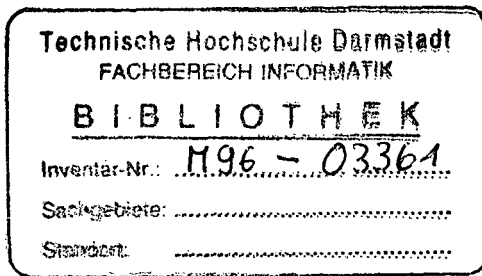


Markus Schneider

Spatial Data Types for Database Systems

Finite Resolution Geometry
for Geographic Information Systems



Springer

Table of Contents

1	Introduction	1
1.1	Background and Motivation	1
1.2	Focus	3
1.3	Organization of the Book	6
2	Spatial Data Types - A Survey	11
2.1	Spatial Data Modelling	12
2.1.1	A Three-Level Model for Phenomena in Space.	12
2.1.2	Spatial Modelling.	14
2.1.3	Properties of Spatial Data	16
2.1.4	Spatial Concepts	18
2.1.5	Spatial Data Models and Spatial Data Structures	20
2.2	Spatial Data Types and Spatial Operations.	22
2.2.1	Conceptual Views of Spatial Objects.	22
2.2.2	Spatial Operations	33
2.2.3	Design Criteria for Modelling Spatial Data Types	43
2.3	Formal Definition Methods.	48
2.3.1	Introduction	48
2.3.2	Mathematical Concepts of Space.	50
2.3.3	Point-Set Theory	55
2.3.4	Point-Set Topology	59
2.3.5	Algebraic Topology	68
2.3.6	Order Theory	73
2.4	Numerical Robustness and Topological Correctness of Geo-Algorithms	77
2.5	Finite Precision Computational Geometry	83
3	Realms: A Foundation for Spatial Data Types in Database Systems	85
3.1	The Realm-Concept	85
3.2	Integer Arithmetic and Robust Geometric Primitives.	88
3.3	Redrawing as a Solution of the Discrete Segment Intersection Problem.	90
3.3.1	The Segment Intersection Problem Defined over a Discrete Space	90
3.3.2	Concepts and Properties of the Redrawing Process.	92

3.3.3	Number-Theoretical Foundations for the Redrawing of a Hooked Segment	97
3.3.4	The Restricted Redrawing Algorithm	103
3.3.5	The Generalized Redrawing Algorithm.	116
3.4	Realms	122
3.5	Operations on Realms: The Realm Interface	122
3.5.1	Modelling the Realm Interface	122
3.5.2	Algorithms of the Realm Interface	126
3.6	Realm-Based Structures and Primitives	130
3.7	Related Work	139
4	Realm-Based Spatial Data Types: The ROSE Algebra	141
4.1	Realm-Based Spatial Data Types	141
4.2	The Type System of the ROSE Algebra	144
4.2.1	Second-Order Signature.	144
4.2.2	The Type of a Partition.	146
4.3	The Object Model Interface	148
4.3.1	OMI Concepts for Defining the ROSE Algebra	148
4.3.2	OMI Concepts for Embedding the ROSE Algebra into a DBMS Query Language	149
4.4	The ROSE Algebra	153
4.4.1	Spatial Predicates Expressing Topological Relationships	154
4.4.2	Spatial Operators Returning Spatial Data Type Values	155
4.4.3	Spatial Operators Returning Numbers.	156
4.4.4	Spatial Operators on Sets of Spatially-Referenced Objects.	158
4.5	Integration with a DBMS Query Language: O ₂ SQL/ROSE	161
4.6	Related Work	167
5	Efficient Algorithms for Realm-Based Spatial Data Types	169
5.1	Descriptive and Executable ROSE Algebra	169
5.2	Data Structures for the Realm-Based Spatial Data Types	172
5.3	Algorithms of the Executable ROSE Algebra	176
5.3.1	Algorithms with Simple or Parallel Object Traversal	177
5.3.2	Algorithms Using the Plane Sweep Paradigm.	182
5.3.3	Graph Algorithms	196
5.3.4	Special Algorithms for Distance Problems	208
5.3.5	Using Filter Techniques: The Bounding Box	209
5.3.6	Algorithms for Operations on Sets of Database Objects	212
5.4	Related Work	214

6	Implementing Concepts: Realm System and ROSE System	215
6.1	Providing Realm System and ROSE System as Modular Components	215
6.2	The Realm System	216
6.2.1	Modularization and Architecture	216
6.2.2	Implementation Aspects	217
6.2.3	The Realm Editor	220
6.3	The ROSE System	226
6.3.1	Modularization and Architecture	226
6.3.2	Implementation Aspects	227
6.3.3	The ROSE Editor	230
6.4	Integration of Realm System and ROSE System	230
6.5	Related Work	231
7	Conclusions, Open Problems, and Future Work	233
7.1	Conclusions	233
7.2	Open Problems	236
7.3	Future Work	237
7.3.1	Spatial Type Extension Packages	237
7.3.2	Vague Spatial Objects	240
7.3.3	Spatiotemporal Objects	244
	Bibliography	245
	Appendix A: Definition of Robust Geometric Primitives	259
	Appendix B: Definition Layers for Realm-Based Spatial Data Types	263
	Appendix C: Translation of the Descriptive ROSE Operators into Executable Operators	265
	Index	269