Contents

Introduction xxvii

Part I: Getting a Grip on ADO.NET 3.5

Chapter 1: Taking a New Approach to Data Access in ADO.NET 3.5 3

Language Integrated Query (LINQ) 5
LINQ to Objects 8
Sample LINQ Queries 9
LINQ Data Binding with the ToList() Operator 12
LINQ to SQL 15
Mapping Tables to Entities with the LINQ to SQL OR Designer 15
Examining the Generated Classes 16
Binding Data-Enabled Controls to Entity Data Sources 21
Programming the DataContext 23
Emulating Joins by Navigating Associations 24
Loading Child Objects Lazily or Eagerly 27
Creating Explicit Joins with LINQ Join . . . On Expressions 27
Applying Operators to Emulate SQL Functions, Modifiers, and Operators 30
Updating Table Data 30
Generating a SQL Server Database with the OR Designer 34
LinqDataSource Control 34
LINQ to DataSets 34
Joining DataSets 35
Navigating Entity Set Associations 37
LINQ to Entities 38
LINQ to XML 39
LINQ to XML's Objects 39
Querying XML Documents 40
Transforming or Creating XML Documents 44
LINQ to XSD 47
The ADO.NET Entity Framework and Entity Data Model 48
Mapping from the Physical to the Conceptual Schema 50
Creating the Default EDM with the Entity Data Model Wizard 52
Modifying Storage to Conceptual Mapping with the EDM Designer 53

COPYRIGHTED MATERIAL

Creating and Binding to a Data Source from a Data Model 54
Materializing an Object Context 56
Summary 57

Part II: Introducing Language Integrated Query

Functional Languages, Haskell, and Cω 60
A Brief History of LINQ 61

Chapter 2: Understanding LINQ Architecture and Implementation 63

Namespaces That Support LINQ in .NET Fx 3.5 64
C# and VB Extensions to Support LINQ 66
Implicitly Typed Local Variables 67
Object Initializers 68
Array Initializers with Object Initializers 70
Collection Initializers 70
Anonymous Types 71
Extension Methods 72
Anonymous Methods and Generic Predicates 75
Lambda Expressions 77
C# 3.0 Lambda Expressions 78
VB 9.0 Lambda Expressions 79
Standard Query Operators 80
C# 3.0 Query Expressions 80
Lazy and Eager Evaluation 82
VB 9.0 Query Expressions 83
Expression Trees and Compiled Queries 83
C# 3.0 Expression Trees 83
VS 2008 SP1's ExpressionTreeVisualizer 84
VB 9.0 Expression Trees 86
Compiled Queries 87
The IQueryable<T> Interface and Domain-Specific LINQ Implementations 88
Summary 89

Chapter 3: Executing LINQ Query Expressions with LINQ to Objects 91

Standard Query Operators by Group 92
SQOs as Keywords in C# 3.0 and VB 9.0 93
The LINQ Project Sample Query Explorers 95
Sample Classes for LINQ to Objects Code Examples 96
C# Class Definition and Initialization Code Example 98

VB Class Definition and Initialization Code Example 100
Restriction Operator: Where 101
Simple Where Expressions 102
Compound Where Expressions 102
Method Calls with Index Arguments and Use of IndexOf() 104
Projection Operators 105
Select 106
Simple Select Projection Expression 106
Multiple Select Projection Expression with Index Value 107
Index Value Expressions with the Let Keyword 107
SelectMany 108
Basic SelectMany Implementation for Associated Objects 108
SelectMany Overload for Equi-Joins of Associated Objects 110
Partitioning Operators 111
Take 112
Skip 112
Skip/Take Example 112
TakeWhile 113
SkipWhile 114
SkipWhile/TakeWhile Example 114
Join Operators 115
Join 116
GroupJoin 117
Concatenation Operator: Concat 120
Ordering Operators 121
OrderByDescending 122
ThenBy 122
ThenByDescending 123
Reverse 123
Ordering Operator Examples 123
Grouping Operator: GroupBy 125
GroupBy with Method Call Syntax 126
GroupBy with Query Expression Syntax 127
Set Operators 128
Distinct 129
Union 129
Intersect 131
Except 132
Conversion operators 132
AsEnumerable 133
AsQueryable 133
Cast 135

