

CONTENTS

I	INTRODUCTION	1
1	INTRODUCTION	3
1.1	Motivation	4
1.2	Objectives	5
1.3	Structure	6
II	PRELIMINARIES AND STATE OF THE ART	9
2	MDE: AUTOMATING CODING IN SOFTWARE DEVELOPMENT	13
2.1	Model Driven Engineering Open standards	15
2.2	Model Driven Architecture	16
2.3	Meta Object Facility	18
2.4	Object Constraint Language	20
2.4.1	Language features	21
2.5	Query/View/Transformation	22
2.5.1	Languages	23
2.5.2	The <i>Relations</i> language	25
2.6	Summary	29
3	SUPPORTING TECHNOLOGIES FOR MDE	31
3.1	The Eclipse Platform	32
3.1.1	Eclipse Modeling Framework	33
3.1.2	Graphical Modeling Framework	38
3.1.3	Model Development Tools	40
3.2	MOMENT: A framework for Model Management	41
3.3	ATLAS Transformation Language	41
3.4	IBM Model Transformation Framework	42
3.5	MediniQVT	42
3.6	Summary	44
4	SOFTWARE PRODUCT LINES	45
4.1	Software Product Line Engineering	46

4.2	Describing variabilities and commonalities	48
4.2.1	Introduction	51
4.2.2	Classic feature models	51
4.2.3	FeatuRSEB and PLUSS feature models	54
4.2.4	Cardinality-based feature models	56
4.2.5	Feature model configurations	58
4.3	Summary	59
III VARIABILITY VIEW ON MULTI-MODEL DRIVEN SOFTWARE PRODUCT LINES		61
5	MULTI-MODEL DRIVEN PRODUCT LINE ENGINEERING	65
5.1	System views and the multi-model	67
5.2	Views, models and metamodels in MULTIPLE	69
5.3	Summary	70
6	FEATURE MODEL CONFIGURATION ISSUES	73
6.1	Introduction	74
6.2	Feature models, configurations and MOF	74
6.3	Describing feature model configurations as instances	79
6.4	Summary and conclusions	81
7	USING FEATURE MODELS IN MDE PROCESSES	83
7.1	Process overview	83
7.2	Cardinality-based feature metamodel	85
7.2.1	Feature models structure	85
7.2.2	Feature model constraints	86
7.2.3	Cardinality-based feature metamodel in MOF	87
7.3	The Domain Variability Model	90
7.3.1	The structure of the DVM	91
7.3.2	Constraints over the DVM	100
7.4	Feature model configurations	109
7.5	Summary and conclusions	112
IV THE MULTIPLE FRAMEWORK AND MMDSP_L DEVELOPMENT AND ANALYSIS		113
8	THE MULTIPLE FRAMEWORK	117

8.1	Subsystems and components overview	118
8.2	The Eclipse Platform	123
8.3	Built-in metamodels	125
8.3.1	Variability metamodel support	125
8.3.2	FAMA metamodel support	138
8.3.3	Modular metamodel support	146
8.3.4	Component–connector metamodel support	154
8.3.5	PRISMA metamodel support	161
8.4	Transformations Subsystem	166
8.4.1	QVT engine	167
8.4.2	QVT transformation invocation model support	168
8.4.3	Traceability metamodel support	171
8.4.4	QVT Launcher	178
8.4.5	QVT Command-line interface	187
8.5	Validation Subsystem	194
8.5.1	OCL Support	195
8.5.2	OCL Support CLI	203
8.5.3	Variability Model Checking	206
8.6	MULTIPLE EMF Utils	214
8.6.1	EMOF Converter utility	214
8.6.2	Register EMF utility	214
8.6.3	Registry viewer utility	216
8.7	Summary and conclusions	216
9	MMDSP FOR DIAGNOSTIC EXPERT SYSTEMS DE- VELOPMENT	219
9.1	Technological spaces	221
9.2	Field Study: Diagnostic Expert Systems	222
9.2.1	Diagnostic Expert Systems Reference Ar- chitecture	223
9.2.2	Diagnostic Expert Systems Structural Vari- ability	224
9.2.3	Diagnostic Expert Systems Behavioral Vari- ability	225

