For Mahnaz Javid and for her work with the Mona Foundation, which she leads

—Lynn Langit, author
Contents at a Glance

Part I  Business Intelligence for Business Decision Makers and Architects
1  Business Intelligence Basics .................................................. 3
2  Visualizing Business Intelligence Results ................................. 27
3  Building Effective Business Intelligence Processes .................... 61
4  Physical Architecture in Business Intelligence Solutions ............. 85
5  Logical OLAP Design Concepts for Architects ......................... 115

Part II  Microsoft SQL Server 2008 Analysis Services for Developers
6  Understanding SSAS in SSMS and SQL Server Profiler ............... 153
7  Designing OLAP Cubes Using BIDS ......................................... 183
8  Refining Cubes and Dimensions .............................................. 225
9  Processing Cubes and Dimensions ........................................... 257
10  Introduction to MDX .......................................................... 293
11  Advanced MDX ............................................................... 329
12  Understanding Data Mining Structures ................................... 355
13  Implementing Data Mining Structures ..................................... 399

Part III  Microsoft SQL Server 2008 Integration Services for Developers
14  Architectural Components of Microsoft SQL Server 2008 Integration Services ......................................................... 435
15  Creating Microsoft SQL Server 2008 Integration Services Packages with Business Intelligence Development Studio .... 463
16  Advanced Features in Microsoft SQL Server 2008 Integration Services ................................................................. 497
17  Microsoft SQL Server 2008 Integration Services Packages in Business Intelligence Solutions ............................................. 515
Contents at a Glance

18 Deploying and Managing Solutions in Microsoft SQL Server 2008 Integration Services ........................................ 539
19 Extending and Integrating SQL Server 2008 Integration Services ................................................................. 567

Part IV Microsoft SQL Server Reporting Services and Other Client Interfaces for Business Intelligence

20 Creating Reports in SQL Server 2008 Reporting Services .......... 603
21 Building Reports for SQL Server 2008 Reporting Services .... 627
22 Advanced SQL Server 2008 Reporting Services ..................... 647
23 Using Microsoft Excel 2007 as an OLAP Cube Client .............. 671
24 Microsoft Office 2007 as a Data Mining Client .................... 687
25 SQL Server Business Intelligence and Microsoft Office SharePoint Server 2007 ..................................................... 723
# Table of Contents

Foreword ................................................................. xix
Acknowledgments ......................................................... xxi
Introduction .............................................................. xxiii

## Part I  Business Intelligence for Business Decision Makers and Architects

1  **Business Intelligence Basics** ........................................ 3
   - Business Intelligence and Data Modeling ......................... 3
   - OLTP and OLAP .......................................................... 5
     - Online Transactional Processing .................................. 5
     - Online Analytical Processing ...................................... 8
   - Common BI Terminology ........................................... 11
     - Data Warehouses ................................................... 11
     - Data Marts ............................................................ 13
     - Cubes .................................................................. 13
     - Decision Support Systems ......................................... 13
     - Data Mining Systems ................................................. 14
     - Extract, Transform, and Load Systems ......................... 14
     - Report Processing Systems ......................................... 15
     - Key Performance Indicators ........................................ 15
   - Core Components of a Microsoft BI Solution .................... 16
     - SQL Server 2008 Analysis Services ............................... 16
     - SQL Server 2008 Reporting Services ............................. 19
     - SQL Server 2008 ....................................................... 19
     - SQL Server 2008 Integration Services ........................... 20
   - Optional Components of a Microsoft BI Solution ............... 21
   - Query Languages Used in BI Solutions ........................... 23
     - MDX ................................................................. 23
     - DMX ................................................................. 24
# Table of Contents

XMLA ................................................................. 24
RDL ................................................................. 24
Summary .......................................................... 25

## 2 Visualizing Business Intelligence Results ............................... 27
- Matching Business Cases to BI Solutions .................................. 27
  - Top 10 BI Scoping Questions .................................................. 30
  - Components of BI Solutions ................................................... 31
- Understanding Business Intelligence from a User’s Perspective ....... 34
  - Demonstrating the Power of BI Using Excel 2007 ...................... 36
  - Understanding Data Mining via the Excel Add-ins ..................... 45
  - Viewing Data Mining Structures Using Excel 2007 .................... 47
- Elements of a Complete BI Solution .......................................... 50
  - Reporting—Deciding Who Will Use the Solution ....................... 51
  - ETL—Getting the Solution Implemented ................................... 52
  - Data Mining—Don’t Leave It Out ............................................ 53
- Common Business Challenges and BI Solutions ............................ 54
- Measuring the ROI of BI Solutions ............................................ 56
- Summary .............................................................................. 58

## 3 Building Effective Business Intelligence Processes .................. 61
- Software Development Life Cycle for BI Projects ......................... 61
  - Microsoft Solutions Framework .............................................. 62
  - Microsoft Solutions Framework for Agile Software Development ... 63
  - Applying MSF to BI Projects .................................................. 65
- Phases and Deliverables in the Microsoft Solutions Framework ....... 65
- Skills Necessary for BI Projects ............................................... 72
  - Required Skills ..................................................................... 72
  - Optional Skills ...................................................................... 74
- Forming Your Team ................................................................... 76
  - Roles and Responsibilities Needed When Working with MSF ........ 76
- Summary ................................................................................. 84

## 4 Physical Architecture in Business Intelligence Solutions .......... 85
- Planning for Physical Infrastructure Change .................................. 85
  - Creating Accurate Baseline Surveys .......................................... 85
  - Assessing Current Service Level Agreements ............................ 87
  - Determining the Optimal Number and Placement of Servers ....... 89
  - Considerations for Physical Servers ......................................... 91
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Logical OLAP Design Concepts for Architects</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>Designing Basic OLAP Cubes</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td>Star Schemas</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Denormalization</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Back to the Star</td>
<td>125</td>
</tr>
<tr>
<td></td>
<td>Other Design Tips</td>
<td>132</td>
</tr>
<tr>
<td></td>
<td>Modeling Snowflake Dimensions</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>More About Dimensional Modeling</td>
<td>138</td>
</tr>
<tr>
<td></td>
<td>Understanding Fact (Measure) Modeling</td>
<td>146</td>
</tr>
<tr>
<td></td>
<td>Other Considerations in BI Modeling</td>
<td>148</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>150</td>
</tr>
<tr>
<td>Part II</td>
<td>Microsoft SQL Server 2008 Analysis Services for Developers</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Understanding SSAS in SSMS and SQL Server Profiler</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>Core Tools in SQL Server Analysis Services</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>Baseline Service Configuration</td>
<td>157</td>
</tr>
<tr>
<td></td>
<td>SSAS in SSMS</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>How Do You Query SSAS Objects?</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Using MDX Templates</td>
<td>175</td>
</tr>
<tr>
<td></td>
<td>Using DMX Templates</td>
<td>179</td>
</tr>
<tr>
<td></td>
<td>Using XMLA Templates</td>
<td>180</td>
</tr>
<tr>
<td></td>
<td>Closing Thoughts on SSMS</td>
<td>181</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>182</td>
</tr>
</tbody>
</table>
### 9 Processing Cubes and Dimensions ......................................................... 257
* Building, Processing, and Deploying OLAP Cubes .................................. 257
  * Differentiating Data and Metadata .................................................. 258
  * Working in a Disconnected Environment ......................................... 259
  * Working in a Connected Environment ............................................. 261
  * Understanding Aggregations ....................................................... 261
* Partitioning ......................................................................................... 263
  * Choosing Storage Modes: MOLAP, HOLAP, and ROLAP ..................... 267
  * OLTP Table Partitioning ............................................................... 268
  * Other OLAP Partition Configurations ............................................. 270
* Implementing Aggregations ............................................................... 270
  * Aggregation Design Wizard ......................................................... 271
  * Usage-Based Optimization Wizard ............................................... 274
  * SQL Server Profiler ...................................................................... 275
  * Aggregation Designer: Advanced View ........................................... 277
* Implementing Advanced Storage with MOLAP, HOLAP, or ROLAP ........ 278
* Proactive Caching ............................................................................... 279
  * Notification Settings for Proactive Caching .................................... 282
  * Fine-Tuning Proactive Caching ....................................................... 283
  * ROLAP Dimensions ...................................................................... 284
* Linking ................................................................................................. 285
* Writeback ............................................................................................. 285
* Cube and Dimension Processing Options .......................................... 287
* Summary ............................................................................................... 292

### 10 Introduction to MDX ................................................................. 293
* The Importance of MDX .................................................................. 293
* Writing Your First MDX Queries ..................................................... 295
  * MDX Object Names ....................................................................... 296
  * Other Elements of MDX Syntax .................................................... 296
* MDX Core Functions ......................................................................... 299
* Filtering MDX Result Sets ............................................................... 306
* Calculated Members and Named Sets .............................................. 307
  * Creating Objects by Using Scripts ................................................ 309
* The TopCount Function ................................................................. 310
* Rank Function and Combinations ................................................... 312
* Head and Tail Functions .................................................................. 315
* Hierarchical Functions in MDX ....................................................... 316
Table of Contents

Date Functions ................................................................. 321
Using Aggregation with Date Functions ................................. 324
About Query Optimization .................................................... 326
Summary .................................................................................. 327

11 Advanced MDX ............................................................... 329
Querying Dimension Properties ............................................. 329
Looking at Date Dimensions and MDX Seasonality .................. 332
Creating Permanent Calculated Members ............................... 333
Creating Permanent Calculated Members in BIDS .................... 334
Creating Calculated Members Using MDX Scripts .................... 335
Using IIf ................................................................................. 337
About Named Sets ................................................................. 338
About Scripts ......................................................................... 341
Understanding SOLVE_ORDER ............................................. 343
Creating Key Performance Indicators ..................................... 345
Creating KPIs Programmatically ............................................ 348
Additional Tips on KPIs ....................................................... 348
Using MDX with SSRS and PerformancePoint Server .............. 349
Using MDX with SSRS 2008 .................................................. 349
Using MDX with PerformancePoint Server 2007 .................... 352
Summary .................................................................................. 354