Of Type 136
To . . . Operators 138
ToArray 138
ToList 139
To Dictionary 139
ToLookup 141
Equality Operator: SequenceEqual 142
Element operators 144
First, FirstOrDefault 144
Last, LastOrDefault 145
Single, SingleOrDefault 145
DefaultIfEmpty 146
ElementAt, ElementAtOrDefault 146
Generation Operators 147
Range 147
Repeat 147
Empty 147
Quantifier Operators 148
Any 148
All 148
Contains 149
Aggregate Operators 149
Count and LongCount 150
Min, Max, Sum, and Average 151
Aggregate 152
Summary 153

Chapter 4: Working with Advanced Query Operators and Expressions 155

Exploring Basic Query Syntax for Aggregate Operators 156
Basic Method Call Syntax with Numerical Operators 157
Expression Syntax with Let as a Temporary Local Aggregate Variable 158
Using a Lambda Function for Aggregation of Child Entity Values 158
Using Visual Basic's Aggregate . . . Into Keywords 159
Formatting the Query Output 159
Using Group By with Aggregate Queries 160
Grouping with Associated Child Objects 161
Using the Aggregate Keyword and Into Expression with VB 161
Using C# Group By Expression Syntax 162
Grouping with Joined Child Objects 163
Combining Join and Group By Operations with Hierarchical Group Join Expressions 164
Comparing Group Joins with Nested LINQ Queries 166
Emulating Left Outer Joins with Entity Associations 168

Taking Full Advantage of the Contains() SQO 169
Emulating SQL Where Clauses with Compound OR Operators 169
Emulating the SQL IN() Function with Contains() 171
Compiling Query Expression Trees to Improve Performance 172
Mocking Collections for Testing LINQ to SQL and LINQ to Entities Projects 176
Creating Mock Object Classes and Initializers 177
Creating Object Graphs with GroupJoin Expressions 182
Summary 187

Part III: Applying Domain-Specific LINQ Implementations

LINQ to SQL 191
LINQ to DataSet 193
LINQ to XML 193

Chapter 5: Using LINQ to SQL and the LinqDataSource 195

Object/Relational Mapping with LINQ to SQL 197
Mapping Tables to Entity Sets with the LINQ to SQL O/R Designer 197
Generating Partial Entity Classes and Mapping Fileswith SqlMetal.exe 200
Working with *.dbml and *.xml Mapping Files 203
Editing *.dbml Files in the Designer 203
Editing *.xml Mapping Files in an XML Editor 205
Examining the Generated Classes 206
Instantiating the DataContext and Its Object Graph 210
Using LINQ to SQL as a Data Access Layer 212
The LINQ to SQL Query Pipeline 212
Adding, Updating, and Removing Objects 215
Detecting and Resolving Concurrency Conflicts 219
Substituting Stored Procedures for Dynamic SQL 222
Using a SELECT Stored Procedure to Return an ISingleResult<TEntity> 223
Using INSERT, UPDATE, and DELETE Stored Procedures 224
Moving the LINQ to SQL Layer to a Middle Tier 225
ASP.NET Databinding with the LinqDataSource Control 226
Adding a LinqDataSource to a Page 226
Substituting EntityRef for ForeignKey Values in Databound Web Controls 228
Eager-Loading EntityRef Values to Reduce Database Server Traffic 231
Databinding Windows Form Controls to Entities 233
Autogenerating the Obligatory Hierarchical Data Editing Form 233
Persisting Entity Edits and Collection Modifications 236
Adding Members to a Collection with a Surrogate, Autoincrementing Primary Key 237
Deleting Members with a Dependent EntitySet from a Collection 238
Summary 242

