

Conceptual Modeling Meets Domain Ontology Development: A Reconciliation

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ABSTRACT

Domain ontologies and conceptual models similarly capture and represent concepts from the real world for inclusion in an information system. This paper examines challenges of conceptual modeling and domain ontology development when mapping to high-level ontologies. The intent is to reconcile apparent differences and position some of the inherent challenges in these closely-coupled areas of research, while providing insights into recognizing and resolving modeling difficulties.

KEYWORDS

Conceptual Model, Construct, Domain Ontology, Knowledge Representation, Mapping, Real World, Representation, Semantics

1. INTRODUCTION

An information system is a representation of some other real world system (Wand and Weber 1995). Capturing the real world and modeling it for inclusion in an information system, however, has always been a challenge because designers must make decisions on the correct details to include, the appropriate level of abstraction, and how information is best captured and represented (Dawson and Swatman 1999; Hadar et al. 2014; Wastell 1996; Clarke et al. 2013). This is important because, to be useful, an information system must consistently and accurately model applications (Choi et al. 2006).

Both domain ontology development and conceptual modeling deal with some notion of information capture and representation. As such, they are two important approaches to modeling the real world for use within an information system. Guarino (1998), in fact, has long asserted that every information system has an ontology that often is not explicit, but, instead, obscurely embedded in parts of the system. Others have, similarly, articulated the need to apply ontology to the theory and practice of conceptual modeling (e.g., Guizzardi and Wagner 2005, Parsons and Wand 1997; Rosemann et al. 2004; Wand and Weber 1995; Weber 2003). Some work has already been carried out to understand conceptual modeling versus ontology (e.g., Fonseca and Martin (2007)). Nevertheless, important issues remain at the intersection of ontology and conceptual modeling.

This paper attempts to reconcile our understanding of domain ontologies and conceptual models as created by domain ontology development and conceptual modeling techniques and methods. To do so, issues related to mapping and merging, semantics, and knowledge representation are presented. The contribution is to understand these issues from the perspective of both applied ontology and conceptual modeling and, in doing so, progress the fields towards integration, which should eventually lead to better modeling efforts.

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The next section of the paper provides an overview of conceptual models and domain ontologies as well as definitions of relevant terms. Section 3 identifies issues related to mapping domain ontologies to a high-level ontology. Section 4 discusses the implications from doing so. Section 5 summarizes and concludes the paper.

2. CONCEPTUAL MODELING AND ONTOLOGY

The interconnection between conceptual modeling and ontology has been widely recognized (Wand and Weber 1993; Guarino and Musen 2005; 2015) because both deal with understanding things and concepts in the real world. Nevertheless, there are different approaches to conceptual modeling activities, as well as to understanding and adapting concepts from the field of ontology. Guarino (2009), for example, argues that, despite all of the work on ontology, there is no consensus on how to build ontological distinctions into knowledge representation languages. Table 1 first reviews some of the main terminology found in both literatures highlighting that much effort has been involved in attempting to understand these complex areas of research.

Figure 1 shows a pizza domain ontology (Horridge 2004), a corresponding conceptual model, and a high-level ontology (see Gristani and Cuel 2005).

2.1. Conceptual Modeling

Conceptual modeling formally describes some aspects of the real world (Mylopoulos 1992) and builds a “representation of selected semantics” of a domain (Weber 2003, p.1). The resulting conceptual models capture the essence of an application domain and represent it in terms of specific constructs. They are intended to be a means by which developers can share an understanding of real world phenomena (Coughlan and Macredie 2002; Lyytinen and Hirschheim 1987; Maass et al. 2011). Burton-Jones and Weber (2014) claim that a high-quality conceptual model is, essentially, a domain ontology expressed in a conceptual modelling grammar. Nonetheless, many conceptual models lack an adequate specification of the semantics of the terminology employed, leading to inconsistent interpretations and uses of knowledge (Grüninger et al. 2000). Theories of ontology have been proposed to advance research in conceptual modeling because they account for the structure and behavior of the world in general (e.g., Guarino 1998; Weber 2003). Ontology-driven conceptual modeling strives to use ontological theories to develop artifacts to improve the theory and practice of conceptual modeling (Guizzardi 2012).

2.2. Ontology

Ontology deals with the nature of existence and theories about the nature of the fundamental types of phenomena that occur in the real world. Claimed usages of ontology include “enabling interoperability across heterogeneous systems and semantic web applications” (Choi et al. 2006, p.34). Top-level ontologies can be used to evaluate conceptual modeling languages and to develop guidelines for their use (Guizzardi and Wagner 2005).

2.2.1. Domain Ontologies

A domain ontology is a conceptualization specific to a particular domain (Weber 2002). Conceptual modeling builds models of some subset of phenomena in the real world. A domain ontology captures specific information about a task or domain; the same is true for a conceptual model. Therefore, the relationship between a domain ontology and a conceptual model should be strong. According to

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