

Contents

Part I Basics

1. Knowledge Representation.....	3
1.1 Basic Concepts	4
1.2 Cognitive Science	7
1.3 Types of Human Knowledge	11
1.4 Knowledge Representation Techniques.....	14
1.4.1 Object–Attribute–Value Triplets	15
1.4.2 Uncertain Facts	15
1.4.3 Fuzzy Facts	16
1.4.4 Rules	17
1.4.5 Semantic networks.....	18
1.4.6 Frames	19
1.5 Knowledge Representation Languages.....	19
1.5.1 Logic-Based Representation Languages.....	20
1.5.2 Frame-Based Representation Languages	27
1.5.3 Rule-Based Representation Languages.....	29
1.5.4 Visual Languages for Knowledge Representation.....	32
1.5.5 Natural Languages and Knowledge Representation	35
1.6 Knowledge Engineering	36
1.7 Open Knowledge Base Connectivity (OKBC)	39
1.8 The Knowledge Level	41
2. Ontologies	45
2.1 Basic Concepts	46
2.1.1 Definitions	46
2.1.2 What Do Ontologies Look Like?	48
2.1.3 Why Ontologies?	50
2.1.4 Key Application Areas.....	55
2.1.5 Examples.....	57
2.2 Ontological Engineering.....	58
2.2.1 Ontology Development Tools.....	58
2.2.2 Ontology Development Methodologies	65
2.3 Applications.....	69
2.3.1 Magpie	69
2.3.2 Briefing Associate.....	70

2.3.3	Quickstep and Foxtrot.....	71
2.4	Advanced Topics	72
2.4.1	Metadata, Metamodeling, and Ontologies	72
2.4.2	Standard Upper Ontology	74
2.4.3	Ontological Level	76
3.	The Semantic Web	79
3.1	Rationale.....	80
3.2	Semantic Web Languages	81
3.2.1	XML and XML Schema	81
3.2.2	RDF and RDF Schema	84
3.2.3	DAML+OIL	87
3.2.4	OWL	90
3.2.5	SPARQL.....	92
3.3	The Role of Ontologies	95
3.4	Semantic Markup	96
3.5	Semantic Web Services	100
3.6	Open Issues.....	104
3.7	Quotations	107
4.	The Model Driven Architecture (MDA).....	109
4.1	Models and Metamodels.....	109
4.2	Platform-Independent Models	110
4.3	Four-Layer Architecture	112
4.4	The Meta-Object Facility	114
4.5	Specific MDA Metamodels	117
4.5.1	Unified Modeling Language	117
4.5.2	Common Warehouse Metamodel (CWM).....	118
4.5.3	Ontology Definition Metamodel.....	119
4.6	UML Profiles.....	120
4.6.1	Examples of UML Profiles.....	121
4.7	An XML for Sharing MDA Artifacts	123
4.8	The Need for Modeling Spaces	126
5.	Modeling Spaces.....	127
5.1	Modeling the Real World	128
5.2	The Real World, Models, and Metamodels	129
5.3	The Essentials of Modeling Spaces	131
5.4	Modeling Spaces Illuminated	134
5.5	A Touch of RDF(S) and MOF Modeling Spaces	137
5.6	A Touch of the Semantic Web and MDA Technical Spaces	139
5.7	Instead of Conclusions	141

Part II The Model Driven Architecture and Ontologies

6. Software Engineering Approaches to Ontology Development.....	145
6.1 A Brief History of Ontology Modeling	145
6.1.1 Networked Knowledge Representation and Exchange Using UML and RDF.....	145
6.1.2 Extending the Unified Modeling Language for Ontology Development	150
6.1.3 The Unified Ontology Language	155
6.1.4 UML for the Semantic Web: Transformation-Based Approach.....	156
6.1.5 The AIFB OWL DL Metamodel.....	159
6.1.6 The GOOD OLD AI ODM Proposal	160
6.2 Ontology Development Tools Based on Software Engineering Techniques	160
6.2.1 Protégé	161
6.2.2 DUET (DAML UML Enhanced Tool)	164
6.2.3 An Ontology Tool for IBM Rational Rose UML Models.....	165
6.2.4 Visual Ontology Modeler (VOM)	167
6.3 Summary of Relations Between UML and Ontologies	168
6.3.1 Summary of Approaches and Tools for Software Engineering-Based Ontology Development	169
6.3.2 Summary of Differences Between UML and Ontology Languages	169
6.3.3 Future Development	172
7. The MDA-Based Ontology Infrastructure.....	173
7.1 Motivation	173
7.2 Overview	174
7.3 Bridging RDF(S) and MOF	176
7.4 Design Rationale for the Ontology UML Profile.....	178
8. The Ontology Definition Metamodel (ODM).....	181
8.1 ODM Metamodels	181
8.2 A Few Issues Regarding the Revised Joint Submission	183
8.3 The Resource Description Framework Schema (RDFS) metamodel.....	184
8.4 The Web Ontology Language (OWL) Metamodel	190
9. The Ontology UML Profile	201
9.1 Classes and Individuals in Ontologies	201
9.2 Properties of Ontologies	204
9.3 Statements.....	206
9.4 Different Versions of the Ontology UML Profile.....	207

10. Mappings of MDA-Based Languages and Ontologies	211
10.1 Relations Between Modeling Spaces.....	211
10.2 Transformations Between Modeling Spaces	214
10.3 Example of an Implementation: an XSLT-Based Approach	217
10.3.1 Implementation Details.....	218
10.3.2 Transformation Example	219
10.3.3 Practical Experience	222
10.3.4 Discussion.....	225

Part III Applications

11. Using UML Tools for Ontology Modeling	229
11.1 MagicDraw.....	230
11.1.1 Starting with MagicDraw	230
11.1.2 Things You Should Know when Working with UML Profiles.....	232
11.1.3 Creating a New Ontology	234
11.1.4 Working with Ontology Classes.....	237
11.1.5 Working with Ontology Properties.....	240
11.1.6 Working with Individuals.....	244
11.1.7 Working with Statements	246
11.2 Poseidon for UML.....	247
11.2.1 Modeling Ontology Classes in Poseidon	249
11.2.2 Modeling Ontology Individuals and Statements in Poseidon	250
11.3 Sharing UML Models Between UML tools and Protégé Using the UML Back End.....	251
12. An MDA Based Ontology Platform: AIR	255
12.1 Motivation	255
12.2 The Basic Idea.....	256
12.3 Metamodel – the Conceptual Building Block of AIR	258
12.4 The AIR Metadata Repository.....	259
12.5 The AIR Workbench	262
12.6 The Role of XML Technologies.....	264
12.7 Possibilities.....	265
13. Examples of Ontology	267
13.1 Petri Net Ontology.....	267
13.1.1 Organization of the Petri Net Ontology	269
13.1.2 The Core Petri Net Ontology in the Ontology UML Profile	272
13.1.3 Example of an Extension: Upgraded Petri Nets.....	275

13.2 Educational Ontologies.....	278
13.2.1 Conceptual Solution.....	279
13.2.2 Mapping the Conceptual Model to Ontologies	281
References.....	291
Index	305