12 Understanding Data Mining Structures ............................... 355
Reviewing Business Scenarios ................................................. 355
Categories of Data Mining Algorithms ..................................... 358
Working in the BIDS Data Mining Interface ............................. 360
Understanding Data Types and Content Types ......................... 361
Setting Advanced Data Properties ......................................... 363
Choosing a Data Mining Model .............................................. 365
Picking the Best Mining Model Viewer ..................................... 368
Mining Accuracy Charts and Prediction ................................. 373
Data Mining Algorithms ......................................................... 376
Microsoft Naïve Bayes .......................................................... 376
Microsoft Decision Trees Algorithm ...................................... 381
Microsoft Linear Regression Algorithm .................................. 383
Microsoft Time Series Algorithm ......................................... 383
Microsoft Clustering Algorithm ............................................. 386
Microsoft Sequence Clustering .............................................. 389
Microsoft Association Algorithm ......................................... 391
<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microsoft Neural Network Algorithm</td>
<td>394</td>
</tr>
<tr>
<td>Microsoft Logistic Regression</td>
<td>395</td>
</tr>
<tr>
<td>The Art of Data Mining</td>
<td>396</td>
</tr>
<tr>
<td>Summary</td>
<td>396</td>
</tr>
<tr>
<td><strong>13 Implementing Data Mining Structures</strong></td>
<td>399</td>
</tr>
<tr>
<td>Implementing the CRISP-DM Life Cycle Model</td>
<td>399</td>
</tr>
<tr>
<td>Building Data Mining Structures Using BIDS</td>
<td>401</td>
</tr>
<tr>
<td>Adding Data Mining Models Using BIDS</td>
<td>404</td>
</tr>
<tr>
<td>Processing Mining Models</td>
<td>407</td>
</tr>
<tr>
<td>Validating Mining Models</td>
<td>409</td>
</tr>
<tr>
<td>Lift Charts</td>
<td>410</td>
</tr>
<tr>
<td>Profit Charts</td>
<td>413</td>
</tr>
<tr>
<td>Classification Matrix</td>
<td>415</td>
</tr>
<tr>
<td>Cross Validation</td>
<td>417</td>
</tr>
<tr>
<td>Data Mining Prediction Queries</td>
<td>419</td>
</tr>
<tr>
<td>DMX Prediction Queries</td>
<td>421</td>
</tr>
<tr>
<td>DMX Prediction Functions</td>
<td>423</td>
</tr>
<tr>
<td>Data Mining and Integration Services</td>
<td>426</td>
</tr>
<tr>
<td>Data Mining Object Processing</td>
<td>429</td>
</tr>
<tr>
<td>Data Mining Clients</td>
<td>431</td>
</tr>
<tr>
<td>Summary</td>
<td>432</td>
</tr>
</tbody>
</table>

**Part III Microsoft SQL Server 2008 Integration Services for Developers**

<table>
<thead>
<tr>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>14 Architectural Components of Microsoft SQL Server 2008 Integration Services</strong></td>
<td>435</td>
</tr>
<tr>
<td>Overview of Integration Services Architecture</td>
<td>436</td>
</tr>
<tr>
<td>Integration Services Packages</td>
<td>438</td>
</tr>
<tr>
<td>Tools and Utilities for Developing, Deploying, and Executing Integration Services Packages</td>
<td>438</td>
</tr>
<tr>
<td>The Integration Services Object Model and Components</td>
<td>442</td>
</tr>
<tr>
<td>Control Flow</td>
<td>442</td>
</tr>
<tr>
<td>Data Flow</td>
<td>444</td>
</tr>
<tr>
<td>Variables</td>
<td>445</td>
</tr>
<tr>
<td>Expressions</td>
<td>447</td>
</tr>
<tr>
<td>Connection Managers</td>
<td>448</td>
</tr>
<tr>
<td>Event Handlers and Error Handling</td>
<td>450</td>
</tr>
</tbody>
</table>
The Integration Services Runtime .............................................. 452
The Integration Services Data Flow Engine .............................. 453
  Data Flow Buffers ..................................................... 454
  Synchronous Data Flow Outputs .................................... 458
  Asynchronous Data Flow Outputs .................................... 459
Log Providers ....................................................................... 459
Deploying Integration Services Packages ............................... 460
  Package Configurations .................................................. 461
  Package Deployment Options .......................................... 461
Summary ............................................................................ 462

15 Creating Microsoft SQL Server 2008 Integration Services Packages with Business Intelligence Development Studio . . . 463
Integration Services in Visual Studio 2008 .............................. 463
  Creating New SSIS Projects with the Integration Services
  Project Template ............................................................ 464
  Viewing an SSIS Project in Solution Explorer ..................... 466
  Using the SSIS Package Designers ................................... 467
  Working with the SSIS Toolbox ........................................ 469
  Choosing from the SSIS Menu ......................................... 472
Connection Managers ......................................................... 473
  Standard Database Connection Managers ....................... 473
  Other Types of Connection Managers ............................... 474
Control Flow ........................................................................ 474
  Control Flow Tasks ...................................................... 476
  Control Flow Containers ............................................... 478
  Precedence Constraints .................................................. 480
Data Flow ............................................................................ 482
  Data Flow Source Components ....................................... 483
  Destination Components ............................................... 485
  Transformation Components ......................................... 486
  Integration Services Data Viewers .................................... 488
Variables ............................................................................ 490
  Variables Window .......................................................... 490
  Variable Properties ....................................................... 491
  System Variables ........................................................... 493
Expressions ......................................................................... 493
  Variables and Default Values Within a Package .................. 494
Summary ............................................................................ 495
# Table of Contents

## 16 Advanced Features in Microsoft SQL Server 2008 Integration Services

- Error Handling in Integration Services ........................................... 497
- Events, Logs, Debugging, and Transactions in SSIS .......................... 499
- Logging and Events ..................................................................... 501
- Debugging Integration Services Packages ..................................... 505
- Checkpoints and Transactions ....................................................... 506
  - Configuring Package Transactions ............................................. 507
- Best Practices for Designing Integration Services Packages .............. 509
- Data Profiling .......................................................................... 510
- Summary ................................................................................... 514

## 17 Microsoft SQL Server 2008 Integration Services Packages in Business Intelligence Solutions

- ETL for Business Intelligence ......................................................... 515
- Loading OLAP Cubes .................................................................. 516
  - Using Integration Services to Check Data Quality ....................... 516
  - Transforming Source Data ....................................................... 519
  - Using a Staging Server ............................................................ 520
  - Data Lineage ........................................................................... 524
- Moving to Star Schema Loading .................................................... 525
  - Loading Dimension Tables ....................................................... 525
  - Loading Fact Tables .................................................................. 527
- Updates ....................................................................................... 530
  - Fact Table Updates .................................................................. 532
  - Dimension Table Updates ........................................................ 532
- ETL for Data Mining ................................................................. 533
  - Initial Loading ........................................................................... 533
  - Model Training ......................................................................... 534
  - Data Mining Queries ................................................................. 535
- Summary ....................................................................................... 538

