

Contents

- 1 Introduction 1**
 - 1.1 Space and Time 1
 - 1.2 Why a Spatio-Temporal Database? 2
 - 1.3 An Application Example 5
 - 1.4 Data Modeling Requirements from the Example Application 9
 - 1.5 Purpose of the Book 11
 - 1.6 Outline of the Book 13
 - 1.7 Acknowledgements 16

- 2 The MADS Data Model..... 17**
 - 2.1 On Conceptual Models..... 17
 - 2.1.1 What is a “Conceptual” Data Model? 18
 - 2.1.2 What is a “Good” Conceptual Data Model? 19
 - 2.1.3 On Orthogonality in Multi-Dimensional Data Modeling..... 22
 - 2.1.4 Data Models and Data Manipulation 23
 - 2.1.5 Spatio-Temporal Conceptual Data Modeling 23
 - 2.1.6 MADS: A Multi-Dimensional Conceptual Data Model 24
 - 2.2 Thematic Data Structures 24
 - 2.2.1 Object Types 25
 - 2.2.2 Attributes 27
 - 2.2.3 Methods 32
 - 2.2.4 Relationship Types 33
 - 2.2.5 Is-a Links 40
 - 2.2.6 Aggregation Semantics 52
 - 2.2.7 Transition Semantics 55
 - 2.2.8 Generation Semantics 57
 - 2.2.9 Summary on Thematic Data Structure Modeling 58
 - 2.3 Spatio-Temporal Data Structures 59
 - 2.3.1 Locating Objects in Space and Time 61
 - 2.3.2 Describing Space and Time Using the Discrete View 66
 - 2.3.3 Space, Time, and Is-a Links..... 73
 - 2.3.4 Constraining Relationships with Space and Time Predicates 77
 - 2.3.5 Describing Space and Time Using the Continuous View 83
 - 2.3.6 Summary on Spatio-Temporal Modeling 91
 - 2.4 Supporting Multiple Perceptions and Multiple Representations 92

2.4.1	Rationale for Multiple Representations	92
2.4.2	Multiple Representation and Spatial Databases.....	96
2.4.3	Identifying Perceptions.....	100
2.4.4	Stamping.....	101
2.4.5	Multiple Representation Modeling.....	103
2.4.6.	Perception-Varying Object Types	105
2.4.7	Perception-Varying Relationship Types.....	111
2.4.8	Consistency of a Multi-Perception Database.....	114
2.4.9	Summary on Multi-Representation Modeling	115
2.5	Integrity Constraints.....	117
2.5.1	Keys.....	120
2.5.2	Temporal Cardinalities	123
2.5.3	Spatial Constraints.....	126
2.5.4	Temporal Constraints	128
2.5.5	Spatio-Temporal Constraints	130
2.5.6	Multiple-Representation Constraints	131
2.5.7	More Constraints	133
2.6	Conclusion	135
3	The Risks Management Application.....	137
3.1	Description of the Application.....	137
3.2	Schema of the Application.....	146
3.2.1	Object Types.....	147
3.2.2	Relationship Types	155
3.2.3	User-Defined Spatial Data Types	162
3.2.4	Is-a Clusters.....	163
3.3	Conclusion	163
4	MADS Data Types.....	165
4.1	General Description of MADS Data Types	166
4.1.1	Related Work in Data Types	167
4.1.2	Undefined Values	170
4.2	Basic Data Types	171
4.2.1	Numeric Types	171
4.2.2	Character Types.....	172
4.2.3	Boolean Type.....	172
4.3	Tuple Types	173
4.4	Enumeration Types	173
4.5	Collection Data Types.....	174
4.5.1	Collection	175
4.5.2	Set.....	176
4.5.3	Bag	177
4.5.4	List.....	177
4.6	Spatial Data Types	178
4.6.1	Geo	180
4.6.2	SimpleGeo	183

4.6.3	Point.....	183
4.6.4	Line.....	183
4.6.5	OrientedLine.....	184
4.6.6	Surface.....	184
4.6.7	SimpleSurface.....	186
4.6.8	ComplexGeo.....	186
4.6.9	PointBag.....	188
4.6.10	LineBag.....	188
4.6.11	OrientedLineBag.....	189
4.6.12	SurfaceBag.....	189
4.6.13	SimpleSurfaceBag.....	190
4.7	Topological Predicates.....	190
4.7.1	Meets.....	192
4.7.2	Adjacent.....	193
4.7.3	Touches.....	193
4.7.4	Crosses.....	194
4.7.5	Overlaps.....	194
4.7.6	Contains/Within.....	195
4.7.7	Disjoint/Intersects.....	195
4.7.8	Equals.....	196
4.7.9	Covers.....	196
4.7.10	Encloses/Surrounded.....	196
4.8	Temporal Data Types.....	197
4.8.1	Time.....	199
4.8.2	SimpleTime.....	201
4.8.3	Instant.....	201
4.8.4	Interval.....	202
4.8.5	ComplexTime.....	202
4.8.6	InstantBag.....	204
4.8.7	IntervalBag.....	204
4.8.8	TimeSpan.....	205
4.9	Temporal Predicates.....	205
4.9.1	Meets.....	207
4.9.2	Overlaps.....	207
4.9.3	Contains/Within.....	207
4.9.4	Disjoint/Intersects.....	208
4.9.5	Equals.....	208
4.9.6	Covers.....	208
4.9.7	Starts/Finishes.....	209
4.9.8	Precedes/Succeeds.....	209
4.10	Perception Stamp Data Types.....	209
4.11	Varying Types.....	210
4.11.1	Manipulating Varying Data Types.....	212
4.11.2	TLifecycle.....	216
4.11.3	Perception-Varying Data Definitions.....	218
4.12	Conclusion.....	219

