

Contents

Part I Introduction	1
1 Introduction to Software Product Line Engineering	3
1.1 Principles of Product Line Engineering	4
1.2 Engineering Customised Products.....	7
1.3 Motivations for Product Line Engineering.....	9
1.4 Software Product Line Engineering	13
2 A Framework for Software Product Line Engineering	19
2.1 Introduction	20
2.2 Two Development Processes.....	20
2.3 Overview of the Framework.....	21
2.4 Domain Engineering.....	23
2.5 Domain Artefacts	28
2.6 Application Engineering.....	30
2.7 Application Artefacts	34
2.8 Role of the Framework in the Book	36
3 Overview of the Example Domain: Home Automation	39
3.1 Smart Home Fundamentals	40
3.2 Building Blocks of a Home Automation System	43
3.3 An Example.....	46
3.4 Software Variability in Smart Home Applications.....	50
3.5 Role of the Home Automation Domain in the Book.....	52
Part II Product Line Variability	53
4 Principles of Variability	57
4.1 Introduction	58
4.2 Variability Subject and Variability Object	59
4.3 Variability in Software Product Line Engineering	61
4.4 Variability in Time vs. Variability in Space.....	65
4.5 Internal and External Variability	68
4.6 Orthogonal Variability Model	72
4.7 Handling Complexity in Variability Models	87

4.8	Differences from Single-System Engineering	88
4.9	Summary	88
5	Documenting Variability in Requirements Artefacts	89
5.1	Introduction	90
5.2	Documenting Requirements	91
5.3	Variability in Textual Requirements	96
5.4	Variability in Requirements Models	99
5.5	Traceability Between Variability Model and Requirements Artefacts.....	109
5.6	Differences from Single-System Engineering	112
5.7	Summary	113
6	Documenting Variability in Design Artefacts	115
6.1	Introduction	116
6.2	Architectural Artefacts	117
6.3	The Reference Architecture.....	123
6.4	Variability in the Development View.....	124
6.5	Variability in the Process View	131
6.6	Variability in the Code View.....	132
6.7	Differences from Single-System Engineering	134
6.8	Summary	134
7	Documenting Variability in Realisation Artefacts	135
7.1	Introduction	136
7.2	Detailed Design Artefacts	137
7.3	Component Interface Variability	139
7.4	Internal Component Variability.....	145
7.5	Differences from Single-System Engineering	147
7.6	Summary	147
8	Documenting Variability in Test Artefacts	149
8.1	Introduction	150
8.2	Test Artefacts	151
8.3	Variability in Test Artefacts	152
8.4	Differences from Single-System Engineering	157
8.5	Summary	157
Part III	Domain Engineering	159
9	Product Management	163
9.1	Introduction	164
9.2	Terminology	166

9.3	Traditional Product Management Activities	167
9.4	Portfolio Management	168
9.5	Extension of the Product Portfolio	177
9.6	Management of Existing Products.....	186
9.7	Scoping.....	188
9.8	Differences from Single-System Engineering.....	189
9.9	Summary	191
10	Domain Requirements Engineering	193
10.1	Introduction	194
10.2	Traditional Requirements Engineering Activities	197
10.3	Challenges of Domain Requirements Engineering	198
10.4	Overview of Major Steps	199
10.5	Requirements Sources	201
10.6	Commonality Analysis.....	201
10.7	Variability Analysis.....	204
10.8	Defining Requirements Variability	206
10.9	Example.....	209
10.10	Differences from Single-System Engineering.....	215
10.11	Summary	216
11	Domain Design	217
11.1	Introduction	218
11.2	Traditional Design Activities	220
11.3	Quality Requirements.....	221
11.4	Commonality and Variability in Design.....	225
11.5	Designing the Reference Architecture.....	231
11.6	Architecture Validation	236
11.7	Differences from Single-System Engineering.....	238
11.8	Summary	239
12	Domain Realisation	241
12.1	Introduction	242
12.2	Traditional Realisation Activities.....	244
12.3	Realising Interfaces	245
12.4	Realising Variable Components	248
12.5	Binding Time of Variability	250
12.6	Realising Configurability	253
12.7	Differences from Single-System Engineering.....	255
12.8	Summary	255
13	Domain Testing	257
13.1	Introduction	258

