

Pro Oracle Spatial

RAVI KOTHURI, ALBERT GODFRIND, and EURO BEINAT

Contents

Foreword	xvii
About the Authors	xix
About the Technical Reviewers	xxi
Acknowledgments	xxiii
Introduction	xxv
Setting Up	xxxix

PART 1 ••• Overview

CHAPTER 1	Spatial Information Management	3
	Using Spatial Information in Various Industries	5
	Sources of Spatial Data	7
	Managing and Analyzing Spatial Data	8
	Storing Spatial Data in a Database	12
	Spatial Analysis	15
	Benefits of Oracle Spatial	17
	Summary	19
	References	20
CHAPTER 2	Overview of Oracle Spatial	21
	Technology and Architecture Overview	22 ₁
	Getting Started with Oracle Spatial	24
	Data Model: Storing Spatial Data	24
	Location Enabling	25
	Query and Analysis	27
	Visualizing Spatial Data	31
	Advanced Spatial Engine	32
	Oracle Spatial Technology Products	34
	Locator	34
	Spatial Option . . . •	36

KONTENTS

	What to Expect in an Oracle Spatial Install.	38
	Installing Oracle Spatial in the Database.	38
	Upgrades.	38
	Understanding a Spatial Install.	39
	Summary.	40
KHAPTER 3	Location-Enabling Your Applications.	41
	Adding Location Information to Tables.	42
	Application-Specific Data.	42
	Geographic Data.	47
	Metadata for Spatial Tables.	50
	Dictionary View for Spatial Metadata.	50
	Populating Spatial Metadata for Your Application.	55
	Additional Information for Visualization and Network Analysis	56
	Summary.	57

PART 2 ••• Basic Spatial

KHAPTER 4	The SDOJ3EOMETRY Data Type.	61
	Types of Spatial Geometries in Oracle.	62
	Points.	62
	Line Strings.	63
	Polygons.	63
	Collections.	64
	Logical Implementation of SDO_GEOMETRY.	64
	SDO_GEOMETRY Type, Attributes, and Values.	66
	SDO_GTYPE Attribute.*	67
	SDO_SRID Attribute.	69
	SDO_POINT Attribute.	75
	SDO_ELEM_INFO and SDO_ORDINATES Attributes.	77
	Simple Geometry Examples.	80
	Point.	80
	Line String: Connected by Straight Lines.	82
	Line String: Connected by Arcs.	83
	Polygon: Ring (Boundary) Connected by Straight Lines.	85
	Polygon: Ring (Boundary) Connected by Arcs.	87
	Rectangle Polygon.	87
	Circle Polygon.	88

Complex Geometry Examples.....	90
Guidelines for Constructing Complex Geometries.....	90
Summary.....	101

BHAPTER 5 Loading, Transporting, and Validating Spatial Data. . . .103

Inserting Data into an SDO_GEOMETRY Column.....	104
Loading and Publishing Spatial Data.....	105
Loading from Text Files Using SQL*Loader.....	105
Transporting Spatial Data Between Oracle Databases.....	108
Loading from External Formats.....	111
Conversion Between SDO_GEOMETRY and WKT/WKB.....	113
Publishing SDO_GEOMETRY Data in GML.....	114
Validating Spatial Data.....	115
VAUDATE_GEOMETRY_WITH_CONTEXT.....	115
VAUDATE_LAYER_WITH_CONTEXT.....	118
Debugging Spatial Data.....	119
REMOVE_DUPUCATE_VERTICES.....	120
EXTRACT.....	121
APPEND.....	125
GETNUMELEM, GETNUMVERTICES, and GETVERTICES.....	126
Miscellaneous Functions.....	126
Summary.....	126

BHAPTER 6 Geocoding.....129

What Is Geocoding?.....	130
Architecture of the Oracle Geocoder.....	131
Parsing the Input Address.....	132
Searching for the Address.....	133
Computing the Spatial Coordinates.....	133
Setting Up the Reference Data for the Geocoder.....	135
Parameter Tables.....	135
Data Tables.....	136
Using Geocoder Functions.....	137
GEOCODE_AS_GEOMETRY.....	138
GEOCODE.....	141
GEOCODE ALL.....	156

