EnOntoModel: A Semantically-Enriched Model for Ontologies

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ABSTRACT

Ontologies are intended to facilitate semantic interoperability among distributed and intelligent information systems where diverse software components, computing devices, knowledge, and data, are involved. Since a single global ontology is no longer sufficient to support a variety of tasks performed on differently conceptualized knowledge, ontologies have proliferated in multiple forms of heterogeneity even for the same domain, and such ontologies are called heterogeneous ontologies. For interoperating among information systems through heterogeneous ontologies, an important step in handling semantic heterogeneity should be the attempt to enrich (and clarify) the semantics of concepts in ontologies. In this article, a conceptual model (called EnOntoModel) of semantically-enriched ontologies is proposed by applying three philosophical notions: identity, rigidity, and dependency. As for the advantages of EnOntoModel, the conceptual analysis of enriched ontologies and efficient matching between them are presented.

Keywords: conceptual modeling; enriched ontologies; knowledge representation; ontology matching; semantic heterogeneity

INTRODUCTION

Today, ontologies have become a silver bullet not only in the development of the semantic Web, but also in several collaborative application areas such as intelligent environments (or smart spaces), e-commerce, life sciences, social networks, multi-agent systems, and so forth, because they are respected as a means of consensus for intelligent reasoning and sharing capabilities. Since a single global ontology is no longer enough to support the variety of tasks pursued in distributed environments, the Web involves a proliferation of ontologies, and faces a trade off between interoperability and heterogeneity.

In order to keep a balance between heterogeneity and interoperability, ontology matching has become a plausible solution in various tasks, such as ontology merging, query answering, information retrieval, exchange, and integra-
Heterogeneity is generally distinguished in terms of syntactic heterogeneity and semantic heterogeneity. Syntactic heterogeneity is caused by using different ontology modeling paradigms (e.g., RDF-based model or frame-based model) and different ontology languages (e.g., DAML or OWL), while semantic heterogeneity is created by conceptualization divergence in describing the semantics of ontological classes. Research on resolving syntactic heterogeneity has been undertaken by many researchers so far (Bowers & Declambre, 2000; Chalupska, 2000). In this article, semantic heterogeneity between ontologies is focused on. Dealing with semantic heterogeneity is a recurrent issue for ontologies, like the problems related to information integration of heterogeneous databases and systems (Batini et al., 1986; March, 1990). Ceri and Widom (1993) listed four categories of semantic conflicts concerning schema matching: naming conflicts, domain conflicts, meta-data (or datatype) conflicts, and structural conflicts. Visser, Jones, Bench-Capon, and Shave (1997) classified ontology mismatches into two levels: conceptualization mismatches (class mismatches and property mismatches) and explication mismatches (abstraction level mismatches and categorization mismatches). According to the works, semantic heterogeneity in ontologies is classified into four categories. For two semantically similar or equivalent classes, there is (a) terminological heterogeneity if they have different names or labels; (b) taxonomical heterogeneity if they have different subsumption structures; (c) schematic heterogeneity if they have different sets of properties and constraints; and (d) instantiation heterogeneity if they are interpreted using different sets of instances.

The main aim of this article is to deal with wide-scale semantic heterogeneity in ontology matching. Although several efforts in ontology mapping have already been contributed, they have different focuses, assumptions, and limitations. A common point among existing methods is that possible correspondences between two ontologies are determined by the similarity of entity names; this is known as name-based matching. In order to decide semantic correspondences between concepts, those methods need to analyze the similarities between all related properties and instances; this is known as content-based matching. In the case of wide-scale semantic heterogeneity, content-based matching becomes complex and user’s approval or expert-interaction needs to verify mapping results.

In the research, two issues are focused on. The first issue is that the chance of correspondence between two terminologically quite different concepts is very less or not obtainable through name-based matching, because the name of a concept cannot express the precise semantics of the concept. In practice, two concepts with the same name may have different semantics, or two differently-naming concepts may have the same semantics. Thus, what is an alternative approach besides name-based matching, to find the possible correspondences between terminologically heterogeneous ontologies? The second issue is how to reduce complexity, concerning wide-scale semantic heterogeneity in content-based matching.

To accomplish the major aim and focuses, the underlying assumption is the more explicit semantics is specified in ontologies, the feasibility of matching will be greater. In order to improve the accuracy and automation of mapping processes, it is necessary that ontologies be well conceptualized with adequate semantics. Hence, an important step in handling semantic heterogeneity should be the attempt to enrich (and clarify) the semantics of concepts in ontologies.

Therefore, a semantically-enriched model of ontologies (called EnOntoModel) is proposed, in which every domain concept is treated as a sort—an entity type that carries criteria for determining the individuation, persistence, and identity of its instances—regarding every individual defined in a universe of discourse is countable and identifiable. In the philosophical literature, ontological concepts can be classified into four disjoint sort categories: type, quasi-type, role, and phase. A logic-based formal system was set up to classify domain
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