Dynamic Horizontal Composition for Semantic Web Services: An Investigation of Real Use

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Abstract. We propose a new dynamic constraint optimization problem (COP) formalization for Web services composition problem that permits extension of the original abstract workflow (in case failure) based on the OWL-S service profile description of the underlying semantic Web services and using OWL-S control constructs. Moreover, we have developed a novel, human-centered, agent-based protocol able to find “satisfying” solutions for this problem in real time. This protocol allows restriction and/or relaxation within the original workflow through addition and/or removal of new sub-tasks, deals with a dynamic environment, and uses incomplete, uncertain information.

Horizontal composition of semantic Web services has become an arduous, complicated task due to the wide proliferation of the WWW and the consequent emergence of a large number of functionally equivalent Web services. Thus, the use of an appropriate Web service is very hard especially when dealing with composite Web services in response to a user’s ostensible long-term complex goal. The automatic horizontal Web service composition task consists of finding an appropriate combination of existing Web services in order to achieve a global goal. Solving this problem involves mixing and matching component Web services according to their OWL-S service profile description of their content and capabilities, to certain features related to the user, such as the user’s preferences and constraints, and to the Web services’ quality of service (QoS). Language Grid [2], an Internet infrastructure, is one real application among existing ones, aiming at finding the “best” composition of language resources in order to enhance intercultural collaboration.

Most of the previous research efforts deal with only vertical composition of Web services despite the growing number of functionally equivalent Web services making the horizontal task NP-hard. Our main objective is to build a sophisticated, human-centered system to streamline and facilitate generation of a “satisfying” executable workflow according to some predefined criteria. Formalization of horizontal Web service composition problems was proposed in [1]. This formalization assumes, however, that each subtask is an atomic process and cannot
be decomposed. For example, assume that we have an abstract workflow (build by human or taken from an abstract workflow repository that stores the best practice) including a translation task using machine translation. This workflow cannot be directly concretized when dealing with the Arabic-Japanese pair of languages. Therefore the translation task should be decomposed into two other sub-tasks, such as translating from Arabic to English then translating from English to Japanese.

To overcome the limitation of the previous formalization, we have developed a more flexible dynamic constraint optimization problem formalization enabling horizontal composition of semantic Web services. This new formalization allows to represent any atomic subtask included in the original abstract workflow as a component process whenever this subtask cannot be concretize. The semantic matching among abstract Web services is expressed as hard constraints and based on OWL-S control constructs.

Moreover, we have developed a real-time, incremental, and interactive agent-based protocol for solving this problem. This work complements existing techniques dealing with vertical composition in that it exploits and extends (if possible) their abstract workflows in order to determine the satisfying executable workflow according to predefined optimality criteria. This solution can be directly described in OWL-S and executed through grounding of the selected semantic Web services. The developed negotiation protocol solves the problems of interoperability among semantic Web services while complying with most natural features of realistic problems such as the dynamism of the environment and the need to deal with volatile, and uncertain information during the composition and execution processes. In addition, This protocol allows the user to interfere in order to enhance the search for a solution by relaxing his/her constraints and/or assisting in the generation of the local abstract workflow.

A preliminary prototype of the multi-agent dynamic was implemented, and the results obtained using randomly generated Web service composition problems show that this approach is able to solve the problem and find “satisfying” solutions within a feasible time, while performing the minimum number of required constraint checks and, reducing the number of exchanged messages as much as possible.

References