9.2.4	Diagnostic Expert Systems Application Domain Variability	226
9.2.5	Conclusions	227
9.3	BOM initial proposal: BOM–Eager	228
9.3.1	Variability management in BOM	228
9.3.2	Software system views in BOM–Eager . .	233
9.3.3	Relationships among system views	234
9.3.4	Modeling the BOM approach	236
9.3.5	BOM–Eager implementation	239
9.4	Turning BOM into a MMDSPLE process	242
9.4.1	Representing the first variability in BOM– Lazy	242
9.4.2	Software system views in BOM–Lazy . .	244
9.4.3	Relationships among metamodels	245
9.5	BOM–Lazy implementation	248
9.5.1	T ₁ transformation	249
9.5.2	T ₂ transformation	260
9.6	Summary and conclusions	268
10	AUTOMATED ANALYSIS OF FEATURE MODELS IN MULTIPLE	273
10.1	Context and Motivation	274
10.2	Case study	276
10.2.1	Feature modeling in Rolls-Royce plc . .	277
10.2.2	Analysis process overview	278
10.2.3	Source Model structure	281
10.2.4	A step by step description of the process .	282
10.3	Interpreting the obtained results	293
10.3.1	Syntactic analysis	293
10.3.2	Semantic Analysis	297
10.3.3	Conclusions about the analysis results .	300
10.3.4	Efficiency and limitations of the auto- mated analysis tool	302
10.4	Summary and conclusions	303

V THE MULTIPLE FRAMEWORK IN 3RD PARTY PROJECTS AND TOOLS	305
11 BIOLOGICAL DATA MIGRATION USING MULTIPLE	309
11.1 Case study	311
11.1.1 Toll-like receptors and the TLR4 signal transduction pathway	313
11.1.2 An approach to the study of the TLR4 signal transduction pathway	315
11.2 A MDSD approach in biological data migration . .	317
11.2.1 Architecture and overview of the tool . .	318
11.2.2 Development of the source and the target models	319
11.2.3 Transformation process	323
11.3 Running example	324
11.3.1 Result files	327
11.3.2 Result file in <i>CPN Tools</i>	328
11.4 Conclusions	329
12 SOFTWARE MEASUREMENT BY USING QVT TRANSFORMATIONS	333
12.1 Related works	335
12.2 Software Measurement Framework	336
12.2.1 Conceptual architecture	337
12.2.2 Technological aspects	339
12.2.3 Method	342
12.3 Example	343
12.4 Conclusions	347
13 MORPHEUS: A TOOL FOR THE ATRIUM METHODOLOGY	349
13.1 ATRIUM at a glance	350
13.2 MORPHEUS: a MDD supporting tool	353
13.2.1 Requirements Environment	354
13.2.2 Scenario Environment	357
13.2.3 Software Architecture Environment . . .	361
13.3 Related works	363
13.4 Conclusions and further works	364

VI CLOSURE	365
14 RELATED WORKS	369
14.1 MULTIPLE feature models and other feature modeling proposals	370
14.2 MULTIPLE and the OMG CVL	371
14.3 Feature models and class diagrams	371
14.4 Feature model constraints	372
14.5 Feature models and other SPL approaches	373
15 SUMMARY AND CONCLUSIONS	377
16 PUBLICATIONS	385
 APPENDICES	 393
A TRANSFORMATION FEATURES2CLASSDIAGRAM	395
B TRANSFORMATION MODULES2COMPONENTS	407
C TRANSFORMATION COMPONENTS2PRISMA	413
D TRANSFORMATION MULTIPLEFEATURES2FAMAFEATURES	421
E FAMA XML SCHEMA DEFINITION	425
F RUNNING A QVT TRANSFORMATION USING MEDINI QVT	429
G TRANSPATH2CPN TRANSFORMATION	435
 BIBLIOGRAPHY	 445