## 18 Deploying and Managing Solutions in Microsoft SQL Server 2008 Integration Services

- Solution and Project Structures in Integration Services ...................... 539
- Source Code Control .................................................................... 540
  - Using Visual SourceSafe ........................................................... 541
- The Deployment Challenge ........................................................... 546
- Package Configurations ................................................................. 548
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Copy File Deployment</td>
<td>552</td>
</tr>
<tr>
<td></td>
<td>BIDS Deployment</td>
<td>553</td>
</tr>
<tr>
<td></td>
<td>Deployment with the Deployment Utility</td>
<td>556</td>
</tr>
<tr>
<td></td>
<td>SQL Server Agent and Integration Services</td>
<td>558</td>
</tr>
<tr>
<td></td>
<td>Introduction to SSIS Package Security</td>
<td>559</td>
</tr>
<tr>
<td></td>
<td>Handling Sensitive Data and Proxy Execution Accounts</td>
<td>563</td>
</tr>
<tr>
<td></td>
<td>Security: The Two Rules</td>
<td>564</td>
</tr>
<tr>
<td></td>
<td>The SSIS Service</td>
<td>564</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>565</td>
</tr>
<tr>
<td>19</td>
<td>Extending and Integrating SQL Server 2008</td>
<td>567</td>
</tr>
<tr>
<td></td>
<td>Integration Services</td>
<td>567</td>
</tr>
<tr>
<td></td>
<td>Introduction to SSIS Scripting</td>
<td>567</td>
</tr>
<tr>
<td></td>
<td>Visual Studio Tools for Applications</td>
<td>568</td>
</tr>
<tr>
<td></td>
<td>The Script Task</td>
<td>568</td>
</tr>
<tr>
<td></td>
<td>The Dts Object</td>
<td>571</td>
</tr>
<tr>
<td></td>
<td>Debugging Script Tasks</td>
<td>572</td>
</tr>
<tr>
<td></td>
<td>The Script Component</td>
<td>573</td>
</tr>
<tr>
<td></td>
<td>The ComponentMetaData Property</td>
<td>580</td>
</tr>
<tr>
<td></td>
<td>Source, Transformation, and Destination</td>
<td>582</td>
</tr>
<tr>
<td></td>
<td>Debugging Script Components</td>
<td>587</td>
</tr>
<tr>
<td></td>
<td>Overview of Custom SSIS Task and Component Development</td>
<td>587</td>
</tr>
<tr>
<td></td>
<td>Control Flow Tasks</td>
<td>591</td>
</tr>
<tr>
<td></td>
<td>Data Flow Components</td>
<td>593</td>
</tr>
<tr>
<td></td>
<td>Other Components</td>
<td>594</td>
</tr>
<tr>
<td></td>
<td>Overview of SSIS Integration in Custom Applications</td>
<td>596</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>600</td>
</tr>
<tr>
<td>Part IV</td>
<td>Microsoft SQL Server Reporting Services and Other</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Client Interfaces for Business Intelligence</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Creating Reports in SQL Server 2008 Reporting Services</td>
<td>603</td>
</tr>
<tr>
<td></td>
<td>Understanding the Architecture of Reporting Services</td>
<td>603</td>
</tr>
<tr>
<td></td>
<td>Installing and Configuring Reporting Services</td>
<td>606</td>
</tr>
<tr>
<td></td>
<td>HTTP Listener</td>
<td>608</td>
</tr>
<tr>
<td></td>
<td>Report Manager</td>
<td>609</td>
</tr>
<tr>
<td></td>
<td>Report Server Web Service.</td>
<td>609</td>
</tr>
<tr>
<td></td>
<td>Authentication</td>
<td>610</td>
</tr>
<tr>
<td></td>
<td>Background Processing (Job Manager)</td>
<td>612</td>
</tr>
<tr>
<td>Chapter</td>
<td>Section</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>21</td>
<td>Creating Reports with BIDS</td>
<td>612</td>
</tr>
<tr>
<td></td>
<td>Other Types of Reports</td>
<td>621</td>
</tr>
<tr>
<td></td>
<td>Sample Reports</td>
<td>622</td>
</tr>
<tr>
<td></td>
<td>Deploying Reports</td>
<td>623</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>625</td>
</tr>
<tr>
<td>21</td>
<td>Building Reports for SQL Server 2008 Reporting Services</td>
<td>627</td>
</tr>
<tr>
<td></td>
<td>Using the Query Designers for Analysis Services</td>
<td>627</td>
</tr>
<tr>
<td></td>
<td>MDX Query Designer</td>
<td>628</td>
</tr>
<tr>
<td></td>
<td>Setting Parameters in Your Query</td>
<td>631</td>
</tr>
<tr>
<td></td>
<td>DMX Query Designer</td>
<td>633</td>
</tr>
<tr>
<td></td>
<td>Working with the Report Designer in BIDS</td>
<td>635</td>
</tr>
<tr>
<td></td>
<td>Understanding Report Items</td>
<td>638</td>
</tr>
<tr>
<td></td>
<td>List and Rectangle Report Items</td>
<td>639</td>
</tr>
<tr>
<td></td>
<td>Tablix Data Region</td>
<td>639</td>
</tr>
<tr>
<td></td>
<td>Using Report Builder</td>
<td>643</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>646</td>
</tr>
<tr>
<td>22</td>
<td>Advanced SQL Server 2008 Reporting Services</td>
<td>647</td>
</tr>
<tr>
<td></td>
<td>Adding Custom Code to SSRS Reports</td>
<td>647</td>
</tr>
<tr>
<td></td>
<td>Viewing Reports in Word or Excel 2007</td>
<td>649</td>
</tr>
<tr>
<td></td>
<td>URL Access</td>
<td>651</td>
</tr>
<tr>
<td></td>
<td>Embedding Custom ReportViewer Controls</td>
<td>652</td>
</tr>
<tr>
<td></td>
<td>About Report Parameters</td>
<td>656</td>
</tr>
<tr>
<td></td>
<td>About Security Credentials</td>
<td>657</td>
</tr>
<tr>
<td></td>
<td>About the SOAP API</td>
<td>658</td>
</tr>
<tr>
<td></td>
<td>What Happened to Report Models?</td>
<td>660</td>
</tr>
<tr>
<td></td>
<td>Deployment—Scalability and Security</td>
<td>662</td>
</tr>
<tr>
<td></td>
<td>Performance and Scalability</td>
<td>663</td>
</tr>
<tr>
<td></td>
<td>Advanced Memory Management</td>
<td>665</td>
</tr>
<tr>
<td></td>
<td>Scaling Out</td>
<td>666</td>
</tr>
<tr>
<td></td>
<td>Administrative Scripting</td>
<td>667</td>
</tr>
<tr>
<td></td>
<td>Using WMI</td>
<td>668</td>
</tr>
<tr>
<td></td>
<td>Summary</td>
<td>669</td>
</tr>
<tr>
<td>23</td>
<td>Using Microsoft Excel 2007 as an OLAP Cube Client</td>
<td>671</td>
</tr>
<tr>
<td></td>
<td>Using the Data Connection Wizard</td>
<td>671</td>
</tr>
<tr>
<td></td>
<td>Working with the Import Data Dialog Box</td>
<td>674</td>
</tr>
<tr>
<td></td>
<td>Understanding the PivotTable Interface</td>
<td>675</td>
</tr>
<tr>
<td></td>
<td>Creating a Sample PivotTable</td>
<td>678</td>
</tr>
</tbody>
</table>
Table of Contents

24 Microsoft Office 2007 as a Data Mining Client ............... 687
   Installing Data Mining Add-ins ........................................ 687
   Data Mining Integration with Excel 2007 .............................. 689
      Using the Table Analysis Tools Group ............................. 690
      Using the Data Mining Tab in Excel 2007 ......................... 700
   Data Mining Integration in Visio 2007 .................................. 714
   Client Visualization ....................................................... 718
   Data Mining in the Cloud .................................................. 720
   Summary ............................................................................. 721

25 SQL Server Business Intelligence and Microsoft Office
   SharePoint Server 2007 ....................................................... 723
   Excel Services ................................................................. 723
      Basic Architecture of Excel Services ............................. 724
      Immutability of Excel Sheets ..................................... 726
   Introductory Sample Excel Services Worksheet .................. 726
   Publishing Parameterized Excel Sheets ............................. 729
   Excel Services: The Web Services API .............................. 732
      A Real-World Excel Services Example ............................. 733
   SQL Server Reporting Services with Office SharePoint Server 2007 ....... 736
      Configuring SQL Server Reporting Services
         with Office SharePoint Server 2007 ......................... 737
      Authoring and Deploying a Report .............................. 738
      Using the Report in Office SharePoint Server 2007: Native Mode ... 740
      Using the Report in Office SharePoint Server 2007:
         SharePoint Integrated Mode ...................................... 742
      Using the Report Center Templates ............................... 744
   PerformancePoint Server .................................................. 745
   Summary ............................................................................. 745

Index .................................................................................... 747

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resources for you. To participate in a brief online survey, please visit:

www.microsoft.com/learning/booksurvey/
When Lynn Langit’s name appears in my inbox or RSS feeds, I never know what to expect—only that it will be interesting! She may be inviting me to share a technical webcast, passing pithy comments about a conference speaker, or recalling the sight of swimming elephants in Zambia, where Lynn tirelessly promotes information technology as a force for improving health care. On this occasion, it was an invitation to write a foreword for this, her latest book, *Smart Business Intelligence Solutions with Microsoft SQL Server 2008*. As so often, when Lynn asks, the only possible response is, “Of course—I’d be happy to!”

When it comes to business intelligence, Lynn is a compulsive communicator. As a Developer Evangelist at Microsoft, this is part of her job, but Lynn’s enthusiasm for the technologies and their implications goes way beyond that. Her commitment is clear in her presentations and webcasts, in her personal engagements with customers across continents, and in her writing. Thinking of this, I am more than pleased to see this new book, especially to see that it tackles the SQL Server business intelligence (BI) technologies in their broad scope.

Business intelligence is never about one technology solving one problem. In fact, a good BI solution can address many problems at many levels—tactical, strategic, and even operational. Part I, “Business Intelligence for Business Decision Makers and Architects,” explores these business scenarios.

To solve these problems, you will find that your raw data is rarely sufficient. The BI developer must apply business logic to enrich the data with analytical insights for business users. Without this additional business logic, your system may only tell the users what they already know. Part II, “Microsoft SQL Server 2008 Analysis Services for Developers,” takes a deep look at using Analysis Services to create OLAP cubes and data mining models.

By their nature, these problems often require you to integrate data from across your business. SQL Server 2008 Integration Services is the platform for this work, and in Part III, “Microsoft SQL Server 2008 Integration Services for Developers,” Lynn tackles this technology. She not only covers the details of building single workloads, but also sets this work in its important architectural context, covering management and deployment of the integration solutions.

Finally, in Part IV, “Microsoft SQL Server Reporting Services and Other Client Interfaces for Business Intelligence,” there is a detailed exploration of the options for designing and publishing reports. This section also covers other popular “clients”—the applications through which business users interact with your BI solution. So, even if you are a Microsoft Office Excel user, there is valuable information here.

When all of these elements—integration, analysis, and reporting—come together, you know you are implementing a “smart solution,” the essence of this most helpful book.
I know from my own work at Microsoft, presenting and writing about BI, how difficult it is to find good symmetry between technology and the business case. I also know how important it is. Architects may build smart technology solutions, but enterprise decision makers put the *business* into BI. For these readers, Lynn makes very few assumptions. She quickly, yet quite thoroughly, takes the reader through a basic taxonomy of the moving parts of a BI solution.

However, this book is more than a basic introduction—it gets down to the details you need to build effective solutions. Even experienced users will find useful insights and information here. For example, all OLAP developers work with Analysis Services data source views. However, many of them do not even know about the useful data preview feature. In Chapter 7, “Designing OLAP Cubes Using BIDS,” Lynn not only describes the feature, but also includes a good example of its use for simple validation and profiling. It is, for me, a good measure of a book that it finds new things to say even about the most familiar features.

For scenarios that may be less familiar to you, such as data mining, Lynn carefully sets out the business cases, the practical steps to take, and the traps to avoid. Having spent many hours teaching and evangelizing about data mining myself, I really admire how Lynn navigates through the subject. In one chapter, she starts from the highest level (“Why would I use data mining?”) to the most detailed (“What is the CLUSTERING_METHOD parameter for?”), retaining a pleasant and easy logical flow.

It is a privilege to work at Microsoft with Lynn. She clearly loves working with her customers and the community. This book captures much of her enthusiasm and knowledge in print. You will enjoy it, and I will not be surprised if you keep it close at hand on your desk whenever you work with SQL Server 2008.

*Donald Farmer*

*Principal Program Manager, US-SQL Analysis Services*

*Microsoft Corporation*
Acknowledgments

Many people contributed to making this book. The authors would like to acknowledge those people and the people who support them.

Lynn Langit

Thanks to all those who supported my efforts on this book.

First I’d like to thank my inspiration and the one who kept me going during the many months of writing this book—Mahnaz Javid—and the work of her Mona Foundation. Please prioritize caring for the world’s needy children and take the time to contribute to organizations that do a good job with this important work. A portion of the proceeds of this book will be donated to the Mona Foundation. For more information, go to http://www.monafoundation.org.

Thanks to my colleagues at Microsoft Press: Ken Jones, Sally Stickney, Maureen Zimmerman; to my Microsoft colleagues: Woody Pewitt, Glen Gordon, Mithun Dhar, Bruno Terkaly, Joey Snow, Greg Visscher, and Scott Kerfoot; and to the SQL Team: Donald Farmer, Francois Ajenstadt, and Zack Owens.

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Thanks especially to my technical reviewer, John Welch. John, I wish I hadn’t made you work so hard!

