

Contents

1	Introduction	<i>page</i> 1
1.1	What are DLs and where do they come from?	1
1.2	What are they good for and how are they used?	3
1.3	A brief history of description logic	4
1.4	How to use this book	7
2	A Basic Description Logic	10
2.1	The concept language of the DL \mathcal{ALC}	10
2.2	\mathcal{ALC} knowledge bases	16
2.2.1	\mathcal{ALC} TBoxes	17
2.2.2	\mathcal{ALC} ABoxes	19
2.2.3	Restricted TBoxes and concept definitions	23
2.3	Basic reasoning problems and services	28
2.4	Using reasoning services	36
2.5	Extensions of the basic DL \mathcal{ALC}	37
2.5.1	Inverse roles	37
2.5.2	Number restrictions	39
2.5.3	Nominals	41
2.5.4	Role hierarchies	42
2.5.5	Transitive roles	42
2.6	DLs and other logics	44
2.6.1	DLs as decidable fragments of first-order logic	44
2.6.2	DLs as cousins of modal logic	46
2.7	Historical context and literature review	48
3	A Little Bit of Model Theory	50
3.1	Bisimulation	51
3.2	Expressive power	53
3.3	Closure under disjoint union	55

3.4	Finite model property	57
3.5	Tree model property	63
3.6	Historical context and literature review	67
4	Reasoning in DLs with Tableau Algorithms	69
4.1	Tableau basics	70
4.2	A tableau algorithm for \mathcal{ALC}	71
4.2.1	ABox consistency	72
4.2.2	Acyclic knowledge base consistency	82
4.2.3	General knowledge base consistency	83
4.3	A tableau algorithm for \mathcal{ALCIN}	90
4.3.1	Inverse roles	90
4.3.2	Number restrictions	93
4.3.3	Combining inverse roles and number restrictions	97
4.4	Some implementation issues	101
4.4.1	Or-branching	101
4.4.2	And-branching	103
4.4.3	Classification	104
4.5	Historical context and literature review	104
5	Complexity	106
5.1	Concept satisfiability in \mathcal{ALC}	107
5.1.1	Acyclic TBoxes and no TBoxes	108
5.1.2	General TBoxes	117
5.2	Concept satisfiability beyond \mathcal{ALC}	123
5.2.1	\mathcal{ALC} with inverse roles and nominals	123
5.2.2	Further adding number restrictions	125
5.3	Undecidable extensions of \mathcal{ALC}	130
5.3.1	Role value maps	130
5.3.2	Concrete domains	134
5.4	Historical context and literature review	137
6	Reasoning in the \mathcal{EL} Family of Description Logics	140
6.1	Subsumption in \mathcal{EL}	141
6.1.1	Normalisation	142
6.1.2	The classification procedure	147
6.2	Subsumption in \mathcal{ELI}	151
6.2.1	Normalisation	151
6.2.2	The classification procedure	152
6.3	Comparing the two subsumption algorithms	159
6.3.1	Comparing the classification rules	159
6.3.2	A more abstract point of view	162

6.4	Historical context and literature review	165
7	Query Answering	168
7.1	Conjunctive queries and FO queries	169
7.2	FO-rewritability and DL-Lite	174
7.2.1	Introducing DL-Lite	175
7.2.2	Universal models	180
7.2.3	FO-rewritability in DL-Lite	184
7.3	Datalog-rewritability in \mathcal{EL} and \mathcal{ELI}	192
7.3.1	Fundamentals of Datalog	193
7.3.2	Datalog-rewritings in \mathcal{ELI}	195
7.3.3	Short Datalog-rewritings in \mathcal{EL}	198
7.4	Complexity aspects	199
7.5	Historical context and literature review	202
8	Ontology Languages and Applications	205
8.1	The OWL ontology language	206
8.1.1	OWL and RDF	206
8.1.2	OWL and \mathcal{SROIQ}	209
8.1.3	OWL ontologies	213
8.1.4	Non-DL features	217
8.1.5	OWL profiles	222
8.2	OWL tools and applications	223
8.2.1	The OWL API	223
8.2.2	OWL reasoners	224
8.2.3	Ontology engineering tools	224
8.2.4	OWL applications	225
	Appendix: Description Logic Terminology	228
A.1	Syntax and semantics of concept and role constructors	228
A.2	Syntax and semantics of knowledge bases	230
A.3	Naming schemes for description logics	231
	<i>References</i>	234
	<i>Index</i>	252