	Geocoding Business Data	163
	Adding the Spatial Column.	163
	Geocoding the Addresses: The "Naive" Approach.	163
	Address Verification and Correction.	165
	Automatic Geocoding.	171
	Summary.	175
•CHAPTER 7	Manipulating SDO_GEOMETRY in Application Programs	177
	Manipulating Geometries Using PL/SQL	179
	VARRAY Manipulation Primer.	182
	Reading and Writing SDO_GEOMETRY Objects.	186
	Creating New Geometries.	186
	Extracting Information from Geometries.	189
	Modifying Existing Geometries.	191
	Manipulating Geometries in Java	196
	Mapping SDO_GEOMETRY to JGeometry.	196
	Reading Geometries.	197
	Creating Geometries.	206
	Modifying Existing Geometries.	212
	Manipulating Geometries in C Using OCI.	212
	Mapping Oracle Objects to C Structures.	213
	Reading Geometries.	214
	Writing Geometries.	218
	OCI Examples.	220
	Manipulating Geometries in C Using Pro*C.	221
	Reading Geometry Objects.	221
	Writing Geometry Objects.	223
	Pro*C Examples.	223
	Summary.	223
PART 3	Analysis and Visualization	
KHAPTER 8	Spatial Indexes and Operators.	227
	Spatial Indexes.	228
	Inserting Metadata for a Spatial Layer Prior to Indexing.	230
	Creating a Spatial Index.	231
	Spatial Indexing Concepts.	232

Spatial Operators.....	238
Syntax of Spatial Operators.....	238
Semantics of Spatial Operators.....	239
Evaluation of Spatial Operators.....	240
A Closer Look at Spatial Operators.....	241
SDO_WITHIN_DISTANCE Operator.....	241
SDO_NN Operator.....	244
Operators for Spatial Interactions (Relationships).....	252
Hints for Spatial Operators.....	267
Advanced Spatial Index Features.....	273
Function-Based Spatial Indexes.....	273
Partitioned Spatial Indexes.....	277
Parallel Indexing.....	280
Spatial Joins.....	281
Summary.....	284

CHAPTER 9 Geometry Processing Functions.....285

Buffering Functions.....	287
Relationship Analysis Functions.....	290
SDO_DISTANCE.....	290
RELATE.....	294
Geometry Combination Functions.....	299
SDOINTERSECTION.....	300
SDOJJNION.....	301
SDO_DIFFERENCE.....	303
SDO_XOR.....	305
Geometric Analysis Functions.....	305
Area and Length Functions.....	306
MBR Functions.....	308
Miscellaneous Geometric Analysis Functions.....	310
Aggregate Functions.....	314
Aggregate MBR Function.....	314
Other Aggregate Functions.....	315
Summary.....	320

CHAPTER 10 Network Modeling.....321

General Network Modeling Concepts.....	323
Examples of Networks.....	325
Oracle Network Data Model.....	326

Data Structures: The Network Tables	327
Node Table	328
Link Table	329
Path Table	329
Path Link Table	330
Network Metadata	330
Defining Networks	332
"Automatic" Network Definition	332
"Manual" Network Definition	334
Dropping a Network	341
Spatial Indexes on Network Tables	342
Getting Information About a Network	342
Example Networks	345
Analyzing and Managing Networks Using the Java API	348
Analyzing Networks: The NetworkManager Class	348
Limiting the Search Space: The SystemConstraint Class	363
Advanced Analysis: Network Constraints	365
Network Structures: The Network, Node, Link, and Path Classes	370
Creating Networks: The NetworkFactory Class	372
The Network Editor	376
Starting the Editor	376
Using the Loaded Network	378
Example Data: The Streets of San Francisco	379
Summary	381