Thanks to my friends and family for understanding the demands that writing makes on my time and sanity: Lynn C, Teri, Chrys, Esther, Asli, Anton, and, most especially, to my mom and my daughter.

Davide Mauri

A very big thanks to my wife Olga, who always supports me in everything I do; and to Gianluca, Andrea, and Fernando, who allowed me to the realize one of my many dreams!

Sahil Malik

Instead of an acknowledgment, I’d like to pray for peace, harmony, wisdom, and inner happiness for everyone.
Introduction

So, why write? What is it that makes typing in a cramped airline seat on an 11-hour flight over Africa so desirable? It’s probably because of a love of reading in general, and of learning in particular. It’s not by chance that my professional blog at http://blogs.msdn.com/SoCalDevGal is titled “Contagious Curiosity.” To understand why we wrote this particular book, you must start with a look at the current landscape of business intelligence (BI) using Microsoft SQL Server 2008.

Business intelligence itself really isn't new. Business intelligence—or data warehousing, as it has been traditionally called—has been used in particular industries, such as banking and retailing, for many years. What is new is the accessibility of BI solutions to a broader audience. Microsoft is leading this widening of the BI market by providing a set of world-class tools with SQL Server 2008. SQL Server 2008 includes the fourth generation of these tools in the box (for no additional fee) and their capabilities are truly impressive. As customers learn about the possibilities of BI, we see ever-greater critical mass adoption. We believe that within the next few years, it will be standard practice to implement both OLTP and (BI) OLAP/data mining solutions for nearly every installation of SQL Server 2008.

One of the most significant hindrances to previous adoption of BI technologies has not been the quality of technologies and tools available in SQL Server 2008 or its predecessors. Rather, what we have found (from our real-world experience) is that a general lack of understanding of BI capabilities is preventing wider adoption. We find that developers, in particular, lack understanding of BI core concepts such as OLAP (or dimensional) modeling and data mining algorithms. This knowledge gap also includes lack of understanding about the capabilities of the BI components and tools included with SQL Server 2008—SQL Server Analysis Services (SSAS), SQL Server Integration Services (SSIS), and SQL Server Reporting Services (SSRS).

The gap is so significant, in fact, that it was one of the primary motivators for writing this book. Far too many times, we’ve seen customers who lack understanding of core BI concepts struggle to create BI solutions. Ironically, the BI tools included in SQL Server 2008 are in some ways too easy to use. As with many Microsoft products, a right-click in the right place nearly always starts a convenient wizard. So customers quickly succeed in building OLAP cubes and data mining structures; unfortunately, sometimes they have no idea what they’ve actually created. Often these solutions do not reveal their flawed underlying design until after they’ve been deployed and are being run with production levels of data.

Because the SQL Server 2008 BI tools are designed to be intuitive, BI project implementation is pleasantly simple, as long as what you build properly implements standard BI concepts. If we’ve met our writing goals, you’ll have enough of both conceptual and procedural knowledge after reading this book that you can successfully envision, design, develop, and deploy a BI project built using SQL Server 2008.
Who This Book Is For

This book has more than one audience. The primary audience is professional developers who want to start work on a BI project using SSAS, SSIS, and SSRS. Our approach is one of inclusiveness—we have provided content targeted at both beginning and intermediate BI developers. We have also included information for business decision makers who wish to understand the capabilities of the technology and Microsoft’s associated tools. Because we believe that appropriate architecture is the underpinning of all successful projects, we’ve also included information for that audience.

We assume that our readers have production experience with a relational database. We also assume that they understand relational database queries, tables, normalization and joins, and other terms and concepts common to relational database implementations.

Although we’ve included some core information about administration of BI solutions, we consider IT pros (or BI administrators) to be a secondary audience for this book.

What This Book Is About

This book starts by helping the reader develop an intuitive understanding of the complexity and capabilities of BI as implemented using SQL Server 2008, and then it moves to a more formal understanding of the concepts, architecture, and modeling. Next, it presents a more process-focused discussion of the implementation of BI objects, such as OLAP cubes and data mining structures, using the tools included in SQL Server 2008.

Unlike many other data warehousing books we’ve seen on the market, we’ve attempted to attain an appropriate balance between theory and practical implementation. Another difference between our book and others is that we feel that data mining is a core part of a BI solution. Because of this we’ve interwoven information about data mining throughout the book and have provided three chapters dedicated to its implementation.

Part I, “Business Intelligence for Business Decision Makers and Architects”

The goal of this part of the book is to answer these questions:

- Why use BI?
- What can BI do?
- How do I get started?

In this first part, we address the business case for BI. We also introduce BI tools, methods, skills, and techniques. This section is written for developers, business decision makers, and
architects. Another way to look at our goal for this section is that we've tried to include all of the information you'll need to understand before you start developing BI solutions using SQL Server Analysis Services in the Business Intelligence Development Studio (BIDS) toolset.

Chapter 1, “Business Intelligence Basics” In this chapter, we provide a practical definition of exactly what BI is as implemented in SQL Server 2008. Here we define concepts such as OLAP, dimensional modeling, and more. Also, we discuss tools and terms such as BIDS, MDX, and more. Our aim is to provide you with a foundation for learning more advanced concepts.

Chapter 2, “Visualizing Business Intelligence Results” In this chapter, we look at BI from an end user's perspective using built-in BI client functionality in Microsoft Office Excel 2007. Here we attempt to help you visualize the results of BI projects—namely, OLAP cubes and data mining models.

Chapter 3, “Building Effective Business Intelligence Processes” In this chapter, we examine software development life-cycle processes that we use when envisioning, designing, developing, and deploying BI projects. Here we take a closer look at Microsoft Solutions Framework (and other software development life cycles) as applied to BI projects.

Chapter 4, “Physical Architecture in Business Intelligence Solutions” In this chapter, we examine best practices for establishing baselines in your intended production BI environment. We cover tools, such as SQL Server Profiler and more, that can help you prepare to begin a BI project. We also talk about physical servers—especially, number and placement. We include an introduction to security concepts. We close by discussing considerations for setting up a BI development environment.

Chapter 5, “Logical OLAP Design Concepts for Architects” In this chapter, we take a close look at core OLAP modeling concepts—namely, dimensional modeling. Here we take a look at star schemas, fact tables, dimensional hierarchy modeling, and more.

Part II, “Microsoft SQL Server 2008 Analysis Services for Developers”

This part provides you with detailed information about how to use SSAS to build OLAP cubes and data mining models. Most of this section is focused on using BIDS by working on a detailed drill-down of all the features included. As we’ll do with each part of the book, the initial chapters look at architecture and a simple implementation. Subsequent chapters are where we drill into intermediate and, occasionally, advanced concepts.

Chapter 6, “Understanding SSAS in SSMS and SQL Server Profiler” In this chapter, we look at OLAP cubes in SQL Server Management Studio and in SQL Server Profiler. We start here because we want you to understand how to script, maintain, and move objects that you’ve created for your BI solution. Also, SQL Server Profiler is a key tool to help you understand underlying MDX or DMX queries from client applications to SSAS structures.
Chapter 7, “Designing OLAP Cubes Using BIDS” In this chapter, we begin the work of developing an OLAP cube. Here we start working with BIDS, beginning with the sample SSAS database Adventure Works 2008 DW.

Chapter 8, “Refining Cubes and Dimensions” In this chapter, we dig deeper into the details of building OLAP cubes and dimensions using BIDS. Topics include dimensional hierarchies, key performance indicators (KPIs), MDX calculations, and cube actions. We explore both the cube and dimension designers in BIDS in great detail in this chapter.

Chapter 9, “Processing Cubes and Dimensions” In this chapter, we take a look at cube metadata and data storage modes. Here we discuss multidimensional OLAP (MOLAP), hybrid OLAP (HOLAP), and relational OLAP (ROLAP). We also look at the aggregation designer and discuss aggregation strategies in general. We also examine proactive caching.

Chapter 10, “Introduction to MDX” In this chapter, we depart from using BIDS and present a tutorial on querying by using MDX. We present core language features and teach via many code examples in this chapter.

Chapter 11, “Advanced MDX” In this chapter, we move beyond core language features to MDX queries to cover more advanced language features. We also take a look at how the MDX language is used throughout the BI suite in SQL Server 2008—that is, in BIDS for SSAS and SSRS.

Chapter 12, “Understanding Data Mining Structures” In this chapter, we take a look at the data mining algorithms that are included in SSAS. We examine each algorithm in detail, including presenting configurable properties, so that you can gain an understanding of what is possible with SQL Server 2008 data mining.

Chapter 13, “Implementing Data Mining Structures” In this chapter, we focus on practical implementation of data mining models using SSAS in BIDS. We work through each tab of the data mining model designer, following data mining implementation from planning to development, testing, and deployment.

Part III, “Microsoft SQL Server 2008 Integration Services for Developers”

The goal of this part is to give you detailed information about how to use SSIS to develop extract, transform, and load (ETL) packages. You’ll use these packages to load your OLAP cubes and data mining structures. Again, we’ll focus on using BIDS while working on a detailed drill-down of all the features included. As with each part of the book, the initial chapters look at architecture and start with a simple implementation. Subsequent chapters are where we drill into intermediate and, occasionally, advanced concepts.
Chapter 14, “Architectural Components of Microsoft SQL Server 2008 Integration Services” In this chapter, we examine the architecture of SSIS. Here we take a look at the data flow pipeline and more.

Chapter 15, “Creating Microsoft SQL Server 2008 Integration Services Packages with Business Intelligence Development Studio” In this chapter, we explain the mechanics of package creation using BIDS. Here we present the control flow tasks and then continue by explaining data flow sources, destinations, and transformations. We continue working through the BIDS interface by covering variables, expressions, and the rest of the BIDS interface.

Chapter 16, “Advanced Features in Microsoft SQL Server 2008 Integration Services” In this chapter, we begin by taking a look at the error handling, logging, and auditing features in SSIS. Next we look at some common techniques for assessing data quality, including using the new Data Profiling control flow task.

Chapter 17, “Microsoft SQL Server 2008 Integration Services Packages in Business Intelligence Solutions” In this chapter, we take a look at extract, transform, and load processes and best practices associated with SSIS when it’s used as a tool to create packages for data warehouse loading. We look at this using both OLAP cubes and data mining models.

Chapter 18, “Deploying and Managing Solutions in Microsoft SQL Server 2008 Integration Services” In this chapter, we drill into the details of SSIS package deployment and management. Here we look at using Visual SourceSafe (VSS) and other source control solutions to manage distributed package deployment.