5	The MADS Query and Manipulation Languages	221
5.1	Manipulating and Querying Multi-Instantiation	224
5.1.1	Creating and Deleting Instances	226
5.1.2	Querying Instances	228
5.1.3	Inheritance and Dynamic Binding	229
5.2	Manipulating and Querying Multiple Representations	232
5.3	Manipulating and Querying Spatial Information	235
5.4	Manipulating and Querying Temporal Information	238
5.5	MADS Manipulation Language	242
5.5.1	Inserting Objects	243
5.5.2	Inserting Relationships	246
5.5.3	Delete Operators	250
5.5.4	Update Operator	253
5.6	MADS Algebra	256
5.7	Selection	264
5.8	Reduction	266
5.9	Projection	268
5.10	Extend	270
5.11	Set Operators	274
5.11.1	Union	276
5.11.2	Intersection	277
5.11.3	Difference	278
5.12	Product	279
5.12.1	Flat Product	279
5.12.2	Nested Product	280
5.13	Objectify	281
5.13.1	Plain Objectify	284
5.13.2	Objectifying Each Value of a Multivalued Attribute	285
5.13.3	Objectifying Each Value of a Varying Attribute	287
5.13.4	Group-By and Spatial Fusion	289
5.14	Rename	290
5.15	Conclusion	291
6	From Conceptual Design to Logical Design	293
6.1	Architecture of the Transformation Process	296
6.2	Structural Transformation Rules	298
6.2.1	Transformation of Multi-Associations	298
6.2.2	Transformation of Is-a Links	300
6.2.3	Transformation of the Semantics of Relationships	302
6.2.4	Transformation of Overlapping Links	303
6.2.5	Removing Relationships	304
6.2.6	Transformations of Multivalued Attributes	306
6.3	Multi-Representation Transformation Rule	309
6.3.1	Transformation of a Multi-Representation Type	310
6.4	Spatial Transformation Rules	311
6.4.1	Transformation of Spatial Object and Relationship Types	312

6.4.2	Transformation of Spatial Attributes	312
6.4.3	Transformation of Spatial Data Types	313
6.4.4	Transformation of Topological Relationship Types	314
6.5	Temporal Transformation Rules	315
6.5.1	Transformation of Temporal Object and Relationship Types.....	315
6.5.2	Transformation of Transition and Generation Relationship Types	316
6.6	Transformation of Space- and Time-Varying Attributes	317
6.7	Specific Modules for Target Systems	318
6.8	Example	320
6.9	Conclusion	325
7	Related Works.....	327
7.1	Structural Dimension	328
7.1.1	MADS and UML	328
7.1.2	MADS and the Relational Model	331
7.1.3	MADS and the Object-Relational Model: SQL:2003.....	334
7.1.4	MADS and the Object-Oriented Model: ODMG.....	338
7.2	Spatio-Temporal Dimension	341
7.2.1	MADS and ISO TC 211	343
7.2.2	MADS and SQL/MM Spatial	348
7.2.3	MADS and STER	353
7.2.4	MADS and Perceptory.....	356
7.2.5	MADS and Oracle Spatial	358
7.2.6	MADS and ArcInfo	360
7.2.7	MADS and MapInfo.....	363
7.3	Multi-Representation Dimension.....	365
7.3.1	Multiple Resolutions.....	367
7.3.2	Multiple Viewpoints	372
7.3.3	Multiple Classification.....	375
7.3.4	Conclusion on Multi-Representation.....	379
7.4	Conclusion	380
8	Conclusion	383
8.1	Space and Time	383
8.2	Perception	384
8.3	Application Requirements.....	385
8.4	MADS Approach	385
8.5	Results Achieved so Far.....	386
8.6	Future Perspectives	388
8.6.1	Tool Support.....	388
8.6.2	Reverse Engineering	390
8.6.3	Schema Evolution.....	392
8.6.4	Schema Integration	392
8.6.5	Integrity Constraints	393
8.6.6	Methodological Support	394

8.7	Conclusions.....	395
A	MADS Formalization	397
A.1	Schema.....	397
A.2	Object types	398
A.3	Attribute and Method Definition.....	402
A.4	Relationship types.....	406
A.5	Multi-Instantiation	412
A.6	Legal database states.....	413
A.6.1	Population of an object type	414
A.6.2	Population of a relationship type	416
A.6.3	Multi-instantiation	422
A.7	Compatibility of Relationship Types	423
A.8	Symbols and Functions	425
B	MADS Notation	427
B.1	Object and Relationship Types	427
B.2	Is-a Links and Overlapping.....	428
B.3	Aggregation, Transition, and Generation.....	429
B.4	Spatio-Temporal Modeling	430
B.5	Multi-Representation Modeling	431
	References.....	435
	Glossary.....	447
	Index.....	459



<http://www.springer.com/978-3-540-30153-0>

Conceptual Modeling for Traditional and
Spatio-Temporal Applications

The MADS Approach

Parent, C.; Spaccapietra, S.; Zimányi, E.

2006, XVIII, 466 p. 115 illus., Hardcover

ISBN: 978-3-540-30153-0