Chapter 6: Querying DataTables with LINQ to DataSet 243

Comparing DataSets and DataContexts 244
Exploring LINQ to DataSet Features 246
Running Read-Only LINQ to DataSet Queries 247
Querying Untyped DataSets 248
Customizing Lookup Lists 253
Querying Typed DataSets 254
Creating LinqDataViews for DataBinding with AsDataView() 257
Copying LINQ Query Results to DataTables 260
Copying Typed DataRows 262
Processing Anonymous Types from Projections 263
Summary 266

Chapter 7: Manipulating Documents with LINQ to XML 267

Integrating XML into the CLR 267
Minimizing XML/Object Mismatch with Xen 268
Querying XML with Cω 269
The System.Xml.Linq Namespace 269
Querying Basic XML Infosets 271
Inferring a Schema and Enabling IntelliSense for VB Queries 273
Taking Advantage of VB 9.0 Axis Properties 275
Implicit versus Explicit Typing of Element and Attribute Content 276
Composing XML Infosets 278
Using Functional Construction with C# 3.0 280
Using Literal XML Construction with VB 9.0 284
Grouping Elements and Aggregating Numeric Values of Business Documents 288
Using GroupJoin to Produce Hierarchical Documents 289
Taking Advantage of 1:Many and Many:1 Associations 290
Aggregating Order_Details and Orders Subtotals per Customer 292
Working with XML Namespaces and Local Names 295
XML Namespaces in C# 3.0 297
Namespaces in C# LINQ to XML Queries 297
Removing Expanded Namespaces from C# Queries 298
Functionally Constructing C# XDocuments with Multiple Namespaces 300
XML Namespaces in VB 9.0 302
Enabling IntelliSense for Namespaces 302
Multiple Namespaces in XML Literal Queries 304
Transforming Documents That Have Multiple Namespaces, with Literal XML Code 306
Performing Heterogeneous Joins and Lookup Operations 308
Using Lookup Operations to Add Child Element Groups 308

Joining Documents to Insert Elements 312
Joining Documents and LINQ to SQL or LINQ to Object Entities 314
Summary 316

Chapter 8: Exploring Third-Party and Emerging LINQ Implementations 317

Emerging Microsoft LINQ Implementations 318
Parallel LINQ 318
Programming with PLINQ 319
Processing Queries 321
Running the PLINQ Samples 322
LINQ to REST 325
Adopting URIs as a Query Language 328
Running the Sample Northwind.svc WCF Service and Client Projects 329
Processing Services Requests with the NwindServicesClient 336
LINQ to XSD 340
LINQ to XSD's History 341
LINQ to Stored XML 341
Third-Party Domain-Specific LINQ Implementations 342
LINQ to Active Directory 342
LINQ to SharePoint 344
Summary 349

Part IV: Introducing the ADO.NET Entity Framework

A Brief History of Entity Framework's Development 353
Entity Framework's Future 354
The ADO.NET Entity Framework Vote of No Confidence 355

Chapter 9: Raising the Level of Data Abstraction with the Entity Data Model 357

Understanding the Entity-Relationship Model 359
Entity-Relationship and EDM Terminology 360
Entity-Relationship Diagrams 361
Comprehending Entity Framework Architecture and Components 363
Mapping from the Physical to the Conceptual Layer with the EDM Designer 365
Creating the XML Mapping Files and Object Layer Class File with the EDM Wizard 365
Adding, Updating, and Deleting the Model's Objects 367
Editing EntityType and AssociationSet Properties 368
Analyzing the **ModelName**.edmx File's Sections 370
Scanning the StorageModels Group 370

Examining the ConceptualModels Group 371
Tracing the Mappings Group 373
Working with the Entity Client, Entity SQL and Client Views 375
Writing EntityQueries in Entity SQL 376
Executing Entity SQL Queries as Client Views 376
Taking Advantage of Object Services 381
Working with ObjectContext 382
Creating an Object Context and ObjectQuery 382
MetadataWorkspace 383
ObjectStateManager 384
Writing ObjectQueries with Entity SQL 384
Composing ObjectQueries with Query Builder Methods 387
Using the LINQ to Entities Provider 388
Understanding the Persistence Ignorance Controversy 390
Summary 391