Chapter 19, “Extending and Integrating SQL Server 2008 Integration Services” In this chapter, we provide an explanation about the details of extending the functionality of SSIS packages using .NET-based scripts.

Part IV, “Microsoft SQL Server Reporting Services and Other Client Interfaces for Business Intelligence”

The goal of this part is to give you detailed information about how to select and implement client interfaces for OLAP cubes and data mining structures. We’ll look in great detail at SSRS. In addition, we’ll examine using Excel, Visio, or Office SharePoint Server 2007 as your BI client of choice. We’ll look at SSRS architecture, then at designing reports using BIDS and other tools. Then we’ll move to a detailed look at implementing other clients, including a discussion of the process for embedding results in a custom Windows Form or Web Form application. As we do with each part of the book, our first chapters look at architecture, after which we start with simple implementation. Subsequent chapters are where we drill into intermediate and, occasionally, advanced concepts.
Chapter 20, “Creating Reports in SQL Server 2008 Reporting Services”  In this chapter, we present the architecture of SQL Server Reporting Services. We cover the various parts and pieces that you’ll have to implement to make SSRS a part of your BI solution.

Chapter 21, “Building Reports for SQL Server 2008 Reporting Services”  In this chapter, we drill into the detail of building reports using BIDS. We take a look at the redesigned interface and then look at the details of designing reports for OLAP cubes and data mining models.

Chapter 22, “Advanced SQL Server 2008 Reporting Services”  In this chapter, we look at programmatically extending SSRS as well as other advanced uses of SSRS in a BI project. Here we look at using the ReportViewer control in custom SSRS clients. We also take a look at the new integration between SSRS and Excel and Word 2007.

Chapter 23, “Using Microsoft Excel 2007 as an OLAP Cube Client”  In this chapter, we walk through the capabilities included in Excel 2007 as an OLAP cube client. We take a detailed look at the PivotTable functionality and also examine the PivotChart as a client interface for OLAP cubes.

Chapter 24, “Microsoft Office 2007 as a Data Mining Client”  In this chapter, we look at using the SQL Server 2008 Data Mining Add-ins for Office 2007. These add-ins enable Excel 2007 to act as a client to SSAS data mining. We look at connecting to existing models on the server as well creating temporary models in the Excel session using Excel source data. We also examine the new tools that appear on the Excel 2007 Ribbon after installing the add-ins.

Chapter 25, “SQL Server 2008 Business Intelligence and Microsoft Office SharePoint Server 2007”  In this chapter, we look at integration between SQL Server Reporting Services and SharePoint technologies. We focus on integration between SSRS and Office SharePoint Server 2007. Here we detail the integrated mode option for SSRS and Office SharePoint Server 2007. We also look at the Report Center template included in Office SharePoint Server 2007 and detail just how it integrates with SSRS. We have also included information about Excel Services.

Prerelease Software

This book was written and tested against the release to manufacturing (RTM) 2008 version of SQL Server Enterprise software. Microsoft released the final version of Microsoft SQL Server 2008 (build number 10.0.1600.22) in August 2008. We did review and test our examples against the final release of the software. However, you might find minor differences between the production release and the examples, text, and screen shots in this book. We made every attempt to update all of the samples shown to reflect the RTM; however, minor variances in screen shots or text between the community technology preview (CTP) samples and the RTM samples might still remain.
Hardware and Software Requirements

You’ll need the following hardware and software to work with the information and examples provided in this book:

- Visual Studio 2008 (Team System is used to show the examples).
- 1.6 GHz Pentium III+ processor or faster.
- 1 GB of available, physical RAM.
- 10 GB of hard disk space for SQL Server and all samples
- Video (800 by 600 or higher resolution) monitor with at least 256 colors.
- CD-ROM or DVD-ROM drive.
- Microsoft mouse or compatible pointing device.

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Lynn Langit is recording a companion screencast series named “How Do I BI?” Find this series via her blog at http://blogs.msdn.com/SoCalDevGal.
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Chapter 1

Business Intelligence Basics

Many real-world business intelligence (BI) implementations have been delayed or even derailed because key decision makers involved in the projects lacked even a general understanding of the potential of the product stack. In this chapter, we provide you with a conceptual foundation for understanding the broad potential of the BI technologies within Microsoft SQL Server 2008 so that you won’t have to be in that position. We define some of the basic terminology of business intelligence, including OLTP and OLAP, and go over the components, both core and optional, of Microsoft BI solutions. We also introduce you to the development languages involved in BI projects, including MDX, DMX, XMLA, and RDL.

If you already know these basic concepts, you can skip to Chapter 2, “Visualizing Business Intelligence Results,” which talks about some of the common business problems that BI addresses.

Business Intelligence and Data Modeling

You’ll see the term business intelligence defined in many different ways and in various contexts. Some vendors manufacture a definition that shows their tools in the best possible light. You’ll sometimes hear BI summed up as “efficient reporting.” With the BI tools included in SQL Server 2008, business intelligence is much more than an overhyped, supercharged reporting system. For the purposes of this book, we define business intelligence in the same way Microsoft does:

Business intelligence solutions include effective storage and presentation of key enterprise data so that authorized users can quickly and easily access and interpret it. The BI tools in SQL Server 2008 allow enterprises to manage their business at a new level, whether to understand why a particular venture got the results it did, to decide on courses of action based on past data, or to accurately forecast future results on the basis of historical data.

You can customize the display of BI data so that it is appropriate for each type of user. For example, analysts can drill into detailed data, executives can see timely high-level summaries, and middle managers can request data presented at the level of detail they need to make good day-to-day business decisions. Microsoft BI usually uses data structures (called cubes or data mining structures) that are optimized to provide fast, easy-to-query decision support. This BI data is presented to users via various types of reporting interfaces. These formats can include custom applications for Microsoft Windows, the Web, or mobile devices as well as Microsoft BI client tools, such as Microsoft Office Excel or SQL Server Reporting Services.
Figure 1-1 shows a conceptual view of a BI solution. In this figure, multiple types of source data are consolidated into a centralized data storage facility. For a formal implementation of a BI solution, the final destination container is most commonly called a cube. This consolidation can be physical—that is, all the source data is physically combined onto one or more servers—or logical, by using a type of a view. We consider BI conceptual modeling in more detail in Chapter 5, “Logical OLAP Design Concepts for Architects.”

Although it’s possible to place all components of a BI solution on a single physical server, it’s more typical to use multiple physical servers to implement a BI solution. Microsoft Windows Server 2008 includes tremendous improvements in virtualization, so the number of physical servers involved in a BI solution can be greatly reduced if you are running this version. We talk more about physical modeling for BI solutions in Chapter 5.

Before we examine other common BI terms and components, let’s review two core concepts in data modeling: OLTP and OLAP.
You’ve probably heard the terms OLTP and OLAP in the context of data storage. When planning SQL Server 2008 BI solutions, you need to have a solid understanding of these systems as well as the implications of using them for your particular requirements.

### Online Transactional Processing

OLTP stands for *online transactional processing* and is used to describe a relational data store that is designed and optimized for transactional activities. Transactional activities are defined as inserts, updates, and deletes to rows in tables. A typical design for this type of data storage system is to create a large number of normalized tables in a single source database.

### Relational vs. Nonrelational Data

SQL Server 2008 BI solutions support both relational and nonrelational source data. Relational data usually originates from a relational database management system (RDBMS) such as SQL Server 2008 (or an earlier version of SQL Server) or an RDBMS built by a different vendor, such as Oracle or IBM. Relational databases generally consist of a collection of related tables. They can also contain other objects, such as views or stored procedures.

Nonrelational data can originate from a variety of sources, including Windows Communication Foundation (WCF) or Web services, mainframes, and file-based applications, such as Microsoft Office Word or Excel. Nonrelational data can be presented in many formats. Some of the more common formats are XML, TXT, CSV, and various binary formats.

Normalization in relational data stores is usually implemented by creating a primary-key-to-foreign-key relationship between the rows in one table (often called the *parent* table) and the rows in another table (often called the *child* table). Typically (though not always), the rows in the parent table have a one-to-many relationship with the rows in the child table. A common example of this relationship is a Customer table and one or more related [Customer] Orders tables. In the real world, examples are rarely this simple. Variations that include one-to-one or many-to-many relationships, for example, are possible. These relationships often involve many source tables.

Figure 1-2 shows the many tables that can result when data stores modeled for OLTP are normalized. The tables are related by keys.
The primary reasons to model a data store in this way (that is, normalized) are to reduce the total amount of data that needs to be stored and to improve the efficiency of performing inserts, updates, and deletes by reducing the number of times the same data needs to be added, changed, or removed. Extending the example in Figure 1-2, if you inserted a second order for an existing customer and the customer's information hadn't changed, no new information would have to be inserted into the Customer table; instead, only one or more rows would have to be inserted into the related Orders tables, using the customer identifier (usually a key value), to associate the order information with a particular customer. Although this type of modeling is efficient for these activities (that is, inserting, updating, and deleting data), the challenge occurs when you need to perform extensive reading of these types of data stores.

To retrieve meaningful information from the list of Customers and the particular Order information shown in Figure 1-2, you'd first have to select the rows meeting the report criteria from multiple tables and then sort and match (or join) those rows to create the information you need. Also, because a common business requirement is viewing aggregated information, you might want to see the total sales dollar amount purchased for each customer, for example. This requirement places additional load on the query processing engine of your OLTP data store. In addition to selecting, fetching, sorting, and matching the rows, the engine also has to aggregate the results.

If the query you make involves only a few tables (for example, the Customer table and the related SalesOrderHeader tables shown in Figure 1-2), and if these tables contain a small
number of rows, the overhead incurred probably would be minimal. (In this context, the
definition of a "small" number is relative to each implementation and is best determined
by baseline performance testing during the development phase of the project.) You might
be able to use a highly normalized OLTP data store to support both CRUD (create, retrieve,
update, delete) and read-only (decision support or reporting) activities. The processing
speed depends on your hardware resources and the configuration settings of your database
server. You also need to consider the number of users who need to access the information
simultaneously.