13.2	Software Testing.....	262
13.3	Domain Testing and Application Testing.....	266
13.4	Testing Variability at Different Test Levels.....	267
13.5	Criteria for Product Line Test Strategies.....	270
13.6	Product Line Test Strategies.....	271
13.7	Domain Test Activities.....	281
13.8	Differences from Single-System Engineering.....	283
13.9	Summary	284
14	Selecting High-Level COTS Components	285
14.1	Introduction	286
14.2	The CoVAR Process	288
14.3	Differences from Single-System Engineering.....	300
14.4	Summary	301
Part IV	Application Engineering	303
15	Application Requirements Engineering	307
15.1	Introduction	308
15.2	Application Requirements Engineering Activities.....	312
15.3	Communication of the Product Line Variability.....	315
15.4	Analysis of Requirements Deltas	318
15.5	Documentation of the Application Requirements	326
15.6	Differences from Single-System Engineering.....	328
15.7	Summary	329
16	Application Design	331
16.1	Introduction	332
16.2	Development of the Application Architecture	334
16.3	Feedback of Application Artefacts to the Domain.....	340
16.4	Effort and Cost of Variants	341
16.5	Differences from Single-System Engineering.....	342
16.6	Summary	343
17	Application Realisation	345
17.1	Introduction	346
17.2	Configuration	348
17.3	Realisation of Application-Specific Components	350
17.4	Building the Application	351
17.5	Differences from Single-System Engineering.....	353
17.6	Summary	354

18	Application Testing	355
18.1	Introduction	356
18.2	Domain Test Artefact Reuse	359
18.3	Tests Related to Variability	362
18.4	Testing Variability at Different Test Levels.....	364
18.5	Application Test Coverage	365
18.6	Application Test Activities.....	367
18.7	Differences from Single-System Engineering.....	369
18.8	Summary	370
 Part V Organisation Aspects		 371
19	Organisation	375
19.1	Introduction	376
19.2	Properties of Organisation Structures.....	376
19.3	Basic Hierarchical Organisation Structures.....	378
19.4	Matrix Organisation Structures	384
19.5	Detailed Structure.....	389
19.6	Cross-Functional Teams.....	389
19.7	Organisation Theory.....	389
19.8	Differences from Single-System Engineering.....	391
19.9	Summary	392
20	Transition Process	393
20.1	Introduction	394
20.2	Motivation and Business Objectives	394
20.3	Transition Strategies.....	395
20.4	Benefits and Drawbacks of the Transition Strategies.....	398
20.5	Cost Model	400
20.6	Application of the Cost Model to the Transition Strategies	402
20.7	Major Steps of a Transition Process.....	406
20.8	Summary	410
 Part VI Experience and Future Research		 411
21	Experiences with Software Product Line Engineering	413
21.1	ABB.....	414
21.2	Boeing Company	415
21.3	CelsiusTech Systems AB	416
21.4	Cummins Inc.	417
21.5	Hewlett-Packard	419

21.6	LG Industrial Systems Co., Ltd.....	420
21.7	Lucent Technologies	421
21.8	MARKET MAKER Software AG.....	422
21.9	Philips.....	424
21.10	Robert Bosch GmbH	427
21.11	Salion Inc.....	428
21.12	Siemens AG Medical Solutions HS IM.....	430
21.13	Testo AG	431
21.14	The National Reconnaissance Office	432
21.15	The Naval Undersea Warfare Center	433
22	Future Research	435
22.1	Domain Specialisation.....	436
22.2	Quality Assurance	436
22.3	Model-Driven Development.....	436
22.4	Evolution	437
22.5	Multiple Product Lines	437
22.6	Tool Support.....	437
22.7	Process Improvement and Assessment.....	438
22.8	Economics	438
	The Authors	439
	References	445
	Glossary	457
	Index	461