

---

# Contents

<b>Preface</b> .....	v
----------------------	---

---

## Part I Models and Software Development

---

<b>1 Introduction</b> .....	3
1.1 The Challenge of Software Development .....	3
1.2 Mastering Complexity: The Role of Modelling .....	4
1.3 The Place of Modelling in Software Development .....	5
1.4 Modelling Structure: Object-oriented Systems .....	6
1.5 Modelling Data and Functionality: VDM++ .....	10
1.6 Using VDM++ in Object-oriented Design .....	14
1.7 Book Organisation and Content .....	15
1.8 Summary .....	18
<b>2 Building a Model in VDM++: An Overview</b> .....	19
2.1 Constructing a Model .....	19
2.2 A Chemical Plant Example .....	20
2.3 Choosing a Structure Using UML Class Diagrams .....	21
2.4 Making the Model More Comprehensive .....	29
2.5 Validating the Model .....	38
2.6 Generating Code .....	41
2.7 Summary .....	41
<b>3 VDM++ Tool Support</b> .....	43
3.1 Introduction .....	43
3.2 Getting Hold of the Software .....	44
3.3 Using Rose .....	44
3.4 Using VDMTools .....	47
3.5 Summary .....	60

---

**Part II Modelling Object-oriented Systems in VDM++**


---

<b>4</b>	<b>Defining Data</b> .....	63
4.1	Introduction .....	63
4.2	Object-oriented Structuring .....	64
4.3	Instance Variables and Invariants .....	68
4.4	Types and Type Definitions .....	71
4.5	Values and Value Definitions .....	83
4.6	Summary .....	84
<b>5</b>	<b>Defining Functionality</b> .....	85
5.1	Introduction .....	85
5.2	Function Definitions .....	86
5.3	Operation Definitions .....	91
5.4	Expressions .....	97
5.5	Pattern Binding .....	100
5.6	Bindings .....	101
5.7	Statements .....	102
5.8	Summary .....	105
<b>6</b>	<b>Modelling Unordered Collections</b> .....	107
6.1	Introduction .....	107
6.2	Overview of Sets .....	107
6.3	The Robot Controller .....	111
6.4	Summary .....	135
<b>7</b>	<b>Modelling Ordered Collections</b> .....	137
7.1	Introduction .....	137
7.2	Overview of Sequences .....	137
7.3	The Congestion Warning System (CWS) .....	142
7.4	Summary .....	165
<b>8</b>	<b>Modelling Relationships</b> .....	167
8.1	Introduction .....	167
8.2	Overview of Mappings .....	167
8.3	The Congestion Warning System Revisited .....	171
8.4	Summary .....	188

---

**Part III Modelling in Practice: Three Case Studies**


---

<b>9</b>	<b>Model Structuring: The Enigma Cipher</b> .....	191
9.1	Introduction .....	191
9.2	The Historic Significance of Enigma .....	192
9.3	The Enigma Cipher Algorithm .....	193
9.4	Building the Enigma Model .....	195
9.5	The VDMUnit Framework .....	214
9.6	Testing the Enigma Model .....	224
9.7	Summary .....	229
<b>10</b>	<b>Combining Views: The CSLaM System</b> .....	231
10.1	Introduction .....	231
10.2	The CSLaM System .....	232
10.3	The On-board CSL System .....	233
10.4	Member Declarations .....	234
10.5	The Cab Display .....	236
10.6	The Beacon Classes .....	238
10.7	Announcements and Restrictions .....	240
10.8	Monitoring the Performance of Drivers .....	241
10.9	Summary .....	246
<b>11</b>	<b>TradeOne: From Enterprise Architecture to Business Application</b> .....	249
11.1	Introduction .....	249
11.2	Enterprise Architectures .....	251
11.3	The TradeOne Architecture .....	255
11.4	The Validation Approach .....	264
11.5	Metrics from TradeOne .....	265
11.6	Lessons Learned from the TradeOne Project .....	270
11.7	Summary .....	271

---

## Part IV From Models to Code

---

<b>12</b>	<b>Concurrency in VDM++</b> .....	275
12.1	Introduction .....	275
12.2	Modelling Concurrency: Threads and Permission Predicates .....	276
12.3	A POP3 Server .....	282
12.4	Synchronising Communication in the POP3 Server .....	291
12.5	Summary .....	294
<b>13</b>	<b>Model Quality</b> .....	295
13.1	Introduction .....	295
13.2	Assessing Internal Consistency: Integrity Checking .....	296
13.3	Assessing External Consistency Using an API .....	303
13.4	Validating the POP3 Example through the API .....	307
13.5	Summary .....	317

<b>14 Implementing in Java</b> .....	319
14.1 Introduction .....	319
14.2 Overview of Java Code Generation .....	320
14.3 Basic Code Generation .....	322
14.4 Code Generation and Concurrency .....	334
14.5 Code Generation of POP3 .....	339
14.6 Summary .....	343

---

**Appendices**

---

<b>Solutions to Exercises</b> .....	349
<b>References</b> .....	383
<b>List of Acronyms</b> .....	387
<b>Subject Index</b> .....	389
<b>Definitions Index</b> .....	399