Preface

The idea of ontologies emerged in applied artificial intelligence some time ago as a means for sharing knowledge [Gruber, 1993]. Following the development of ontologies and related Web technologies (e.g., HTML and XML), Tim Berners-Lee, Jim Hendler, and Ora Lassila envisioned the next generation of the Web, called the Semantic Web [Berners-Lee et al., 2001]. Being based on ontologies, the Semantic Web has the potential for semantically richer representations of things (e.g., Web pages, applications, and persons) and their relations on the Web, and thus should provide us with more intelligent services. That idea might have initially sounded very futuristic and too enthusiastic, but it has recruited a lot of important players from both academia and industry into very extensive and well-funded research efforts. Today, we have quite impressive results, manifested by standards that have been adopted (RDF and OWL), development frameworks (Jena), best-practice and deployment recommendations, and many applications (e.g. PiggyBank).

Of course, researchers are still facing many challenges in their efforts to accomplish the full vision of the Semantic Web. Probably the first and most important goal is to persuade many industrial developers and software engineers to use and develop ontologies in their everyday practice. However, ontologies rely on well-defined and semantically powerful concepts in artificial intelligence such as description logics, reasoning, and rule-based systems. Since software engineers are largely unfamiliar with these concepts, ontologies have a price that must be paid for the benefits that they provide.

Trying to address the above problems, researchers have started exploring the potential of some widely adopted software engineering tools and methodologies for ontology development. Stephen Cranefield did the pioneering research by proposing that UML, a well-known software modeling language, should be used for ontology development [Cranefield, 2001a]. After him, several researchers have explored further the similarities, differences, and equivalences between UML and ontology languages, as well as the potential of the most recent software engineering initiative called the Model Driven Architecture (MDA), and its accompanying standards (the Meta-Object Facility (MOF) and XML

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Metadata Interchange (XMI)) for ontology development [Baclawski et al., 2002a; Djurić et al., 2005a; Falkovych et al., 2003]. This resulted in the initiation of a process for adopting an MDA-based ontology standard by the Object Management Group (OMG), a software engineering standardization consortium [OMG ODM RFP, 2003]. The standard is intended to define the Ontology Definition Metamodel (ODM) using the MOF (used for specifying UML as well), a UML extension (the Ontology UML Profile, or OUP) to allow UML tools to be used to fully develop ontologies, and a set of transformations between the ODM, the OUP, UML, and Semantic Web ontology languages (e.g., RDF(S) and OWL). When completed, the ODM specification is expected to be in the form of an OMG language, like UML and CWM.

In this book we try to fill the gap in the literature covering the subject of applications of the MDA for ontology development on the Semantic Web. Other books cover either the MDA initiative [Kleppe et al., 2003; Mellor et al., 2003b] or the Semantic Web (i.e., ontology development) [Fensel, 2004; Stuckenschmidt & van Harmelen, 2005; Zhong et al., 2003] only. This book gives a comprehensive overview of both themes, with the main emphasis on how we can employ MDA-related standards to develop Semantic Web ontologies. The book is closely related to the recent OMG initiative for the ODM. The book is the first description of that new language.

The book is based on our experience obtained from a series of tutorials entitled "MDA Standards for Ontology Development" that we have given at several international conferences on the Semantic Web (the International Semantic Web Conference and the European Semantic Web Conference) and on software engineering (the International UML Conference and the International Conference of Web Engineering).

Organization and Structure

The book is divided into three parts. Part I covers the basics of both the main topics – ontologies and the MDA. First, Chap. 1 gives a brief overview of the field of knowledge representation in artificial intelligence. Chapters 2 and 3 introduce the main concepts of ontologies, the Semantic Web, standards, applications, tools, and some open research questions. Next, Chap. 4 explains the Model Driven Architecture, and its main standards (the MOF and XMI) and mechanisms (UML profiles). Part I is concluded by Chap. 5 with modeling spaces, a conceptual framework

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defined to provide an easier understanding of approaches to modeling such as ontologies and MOF-defined modeling languages (UML and the ODM).

Part II is the central part of the book. It starts with Chap. 6, which presents a comprehensive review of several approaches and tools that aim to bridge the gap between ontology development and software engineering methodologies. This chapter also lists the relations between UML and ontology languages. Chapter 7 explains the motivation for the forthcoming OMG ontology development standard for the ODM, and the requirements the standard has to fulfill. Next, Chaps. 8 and 9 describe the current specifications of the OMD and the Ontology UML Profile, respectively. Finally, Chap. 10 analyzes the mappings between MDA-based languages (the ODM and the OUP) and Semantic Web ontology languages.

Part III is dedicated to applications that will support the practical use of languages that conform to the OMG ontology development standard, and to some practical aspects of how to develop ontologies using those MDA-based languages. First, Chap. 11 is a short tutorial showing how to develop ontologies using the OUP in two state-of-the-art UML tools (MagicDraw and Poseidon for UML). Chapter 12 describes an implementation of an ontology-building platform called AIR, developed entirely following MDA principles. Finally, Chap. 13 discusses two examples of ontologies developed using the OUP and MDA standards.

Throughout the book, we use many ontologies, UML and other MDA-based models, and transformations between them. In order to allow you to try them out and use them in practice, we have created a Web page containing supplementary resources. You can reach this Web page at http://www.modelingspaces.org. Besides the resources referred to in the book, this Web page contains the slide handouts of the tutorials that we have given at many international conferences.

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