BHAPTER 11 Generating Maps Using MapViewer..... 383

Why Use Maps in Location-Enabled Applications?	383
Overview of Oracle MapViewer	386
Getting Started with MapViewer	389
Installing OC4J	389
Installing MapViewer	390
Viewing Predefined Maps	392
Configuring MapViewer	396
Constructing Maps	401
Styles	402
Managing Styles Using the Map Definition Tool	404
Themes	412
Defining Maps	418

Using MapViewer in Applications.	423
Map Requests and Responses.	424
Simple Map Request.	425
Adding Themes to a Base Map.	427
Using Multiple Data Sources.	429
Constructing a Map from Themes.	429
Dynamic Themes.	431
Dynamic Features.	434
Legends.	437
The XML Map Response.	439
Interacting with Maps.	440
Controlling the Level of Detail: Zoom In and Zoom Out.	440
Controlling the Area Seen on the Map: Pan and Recenter.	441
Selecting Features: Identify.	441
Choosing the Information to Appear on the Map:	
Layer Control.	442
Using the XML API.	442
Static Map Embedded in HTML.	442
Simple Interaction Using JavaScript.	443
Using the XML API in a JSP Page.	445
Using the Java API.	449
Sending Map Requests.	450
Zooming and Panning.	453
Theme Control.	456
Style Control.	460
Identification and Queries.	460
Dynamic Features.	463
Legend.	463
Data Sources.	464
Using JSPTags.	465
Initialization and Setup: The init Tag.	467
Setting Up the Map.	467
Interacting with the Map: The run Tag.	468
Displaying the Map: The getMapURL Tag.	469
Getting Feature Details: The identify Tag.	469
Combining MapViewer JSP Tags and the Java API.	470
Using the Administrative API.	471
Browsing Map Definitions.	471
Managing the MapViewer Server.	474
Summary.	477

BHAPTER 12 A Sample Application.....	479
Data Preparation and Setup.....	480
Loading the Geographical Data.....	481
Location-Enabling the Application Tables.....	481
Loading Map and Style Definitions for MapViewer.....	482
PL/SQL Tools.....	482
Application Walk-Through.....	483
Setting Up the Application.....	484
Starting the Application.....	484
Application Home Page.....	485
Location Mark.....	485
Zooming, Panning, and Recentering.....	486
Adding Application Data to the Map.....	487
Positioning on a Street Address.....	487
Identifying a Branch, Customer, or Competitor.....	488
Searching "Within Distance".....	489
Setting a Mark on the Map.....	490
Searching for Nearest Neighbors.....	490
Route Calculation.....	491
Under the Hood.....	491
Initialization: The "Reset" Action.....	492
Zooming, Panning, and Recentering.....	494
Adding Application Data to the Map.....	495
Positioning on a Street Address.....	496
Identifying a Branch, Customer, or Competitor.....	498
Setting a Mark on the Map.....	501
Searching "Within Distance".....	502
Searching for Nearest Neighbors.....	504
Route Calculation.....	506
Summary.....	507
Application Source Code.....	507

PART 4 ••• Advanced Spatial

KHAPTER 13 Case Studies.....	535
Overview of the Case Studies.....	535
Spatial Information for Managing the London Bus Network.....	536
BusNet.....	537
Spatial Data and Oracle Spatial in BusNet.....	538
User Interface for Spatial Data in BusNet.....	541
BusNet Conclusions.....	543

P-Info: A Mobile Application for Police Forces.	544
P-Info Functionality.	546
P-Info Architecture.	547
Use of Oracle Spatial in P-Info.	549
Measurable Added Value of P-Info.	551
Risk Repository for Hazardous Substances.	552
RRGS Technology.	555
Use of Oracle Spatial in the RRGs.	556
From Hazardous Substances to Risk Management	558
GeoStor: Spatial Data Warehouse for the State of Arkansas.	560
GeoStor Data Warehouse.	560
GeoStor Architecture and Data Model.	562
Oracle Spatial in GeoStor.	564
Use of GeoStor.	565
Location Services for Third-Generation Mobile Networks.	566
Location-Enabled Applications at "3".	568
Logical and Physical Data Models for Maps and POIs:	
The GSS Repository.	569
Data Ingestion and Preparation.	571
Nonfunctional Specification.	572
Summary.	573