Chapter 10: Defining Storage, Conceptual, and Mapping Layers 393

Exploring and Customizing the EDMX File 395
Storage Models (SSDL Content) 397
The EntityContainer Subgroup 398
EntityType Subgroups 400
The Product EntityType Subgroup 402
Function Subelements and Subgroups 402
Association Subgroups 409
Conceptual Models (CSDL Content) 411
The EntityContainer Subgroup 411
The EntityType Subgroup 413
The Association Subgroup 414
Mapping (MSL Content) 414
The EntitySetMapping Subgroup 415
The AssociationSetMapping Subgroup 417
The FunctionImportMapping Element 418
Implementing Table-per-Hierarchy Inheritance 419
Specifying the Discriminator Column and Creating a Derived Class 419
Querying Base and Derived Classes 421
Incorrect Results from is, Is, TypeOf, and OfType() Operators 423
Type Discrimination in Entity SQL Queries 424
Disambiguate Derived Object Types with an Abstract Base Type 425
Traversing the MetadataWorkspace 427
Summary 431

Chapter 11: Introducing Entity SQL 433

Using the eSqlBlast Entity SQL Query Utility 434
Connection Page 434
Model Page 435
Query Page 436
Result Page 437
Understanding How Entity SQL Differs from Transact-SQL 439
Entity Alias Prefixes Are Mandatory 440
Explicit Projections Are Required 441
The VALUE Modifier Flattens Results 441
Dot-Notation Syntax Returns Many:One Navigation Properties 442
Nested Queries Are Required for One:Many Navigation Properties 444
JOINs Are the Last Resort 445
NAVIGATE Is a Complex Substitute for Dot Notation or Nested Queries 445
REF, DEREF, CREATEREF, ROW, and KEY Manage Entity References 446
Type Constructors Create ROWs, Multisets, and Instances of EntityTypes 449
The UNION, INTERSECT, OVERLAPS, and EXCEPT Set Operators Require Sub-Queries 450
Sorting Collections Returned by Set Operators Requires a Nested Query 451
Set Operators ANYELEMENT and FLATTEN Work on Collections 452
SKIP and LIMIT Sub-Clauses of the ORDER BY Clause Handle Paging 452
IS OF, OFTYPE, and TREAT Are Type Operators for Polymorphic Queries 453
Subqueries That Return Aggregate Values for WHERE Clause Constraints Throw Exceptions 454
Executing eSQL Queries against the EntityClient 455
Parsing the IExtendedDataRecord from an EntityDataReader 456
Measuring the Performance Penalty of EntitySQL Queries 459
Executing Parameterized eSQL Queries 460
Using SQL Server Compact as an Entity Framework Data Store 461
Substituting SSCE for SQL Server [Express] as a Data Store 462
Summary 463

Part V: Implementing the ADO.NET Entity Framework

Entity Framework vs. LINQ to SQL 466
Entity Framework Futures 467

Chapter 12: Taking Advantage of Object Services and LINQ to Entities 469

Exploring the Generated Entity Classes 470
ModelNameEntities Partial Classes 471
EntityName Partial Classes 472

Entity Class Serialization 477
Serialization with Deferred-Loaded Associated Entities 478
Serialization with Eager-Loaded Associated Entities 478
Executing eSQL ObjectQueries 480
Enabling Deferred or Eager Loading of Associated Entities 483
Deferred Loading with the Load() Method 484
Eager Loading with Include() Operators 485
Ordering and Filtering Associated EntityCollections during Loading 489
Composing Query Builder Methods to Write ObjectQueries 491
Writing LINQ to Entities Queries 493
Unsupported LINQ Keywords, Standard Query Operators, and Overloads 494
Conventional LINQ to Entities Queries 494
Using the Include() Operator with LINQ to Entities Queries 495
Compiling LINQ to Entity Queries 497
Comparing the Performance of LINQ to Entities Queries 499
Parameterizing Object Queries 500
Summary 500

