL-Analyzer.

Finally, the adaptive hybrid matchmaker variant SAWSDL-MX2 computes three kinds of semantic matching, logical, text, and structural similarity-based. In addition, it learns the optimally weighted aggregation of these different types of semantic matching to decide on the semantic relevance of a service to a given request.

One major advantage of this off-line learning is that it renders SAWSDL-MX2, in principle, independent from any given service test collection or future extensions with other matching filters. In fact, the configuration of any non-adaptive matchmaker such as SAWSDL-MX1 would have to be manually retuned by the developer of the matchmaker to reflect such changes.

Whether this adaptation feature may even improve the precision of non-adaptive variants in practice has been checked by us against the only publicly available SAWSDL service retrieval test collection SAWSDL-TC1 consisting of more than 900 SAWSDL services from different application domains. The results of our experiments show that all hybrid semantic service matchmaker variants outperform the single matching type variants (logic-based or text similarity or structural XML similarity only) in terms of precision, while all SAWSDL matchmaker variants available today, whether adaptive or not, do not significantly differ from each other in terms of their precision with respect to this collection SAWSDL-TC1.

The remainder of the paper is structured as follows. After a brief introduction to SAWSDL in the following section, the SAWSDL service matching approach of the non-adaptive matchmaker SAWSDL-MX1 is recapitulated. The subsequent section presents the structural matching of Web services in WSDL performed by the WSDL-Analyzer tool, followed by an illustration of the application of all three matching filters by example. The adaptive aggregation of different matching results based on an off-line learned binary Support Vector Machine (SVM) classifier with ranking by the adaptive matchmaker SAWSDL-MX2 is described thereafter. We briefly present implementation details and then report the results of our experimental evaluation over the public test collection SAWSDL-TC1 in terms of macro-averaged recall/precision, average precision and average query response time. Eventually, we comment on related work on SAWSDL service matchmaking and conclude. This paper is an extended version of (Klusch et al., 2009).

**SERVICE DESCRIPTIONS IN SAWSDL**

SAWSDL is designed as an extension of WSDL enabling service providers to enrich their service descriptions with additional semantic information.