BHAPTER 14 Tips, Common Mistakes, and Common Errors. 575

Tips.	575
Data Modeling and Loading.	575
Performance of Spatial Operator Query.	579
Performance of Other Spatial Processing Functions.	582
Performance of Inserts, Deletes, and Updates.	585
Best Practices for Scalability and Manageability of Spatial Indexes.	586
Common Mistakes.	592
Bounds and Tolerance for Geodetic Data.	592
Longitude, Latitude Dimensions.	592
NULL Values for SD0_GEOMETRY.	592
Use GEOCODE or GEOCODE_ALL	592
Specify "INDEXTYPE is mdsys.spatialIndex" in CREATE INDEX ... •.	593
Do Not Move, Import, or Replicate MDRT Tables.	593
Network Metadata.	593
Map Metadata.	593

Common Errors.	594
ORA-13226: interface not supported without a spatial index	594
ORA-13203: failed to read USER_SDO_GEOMJ/IETADATA view.	594
ORA-13365: layer SRID does not match geometry SRID.	594
ORA-13223: duplicate entry for <table_name, column_name> in SDO_GEOM_METADATA.	595
ORA-13249, ORA-02289: cannot drop sequence/table.	595
ORA-13249: multiple entries in sdo_index_metadata table.	595
ORA-13207: incorrect use of the <operator-name> operator.	595
ORA-13000: dimension number is out of range.	596
ORA-00939: too many arguments for function.	596
ORA-13030: invalid dimensionality for the SDO_GEOMETRY, or ORA-13364: layer dimensionality does not match geometry dimensions.	597
Summary.	598
"APPENDIX A Additional Spatial Analysis Functions.	599
Tiling-Based Analysis.	599
TILED_BINS.	600
TILED_AGGREGATES.	601
Neighborhood Analysis.	604
AGGREGATES_FOR_GEOMETRY.	604
AGGREGATES_FOR_LAYER.	606
Clustering Analysis.	607
SPATIAL_CLUSTERS.	607
Refining the Candidates for Site Selection.	609
Geometry Simplification for Speeding Up Analysis.	609
Summary.	609
•APPENDIX B Linear Referencing.	611
Concepts and Definitions.	612
Measure.	612
Linear Referenced Segments.	612
Direction.	612
Shape Points.	613
Offset.	613
Typical Application.	614

Creating Linear Referenced Geometries.	616
SDO_GTYPE in LRS Geometries.	616
Constructing LRS Geometries.	616
Metadata.	618
Spatial Indexes and Spatial Operators on LRS Geometries.	618
Dynamic Segmentation Operations.	618
Clip a Segment	619
Locate a Point	619
Project a Point.	620
Validation of LRS Segments.	621
Dynamic Segmentation on 3D Geometries.	622
Other Operations.	622
Summary.	622
APPENDIX c Topology Data Model in Oracle.	623
Topology Data Model.	624
Benefits of the Topology Data Model.	625
Storing a Topology Data Model in Oracle.	626
Operating on a Topology in Oracle.	629
Creating a Topology.	630
Associating a Feature Layer with a Topology.	630
Inserting, Updating, and Populating Feature Layers.	631
Updating Topological Elements.	631
Querying for Topological Relationships.	632
Hierarchical Feature Model.	632
Summary.	633
JRPPENDIX D Storing Raster Data in Oracle.	635
SDO_GEORASTER Data Type.	636
Storage for SDO_GEORASTER Data.	638
Metadata in SDO_GEORASTER Data.	641
Populating SDO_GEORASTER Columns.	642
Manipulating Raster Objects.	643
Generating Pyramids.	643
Subsetting.	645
Georeferencing.	645
Visualizing Raster Data in Oracle MapViewer.	647
Summary.	649
INDEX.	651