Metamodel Matching Techniques: Review, Comparison and Evaluation

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ABSTRACT

During the last decade, Model Driven Engineering (MDE) has been proposed for supporting the development, maintenance and evolution of software systems. Model Driven Architecture (MDA), Software Factories and Eclipse Modeling Framework (EMF) are among the most representatives MDE approaches. Nowadays, it is well recognized that model transformation is at the heart of MDE approaches and, consequently represents one of the most important operations in MDE. However, despite the multitude of model transformation language proposals emerging from academic world and industry, these transformations are often manually specified: which is a tedious and error-prone task, and therefore an expensive process. Matching operation between metamodels is the keystone toward a (semi-)automatic transformation process. In this paper, the authors review metamodel matching techniques of the literature and then analyze their pros and cons in order to show how they can be useful for a semi-automatic transformation process. The result is a comparison of metamodel matching techniques, highlighting their similarities and differences in terms of information used for matching, demonstrating significant similarities between these techniques. Next, the authors compare four well-known metamodel matching techniques namely Similarity flooding, SAMT4MDE+ (extended Semi-Automatic Matching Tool for Model Driven Engineering), ModelCVS and AML (AtlanMod Matching Language) on ten couples of metamodels. For this comparison, the authors define a set of six criteria inspired from the database schema matching. One among these criteria is relevant to the quality of matching and for which we define a quality measure metrics. Furthermore, the authors develop a plug-in under Eclipse to support our comparison using ten couples of metamodels.

Keywords: Comparison Criteria, Mapping, Metamodel Matching, Model Driven Engineering, Transformation Process

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1. INTRODUCTION

Over the last two decades, the matching operation has been thoroughly studied in database systems and ontology development (Shvaiko, 2005; Mitra, 2000; Ehrig, 2005; David, 2005; Euzenat, 2011). This operation is crucial in several application domains such as: semantic Web (Berners, 2001) schema and data integration (Madhavan, 2001) data translation, e-commerce (Jeffrey, 2001), query mediation ...etc. Generally, the matching operation is a process that accepts two structures (e.g., database schemas, XML-schemas, catalogs and directories, conceptual graphs, UML diagrams) each consisting of a set of discrete entities (e.g., tables, XML elements, classes, properties, rules, predicates), and then determines as output the mappings (e.g., equivalence, aggregation, composition) holding between these entities. In the context of Model Driven Engineering (MDE) and particularly in Model Driven Architecture (MDA), matching techniques between two metamodels are the centerpieces of a semi-automatic transformation process. Nowadays transformation rules between metamodels are created manually, often a tedious and error-prone task due to the complexity and the size of metamodels, and therefore an expensive process. These transformations consist of creating a set of rules involving, and at the same time merging, mapping and transformation techniques between two metamodels. A semi-automation of the transformation process leads to a real challenge allowing many advantages: It enhances significantly the development time of transformation, and decreases the errors that may occur in a manual definition of transformations. The operation of metamodel matching allows discovering mappings between two metamodels so that, in turn these mappings would allow generating transformation rules between two metamodels: this is the kernel of this research work. It has twofold objective: First, it reviews the existing Metamodel matching techniques in the context of MDE, and secondly it analyses their pros and cons in order to point out how they can be useful for assisting the expert-user in a semi-automatic transformation process.

This paper is organized as follows: Section 2 positions our contribution compared to the related work. Section 3 introduces the main concepts and techniques for a semi-automatic transformation process, and positions this process in the context of metamodel matching. Section 4 reviews several literature metamodel matching techniques that have been proposed in the MDE context. In Section 5 we define our set of evaluation criteria for comparing matching techniques. In Section 6 we compare these techniques according to our established criteria. In Section 7, we experimentally compare four recent matching techniques. Section 8 highlights the main lessons learned. Section 9 overviews the proposed measure to assist expert users to select a suitable matching technique for a given couple of metamodel. Section 10 presents a plug-in for metamodel matching evaluation. Finally, Section 11 concludes the paper and enumerates some perspectives.

2. RELATED WORKS

Matching techniques, which are the centerpieces of a semi-automatic transformation process in MDE, have been studied intensively in various fields. The schema matching in database (Rahm, 2001) was a precursor whereas, today, with the semantic Web, research on techniques for ontology matching is very active (Feiyu, 2007; Shvaiko, 2005). A prosperous bibliography on the topic of matching and research around this theme is maintained on the Web. Concerning the benchmarking issues, the authors in Do (2007) present an evaluation of the main approaches for schema matching in databases. In the context of ontologies, since 2004, the Ontology Alignment Evaluation Initiative (OAEI) makes available a collection of data sets for evaluating matching systems. In Rosoiu (2011) the authors present a comprehensive benchmark on ontology matching.
Cloud Service Brokerage: A Conceptual Ontology-Based Service Description Framework
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