Chapter 13: Updating Entities and Complex Types 503

Understanding the ObjectContext's ObjectStateManager and Its Children 503
Updating or Deleting Entities 505
Persisting Changes to the Data Store 506
Logging Entities' State 506
Deleting Selected Entities 507
Updating Associated EntitySets or EntityObjects 507
Deleting Entities with Dependent Associated Entities 508
Transacting Updates and Deletions 508
Adding Entities 509
Refreshing Stale Entities 509
Validating Data Additions and Updates 510
Optimizing the ObjectContext Lifetime 513
Comparing the Performance of LINQ to Entities and Out-of-Band SQL Updates 514
Managing Optimistic Concurrency Conflicts 515
Enabling Optimistic Concurrency Management for Entity Properties 516
Implementing Optimistic Concurrency Management with Code 517
Performing CRUD Operations with Stored Procedures 521
Creating the Initial Data Model 521
Adding FunctionImports to Populate the EntitySets 522
Assigning Insert, Update and Delete Stored Procedures to Entities 524
Using a Stored Procedure to Insert a New Entity Instance 524
Updating an Entity Instance and Managing Concurrency with Original Values 525

Updating an Entity Instance and Managing Concurrency with a Timestamp Property 527
Deleting Entity Instances with Stored Procedures 528
Working with Complex Types 528
Modeling a Complex Type 529
Modifying the CSDL Section 529
Modifying the MSL Section 530
Reusing a ComplexType Definition 530
Summary 532

Chapter 14: Binding Entities to Data-Aware Controls 533

Binding Windows Form Controls to Entities with Object Data Sources 534
Using the Load(), Include(), and Attach() Methods for Shaping Object Graphs 535
Deferred Loading of Associated Objects with the Load() Method 537
Eager Loading of Multiple Associated Objects with the Include() Method 538
Deferred Loading of Associated Objects with the Attach() Method 539
Selecting the Active Top-Level and Associated Entity Instances 540
Using Unbound ComboBoxes to Specify Associations 543
Adding Event Handlers for ComboBoxColumns 543
Updating Association Sets with the SelectedIndexChanged Event Handler 545
Setting Composite Primary-Key Members with Combo Boxes 546
Detecting Attempts to Change Composite Primary-Key Values 546
Enforcing Object Deletion and Addition Operations for Updates 549
Selecting and Adding a New EntityObject and AssociationSets 551
Persisting Changes to the Data Store 553
Using the EntityDataSource with ASP.NET Server Controls 554
Adding an EntityDataSource Control to an ASP.NET Web Application Page 555
Exploring the Entity Datasource 557
EntityDataSource Properties 557
Where and Group By Clauses 559
EntityDataSource Events 561
Binding and Formatting a GridView Control 562
Using the GroupBy Property and a Drop-Down List to Display Customers by Country 563
Adding a Linked DetailsView 564
Summary 565

Chapter 15: Using the Entity Framework as a Data Source 567

Creating an ADO.NET Data Services Data Source 568
Understanding REST Architecture 570
Creating a Simple Web Service and Consuming It in a Browser 571
Navigating Collections and their Members 573

Taking Advantage of Query String Options 576
Invoking Service Operations 580
Consuming ADO.NET Data Services with the .NET 3.5 Client Library 581
Executing Queries from Windows Form Clients 583
Executing a Query-String URI from a Client 583
Executing a DataServiceQuery 585
Executing LINQ to REST Queries 586
Returning Associated Entities 587
Executing Batch Queries with DataServiceRequests 589
Changing EntitySets with URI Queries and DataService.SaveChanges() 592
Adding New Entities 592
Updating Entities 594
Deleting Entities 596
Managing Optimistic Concurrency Conflicts 597
Batching Changes 597
Consuming ADO.NET Data Services with the AJAX Client Library 598
Becoming Familiar with JavaScript Object Notation 598
Creating an AJAX Test Client for Astoria 599
Adding, Editing, and Removing Entities 602
Summary 604

Index 607