These days, the OLTP data stores you are querying often contain hundreds or even thou-
ousands of source tables. The associated query processors must filter, sort, and aggregate mil-
ions of rows from the related tables. Your developers need to be fluent in the data store
query language so that they can write efficient queries against such a complex structure, and
they also need to know how to capture and translate every business requirement for report-
ing. You might need to take additional measures to improve query (and resulting report)
performance, including rewriting queries to use an optimal query syntax, analyzing the
query execution plan, providing hints to force certain execution paths, and adding indexes
to the relational source tables. Although these strategies can be effective, implementing
them requires significant skill and time on the part of your developers. Figure 1-3 shows an
example of a typical reporting query—not the complexity of the statement, but the number
of tables that can be involved.

```
SELECT emp.BusinessEntityID,
    p.FirstName + ' ' + COALESCE(p.MiddleName, '') ' ' + p.LastName AS [FullName],
    sp.TerritoryID,
    sp.JobTitle,
    sp.BusinessEntityID AS Expr1,
    sph.SalesPersonID,
    tct.Name,
    tct.CountryRegionCode,
    tsoh.SalesOrderID,
    tsoh.ProductID,
    tsoh.UnitPrice,
    tsoh.OrderQty,
    tsoh.DueDate
FROM Sales.SalesPerson sp
    INNER JOIN
    INNER JOIN
        Sales.SalesTerritory tct ON sp.TerritoryID = tct.TerritoryID
    INNER JOIN
        Sales.SalesOrderHeader soh ON sp.BusinessEntityID = soh.SalesPersonID
            AND tct.TerritoryID = soh.TerritoryID
    INNER JOIN
        Sales.SalesOrderDetail sod ON soh.SalesOrderID = sod.SalesOrderID
            AND soh.SalesOrderID = sod.SalesOrderID
    INNER JOIN
        HumanResources.Employee emp ON sp.BusinessEntityID = emp.BusinessEntityID
```

**FIGURE 1-3** Sample reporting query against a normalized data store
SQL Server 2008 includes a powerful tool, the Database Engine Tuning Advisor, that can assist you in manual tuning efforts, though the amount of time needed to implement and maintain manual query tuning can become significant. Other costs are also involved with OLTP query optimization, the most significant of which is the need for additional storage space and maintenance tasks as indexes are added. A good way to think of the move from OLTP alone to a combined solution that includes both an OLTP store and an OLAP store is as a continuum that goes from OLTP (single RDBMS) relational to relational copy to OLAP (cube) nonrelational. In particular, if you’re already making a copy of your OLTP source data to create a more efficient data structure from which to query for reporting and to reduce the load on your production OLTP servers, you’re a prime candidate to move to a more formalized OLAP solution based on the dedicated BI tools included in SQL Server 2008.

Online Analytical Processing

OLAP stands for online analytical processing and is used to describe a data structure that is designed and optimized for analytical activities. Analytical activities are defined as those that focus on the best use of data for the purpose of reading it rather than optimizing it so that changes can be made in the most efficient way. In fact, many OLAP data stores are implemented as read-only. Other common terms for data structures set up and optimized for OLAP are decision support systems, reporting databases, data warehouses, or cubes.

As with OLTP, definitions of an OLAP data store vary depending on who you’re talking to. At a minimum, most professionals would agree that an OLAP data store is modeled in a denormalized way. When denormalizing, you use very wide relational tables (those containing many columns) with deliberately duplicated information. This approach reduces the number of tables that must be joined to provide query results and lets you add indexes. Reducing the size of surface area that is queried results in faster query execution. Data stores that are modeled for OLAP are usually denormalized using a specific type of denormalization modeling called a star schema. We cover this technique extensively in Chapter 4, “Physical Architecture in Business Intelligence Solutions.”

Although using a denormalized relational store addresses some of the challenges encountered when trying to query an OLTP (or normalized) data store, a denormalized relational store is still based on relational tables, so the bottlenecks are only partially mitigated. Developers still must write complex queries for each business reporting requirement and then manually denormalize the copy of the OLTP store, add indexes, and further tune queries as performance demands. The work involved in performing these tasks can become excessive.

Figure 1-4 shows a portion of a denormalized relational data store. We are working with the AdventureWorksDW sample database, which is freely available for download and is designed to help you understand database modeling for loading OLAP cubes. Notice the numerous columns in each table.
Another way to implement OLAP is to use a cube rather than a group of tables. A cube is one large store that holds all associated data in a single structure. The structure contains not only source data but also pre-aggregated values. A cube is also called a **multidimensional data store**.

**Aggregation**

Aggregation is the application of some type of mathematic function to data. Although aggregation can be as simple as doing a SUM on numeric values, in BI solutions, it is often much more complex. In most relational data stores, the number of aggregate functions available is relatively small. For SQL Server 2008, for example, Transact-SQL contains 12 aggregate functions: AVG, MIN, CHECKSUM_AGG, SUM, COUNT, STDEV, COUNT_BIG, STDEVP, GROUPING, VAR, MAX, and VARP. Contrast this with the number of built-in functions available in the SQL Server cube store: over 150. The number and type of aggregate functions available in the cube store are more similar to those available in Excel than to those in SQL Server 2008.

So, what exactly does a cube look like? It can be tricky to visualize a cube because most of us can imagine only in three dimensions. Cubes are \( n \)-dimensional structures because they can store data in an infinite number of dimensions. A conceptual rendering of a cube is shown in...
Figure 1-5. Cubes contain two major aspects: facts and dimensions. Facts are often numeric and additive, although that isn’t a requirement. Facts are sometimes called measures. An example of a fact is “gross sales amount.” Dimensions give meaning to facts. For example, you might need to be able to examine gross sales amount by time, product, customer, and employee. All of the “by xxx” values are dimensions. Dimensional information is accessed via a hierarchy of information along each dimensional axis. You’ll also hear the term Unified Dimensional Model (UDM) to describe an OLAP cube because, in effect, such a cube “unifies” a group of dimensions. We discuss this type of modeling in much greater detail in Chapter 5.

![Sample cube structure](https://example.com/cube_structure.png)

**FIGURE 1-5** Sample cube structure

You might be wondering why a cube is preferable to a denormalized relational data store. The answer is efficiency—in terms of scalability, performance, and ease of use. In the case of using the business intelligence toolset in SQL Server 2008, you’ll also get a query processing engine that is specifically optimized to deliver fast queries, particularly for queries that involve aggregation. We’ll review the business case for using a dedicated OLAP solution in more detail in Chapter 2. Also, we’ll look at real-world examples throughout the book.

The next phase of understanding an OLAP cube is translating that \( n \)-dimensional structure to a two-dimensional screen so that you can visualize what users will see when working with an OLAP cube. The standard viewer for a cube is a pivot table interface, a sample of which
is shown in Figure 1-6. The built-in viewer in the developer and administrative interfaces for SQL Server 2008 OLAP cubes both use a type of pivot table to allow developers and administrators to visualize the cubes they are working with. Excel 2007 PivotTables are also a common user interface for SQL Server 2008 cubes.

**FIGURE 1-6 SQL Server 2008 cube presented in a PivotTable**

## Common BI Terminology

A number of other conceptual terms are important to understand when you’re planning a BI solution. In this section, we’ll talk about several of these: data warehouses; data marts; cubes; decision support systems; data mining systems; extract, transform, and load systems; report processing systems; and key performance indicators.

### Data Warehouses

A data warehouse is a single structure that usually consists of one or more cubes. Figure 1-7 shows the various data sources that contribute to an OLAP cube. Data warehouses are used to hold an aggregated, or rolled-up (and most commonly) read-only, view of the majority of an organization’s data. This structure includes client query tools. When planning and implementing your company’s data warehouse, you need to decide which data to include and at what level of detail (or granularity). We explore this concept in more detail in “Extract, Transform, and Load Systems” later in this chapter.
The terms *OLAP* and *data warehousing* are sometimes used interchangeably. However, this is a bit of an oversimplification because an OLAP store is modeled as a cube or multidimensionally, whereas a data warehouse can use either denormalized OLTP data or OLAP. OLAP and data warehousing are not new technologies. The first Microsoft OLAP tools were part of SQL Server 7. What is new in SQL Server 2008 is the inclusion of powerful tools that allow you to implement a data warehouse using an OLAP cube (or cubes). Implementing BI solutions built on OLAP is much easier because of improved tooling, performance, administration, and usability, which reduces total cost of ownership (TCO).

**Pioneers of Data Warehousing**

Data warehousing has been available, usually implemented via specialized tools, since the early 1980s. Two principal thought leaders of data warehousing theory are Ralph Kimball and Bill Inmon. Both have written many articles and books and have popular Web sites talking about their extensive experience with data warehousing solutions using products from many different vendors.

To read more about Ralph Kimball’s ideas on data warehouse design modeling, go to [http://www.ralphkimball.com](http://www.ralphkimball.com). I prefer the Kimball approach to modeling and have had good success implementing Kimball’s methods in production BI projects. For a simple explanation of the Kimball approach, see [http://en.wikipedia.org/wiki/Ralph_Kimball](http://en.wikipedia.org/wiki/Ralph_Kimball).
Data Marts

A data mart is a defined subset of enterprise data, often a single cube from a group of cubes, that is intended to be consolidated into a data warehouse. The single cube represents one business unit (for example, marketing) from a greater whole (for example, the entire company). Data marts were the basic units of organization in the OLAP tools that were included in earlier versions of SQL Server BI solutions because of restrictions in the tools themselves. The majority of these restrictions were removed in SQL Server 2005. Because of this, data warehouses built using the tools provided by SQL Server 2008 often consist of one huge cube. This is not the case with many competitive OLAP products. There are, of course, exceptions to this single-cube design. However, limits in the product stack are not what determines this type of design, rather, it is determined by OLAP modeler or developer preferences.

Cubes

As described earlier in the chapter, a BI cube is a data structure used by classic data warehousing products (including SQL Server 2008) in place of many relational tables. Rather than containing tables with rows and columns, cubes consist of dimensions and measures (or facts). Cubes can also contain data that is pre-aggregated (usually summed) rather than included as individual items (or rows). In some cases, cubes contain a complete copy of production data; in other cases, they contain subsets of source data.

In SQL Server 2008, cubes are more scalable and perform better than in previous versions of SQL Server, so you can include data with much more detail than you could include when using previous versions of the SQL Server 2008 OLAP tool, with many fewer adverse effects on scalability and performance. As in previous versions, when you are using SQL Server 2008, you will copy the source data from any number of disparate source systems to the destination OLAP cubes via extract, transform, and load (ETL) processes. (You’ll find out more about ETL shortly.)

We talk a lot about cubes in this book, from their physical and logical design in Chapters 5 and 6 to the use of the cube-building tools that come with SQL Server 2008 in Part II, “Microsoft SQL Server 2008 Analysis Services for Developers.”

Decision Support Systems

The term decision support system can mean anything from a read-only copy of an OLTP data store to a group of OLAP cubes, or even a mixture of both. If the data source consists of only an OLTP data store, then this type of store can be limited in its effectiveness because of the challenges discussed earlier in this chapter, such as the difficulty of efficient querying and the overhead required for indexes. Another way to think about a decision support system is some type of data structure (such as a table or a cube) that is being used as a basis for developing end-user reporting. End-user in this context means all types or categories of users. These
usually include business decision makers, middle managers, and general knowledge workers. It is critical that your solution be able to provide data summarized at a level of detail that is useful to these various end-user communities. The best BI solutions are intuitive for the various end-user communities to work with—little or no end-user training is needed.

In this book, we focus on using the more efficient OLAP data store (or cube) as a source for a decision support system.

Data Mining Systems

Data mining can be understood as a complementary technique to OLAP. Whereas OLAP is used to provide decision support or the data to prove a particular hypothesis, data mining is used in situations in which you have no solid hypothesis about the data. For example, you could use an OLAP cube to verify that customers who purchased a certain product during a certain timeframe had certain characteristics. Specifically, you could prove that customers who purchased cars during December 2007 chose red-colored cars twice as often as they picked black-colored cars if those customers shopped at locations in postal codes 90201 to 90207. You could use a data mining store to automatically correlate purchase factors into buckets, or groups, so that decision makers could explore correlations and then form more specific hypotheses based on their investigation. For example, they could decide to group or cluster all customers segmented into “car purchasers” and “non-car-purchasers” categories. They could further examine the clusters to find that “car purchasers” had the following traits most closely correlated, in order of priority: home owners (versus non–home owners), married (versus single), and so on.

Another scenario for which data mining is frequently used is one where your business requirements include the need to predict one or more future target values in a dataset. An example of this would be the rate of sale—that is, the number of items predicted to be sold over a certain rate of time.

We explore the data mining support included in SQL Server 2008 in greater detail in Chapter 6, “Understanding SSAS in SSMS and SQL Server Profiler,” in the context of logical modeling. We also cover it in several subsequent chapters dedicated to implementing solutions that use data mining.

Extract, Transform, and Load Systems

Commonly expressed as ETL, extract, transform, and load refers to a set of services that facilitate the extraction, transformation, and loading of the various types of source data (for example, relational, semi-structured, and unstructured) into OLAP cubes or data mining structures. SQL Server 2008 includes a sophisticated set of tools to accomplish the ETL processes associated with the initial loading of data into cubes as well as to process subsequent
incremental inserts of data into cubes, updates to data in cubes, and deletions of data from cubes. ETL is explored in detail in Part III, “Microsoft SQL Server 2008 Integration Services for Developers.” A common error made in BI solutions is underestimating the effort that will be involved in the ETL processes for both the initial OLAP cube and the data mining structure loads as well as the effort involved in ongoing maintenance, which mostly consists of inserting new data but can also include updating and deleting data. It is not an exaggeration to say that up to 75 percent of the project time for the initial work on a BI project can be attributed to the ETL portion of the project. The “dirtiness,” complexity, and general incomprehensibility of the data originating from various source systems are factors that are often overlooked in the planning phase. By “dirtiness,” we mean issues such as invalid data. This can include data of an incorrect type, format, length, and so on.

Report Processing Systems

Most BI solutions use more than one type of reporting client because of the different needs of the various users who need to interact with the cube data. An important part of planning any BI solution is to carefully consider all possible reporting tools. A common production mistake is to under-represent the various user populations or to clump them together when a more thorough segmentation would reveal very different reporting needs for each population.

SQL Server 2008 includes a report processing system designed to support OLAP data sources. In Part IV, “Microsoft SQL Server Reporting Services and Other Client Interfaces for Business Intelligence,” we explore the included tools—such as SQL Server Reporting Services, Office SharePoint Server 2007, and PerformancePoint Server—as well as other products that are part of the Microsoft product suite for reporting.

Key Performance Indicators

Key performance indicators (KPIs) are generally used to indicate a goal that consists of several values—actual, target, variance to target, and trend. Most often, KPIs are expressed and displayed graphically—for example, as different colored traffic lights (red, yellow, or green). KPIs usually include drill-down capabilities that allow interested decision makers to review the data behind the KPI. KPIs can be implemented as part of an OLAP system, and they are often part of reporting systems, which are most typically found on reporting dashboards or scorecards. It is quite common for business requirements to include the latter as part of a centralized performance management strategy. Microsoft’s BI tools include the ability to create and view KPIs. You can create KPIs from nearly any type of data source, such as OLAP cubes, Excel workbooks, or SharePoint lists.
Core Components of a Microsoft BI Solution

The core components of a Microsoft BI solution are SQL Server Analysis Services (SSAS), SQL Server Reporting Services (SSRS), and SQL Server 2008 itself. SQL Server is often used as a data source or an intermediate repository for data as it is being validated in preparation for loading into an OLAP cube. The ETL toolset, called SQL Server Integration Services (SSIS), also requires a SQL Server 2008 license. Each of these core services comes with its own set of management interface tools. The SSAS development interface is the Business Intelligence Development Studio (BIDS); SSIS and SSRS use the same development interface. The administrative interface all three use is SQL Server Management Studio (SSMS).

We typically use SQL Server Reporting Services in our solutions. Sometimes a tool other than SSRS will be used as the report engine for data stores developed using SSAS. However, you will typically use, at a minimum, the components just listed for a BI solution built using SQL Server 2008. For example, you could purchase or build a custom application that doesn’t use SSRS to produce reports. In that case, the application would include data queries as well as calls to the SSAS structures via the application programming interfaces (APIs) included for it.

SQL Server 2008 Analysis Services

SSAS is the core service in a Microsoft BI solution. It provides the storage and query mechanisms for the data used in OLAP cubes for the data warehouse. It also includes sophisticated OLAP cube developer and administrative interfaces. SSAS is usually installed on at least one dedicated physical server. You can install both SQL Server 2008 and SSAS on the same physical server, but this is done mostly in test environments. Figure 1-8 shows the primary tool you’ll use to develop cubes for SSAS, the Business Intelligence Development Studio. BIDS opens in a Microsoft Visual Studio environment. You don’t need a full Visual Studio installation to develop cubes for SSAS. If Visual Studio is not on your development machine, when you install SSAS, BIDS installs it as a stand-alone component. If Visual Studio is on your development machine, BIDS installs as a component (really, a set of templates) in your existing Visual Studio instance.
Figure 1-8 AdventureWorksDW in the OLAP cube view within BIDS

**Note** If you’re running a full version of Visual Studio 2008 on the same machine where you intend to work with SSAS, you must install Service Pack 1 (SP1) for Visual Studio 2008.

**AdventureWorksDW**

AdventureWorksDW is the sample data and metadata that you can use while learning about the tools and capabilities of the SQL Server 2008 BI tools. We provide more information about how to work with this sample later in this chapter. All screen shots in this book show this sample being used. The samples include metadata and data so that you can build OLAP cubes and mining structures, SSIS packages, and SSRS reports. These samples are also available on Microsoft’s public, shared-source Web site: CodePlex at [http://codeplex.com/SqlServerSamples](http://codeplex.com/SqlServerSamples). Here you’ll find the specific locations from which you can download these samples. Be sure to download samples that match your version (for example, 2008 or 2005) and platform (x86 or x64). When running the samples, be sure to use the sample for your edition of SQL Server.
Data Mining with Analysis Services 2008

SSAS also includes a component that allows you to create data mining structures that include data mining models. Data mining models are objects that contain source data (either relational or multidimensional) that has been processed using one or more data mining algorithms. These algorithms either classify (group) data or classify and predict one or more column values. Although data mining has been available since SSAS 2000, its capabilities have been significantly enhanced in the SQL Server 2008 release. Performance is improved, and additional configuration capabilities are available. Figure 1-9 shows a data mining model visualizer that comes with SQL Server 2008. Data mining visualizers are included in the data mining development environment (BIDS), as well as in some client tools, such as Excel. Chapter 12, “Understanding Data Mining Structures,” and Chapter 13, “Implementing Data Mining Structures,” cover the data mining capabilities in SSAS in more detail.

FIGURE 1-9 Business Intelligence Development Studio (BIDS) data mining visualizer
SQL Server 2008 Reporting Services

Another key component in many BI solutions is SQL Server Reporting Services (SSRS). When working with SQL Server 2008 to perform SSRS administrative tasks, you can use a variety of included tools such as SSMS, a reporting Web site, or a command-line tool.

The enhancements made in SQL Server 2008 Reporting Services make it an attractive part of any BI solution. The SSRS report designer in BIDS includes a visual query designer for SSAS cubes, which facilitates rapid report creation by reducing the need to write manual queries against OLAP cube data. SSRS includes another report-creation component, Report Builder, which is intended to be used by analysts, rather than developers, to design reports. SSRS also includes several client tools: a Web interface (illustrated in Figure 1-10), Web Parts for Microsoft Office SharePoint Server, and client components for Windows Forms applications.

We discuss all flavors of reporting clients in Part IV.

![SSRS report designer](image)

**FIGURE 1-10** SSRS reports can be displayed by using the default Web site interface.

SQL Server 2008

In addition to being a preferred staging source for BI data, SQL Server 2008 RDBMS data is often a portion of the source data for BI solutions. As we mentioned earlier in this chapter, data can be and often is retrieved from a variety of relational source data stores (for example, Oracle, DB2, and so forth). To be clear, data from any source for which there is a provider can be used as source data for an OLAP (SSAS) cube, which means data from all versions of SQL Server along with data from other RDBMS systems.

A SQL Server 2008 installation isn’t strictly required to implement a BI solution; however, because of the integration of some key toolsets that are part of nearly all BI solutions, such as SQL Server Integration Services—which is usually used to perform the ETL processes for the OLAP cubes and data mining structures—most BI solutions should include at least one SQL Server 2008 installation. As we said earlier, although the SQL Server 2008 installation can be on the same physical server where SSAS is installed, it is more common to use a dedicated server.

You use the SQL Server Management Studio to administer OLTP databases, SSAS (OLAP) cubes and data mining models, and SSIS packages. The SSMS interface showing only the Object Explorer is shown in Figure 1-11.
SSIS is a key component in most BI solutions. This toolset is used to import, cleanse, and validate data prior to making the data available to SSAS for OLAP cubes or data mining structures. It is typical to use data from many disparate sources (for example, relational, flat file, XML, and so on) as source data to a data warehouse. For this reason, a sophisticated toolset such as SSIS facilitates the complex data loads (ETL) that are common to BI solutions. The units of execution in SSIS are called packages. They are a type of XML files that you can consider to be a set of instructions that are designed using visual tools in BIDS. We discuss planning, implementation, and many other considerations for SSIS packages in Part III.

You’ll use BIDS to design, develop, execute, and debug SSIS packages. The BIDS SSIS package design environment is shown in Figure 1-12.
Optional Components of a Microsoft BI Solution

In addition to the components that are included with SQL Server 2008, a number of other Microsoft products can be used as part of your BI solution. Most of these products allow you to deliver the reports generated from Analysis Services OLAP cubes and data mining structures in formats customized for different audiences, such as complex reports for business analysts and summary reports for executives.

Here is a partial list of Microsoft products that include integration with Analysis Services OLAP cubes and data mining models:

- **Microsoft Office Excel 2007**  Many companies already own Office 2007, so using Excel as a BI client is often attractive for its low cost and relatively low training curve. In addition to being a client for SSAS OLAP cubes through the use of the PivotTable feature or the Data Mining Add-ins for SQL Server 2008, Excel can also be a client for data mining structures. (Note that connecting to an OLAP data source from Excel 2003 only does require that MS Query be installed. MS Query is listed under optional components on the Office installation DVD.)

- **Microsoft Word 2007**  SSRS reports can be exported as Word documents that are compatible with Office 2003 or 2007.

- **Microsoft Visio 2007**  Using the Data Mining Add-ins for SQL Server 2008, you can create customized views of data mining structures.

- **Microsoft Office SharePoint Server 2007**  Office SharePoint Server 2007 contains both specialized Web site templates designed to show reports (with the most common one being the Report Center) as well as Web Parts that can be used to display individual reports on Office SharePoint Server 2007 Web pages. A Web Part is a pluggable user interface (UI) showing some bit of content. It is installed globally in the SharePoint
Portal Server Web site and can be added to an Office SharePoint Server 2007 portal Web page by any user with appropriate permissions.

- **Microsoft PerformancePoint Server** PerformancePoint Server allows you to quickly create a centralized Web site with all of your company’s performance metrics. The environment is designed to allow business analysts to create sophisticated dashboards that are hosted in a SharePoint environment. These dashboards can contain SSRS reports and visualizations of data from OLAP cubes as well as other data sources. It also has a strong set of products that support business forecasting.

  PerformancePoint Server includes the functionality of the Business Scorecard Manager and ProClarity Analytics Server. Its purpose is to facilitate the design and hosting of enterprise-level scorecards via rich data-visualization options such as charts and reports available in Reporting Services, Excel, and Visio. PerformancePoint Server also includes some custom visualizers, such as the Strategy Map.

  **Note** We are sometimes asked what happened to ProClarity, a company that had provided a specialized client for OLAP cubes. Its target customer was the business analyst. Microsoft acquired ProClarity in 2006 and has folded features of its products into PerformancePoint Server.

Microsoft also offers other products—such as Dynamics, Project Server, and BizTalk Server—that use the Analysis Services storage mechanism and query engine. In addition to Microsoft products that are designed to integrate with the BI tools available in SQL Server 2008, you might elect to use some other developer products to improve productivity if your project’s requirements call for .NET coding. Recall that the primary development tool is BIDS and that BIDS does not require a Visual Studio installation. Microsoft has found that BI developers are frequently also .NET developers, so most of them already have Visual Studio 2008. As was mentioned, in this situation, installing SSAS, SSIS, or SSRS installs the associated developer templates into the default Visual Studio installation.

Another consideration is the management of source code for large or distributed BI development teams. In this situation, you can also elect to add Visual Studio Team System (VSTS) for source control, automated testing, and architectural planning.

The data that you integrate into your BI solution might originate from relational sources. These sources can, of course, include SQL Server 2008. They can also include nearly any type of relational data—SQL Server (all versions), Oracle, DB2, Informix, and so forth. It is also common to include nonrelational data in BI solutions. Sources for this data can include Microsoft Access databases, Excel spreadsheets, and so forth. It is also common to include text data (often from mainframes). This data is sometimes made available as XML. This XML might or might not include schema and mapping information. If complex XML processing is part of your requirements, you can elect to use BizTalk Server to facilitate flexible mapping and loading of this XML data.
You might be thinking at this point, “Wow, that’s a big list! Am I required to buy (or upgrade to) all of those Microsoft products in order to implement a BI solution for my company?” The answer is no. The only service that is required for an OLAP BI solution is SSAS. Also, many companies provide tools that can be used as part of a Microsoft BI solution. Although we occasionally refer to some third-party products in this book, we’ll focus primarily on using Microsoft’s products and tools to build a BI solution.

**Query Languages Used in BI Solutions**

When working with BI solutions built on SSAS cubes and data mining structures, you use several query languages. The primary query language for OLAP cubes is MDX. SSAS also includes the ability to build data mining structures. To query the data in these structures, you use DMX. XMLA is a specialized administrative scripting language used with SSAS objects (OLAP cubes, SSIS packages, and data mining structures). Finally, RDL is the XML dialect behind SSRS reports. In the following sections, we briefly describe each language and provide a sample.

**MDX**

MDX, which stands for *Multidimensional Expressions*, is the language used to query OLAP cubes. Although MDX is officially an open standard and some vendors outside of Microsoft have adopted parts of it in their BI products, the reality is that comparatively few working .NET developers are proficient in MDX. A mitigating factor is that the need to manually write MDX in a BI solution can be relatively small—with not nearly as much Transact-SQL as you would manually write for a typical OLTP database. However, retaining developers who have at least a basic knowledge of MDX is an important consideration in planning a BI project.

We review core techniques as well as best practices for working with MDX in Chapter 10, “Introduction to MDX,” and Chapter 11, “Advanced MDX.”

The MDX query language is used to retrieve data from SSAS cubes. A simple MDX query is shown in Figure 1-13. Although MDX has an SQL-like structure, it is far more difficult to master because of the complexity of the SSAS source data structures—which are multidimensional OLAP cubes.

![Figure 1-13 A sample MDX query](image-url)
DMX

Data Mining Extensions (DMX) is used to query Analysis Services data mining structures. (We devote several future chapters to design and implementation of SSAS data mining structures.) Although this language is based loosely on Transact-SQL, it contains many elements that are unique to the world of data mining. As with MDX, very few working .NET developers are proficient in DMX. However, the need for DMX in BI solutions is relatively small because the SSAS data mining structure in BIDS provides tools and wizards that automatically generate DMX when you create those structures. Depending on the scope of your solution, retaining developers who have at least a basic knowledge of DMX might be an important consideration in planning a BI project that includes a large amount of data mining. A simple DMX query is shown in Figure 1-14.

XMLA

XML for Analysis (XMLA) is used to perform administrative tasks in Analysis Services. It is an XML dialect. Examples of XMLA tasks include viewing metadata, copying, backing up databases, and so on. As with MDX and DMX, this language is officially an open standard, and some vendors outside of Microsoft have chosen to adopt parts of it in their BI products. Again, the reality is that very few developers are proficient in XMLA. However, you will seldom author any XMLA from scratch; rather, you’ll use the tools and wizards inside SQL Server 2008 to generate this metadata. In SSMS, when connected to SSAS, you can right-click on any SSAS object and generate XMLA scripts using the graphical user interface (GUI). XMLA is used to define SSAS OLAP cubes and data mining structures.

RDL

RDL, or the Report Definition Language, is another XML dialect that is used to create Reporting Services reports. As with the other BI languages, RDL is officially an open standard,
and some vendors outside of Microsoft have chosen to adopt parts of it in their BI products. You rarely need to manually write RDL in a BI solution because it is generated for you automatically when you design a report using the visual tools in BIDS. We’ll review core techniques as well as best practices for working with RDL in future chapters.

Summary

In this chapter, we covered basic data warehousing terms and concepts, including BI, OLTP, OLAP, dimensions, and facts (or measures). We defined each term so that you can better understand the possibilities you should consider when planning a BI solution for your company.

We then introduced the BI tools included with SQL Server 2008. These include SSAS, SSIS, SSRS, and Data Mining Add-ins. For each of these BI tools, we defined what parts of a BI solution’s functionality that particular tool could provide. Next, we discussed other Microsoft products that are designed to be integrated with BI solutions built using SSAS OLAP cubes or data mining structures. These included Excel, Word, and Office SharePoint Server 2007. We also touched on the integration of SSAS into PerformancePoint Server. We concluded our conceptual discussion with a list and description of the languages involved in BI projects.

In Chapter 2, we work with the sample database AdventureWorksDW, which is included in SQL Server 2008, so that you get a quick prototype SSAS OLAP cube and data mining structure up and running. This is a great way to begin turning the conceptual knowledge you’ve gained from reading this chapter into practical understanding.
Chapter 6

Understanding SSAS in SSMS and SQL Server Profiler

We covered quite a bit of ground in the preceding five chapters—everything from the key concepts of business intelligence to concepts, languages, processes, and modeling methodologies. By now, we’re sure you’re quite ready to roll up your sleeves and get to work in the Business Intelligence Development Studio (BIDS) interface. Before you start, though, we have one more chapter’s worth of information. In this chapter, we’ll explore the ins and outs of some tools you’ll use when working with Microsoft SQL Server Analysis Services (SSAS) objects. After reading this chapter, you’ll be an expert in not only SQL Server Profiler but also SQL Server Management Studio (SSMS) and other tools that will make your work in SSAS very productive. We aim to provide valuable information in this chapter for all SSAS developers—from those of you who are new to the tools to those who have some experience. If you’re wondering when we’re going to get around to discussing BIDS, we’ll start that in Chapter 7, “Designing OLAP Cubes Using BIDS.”

Core Tools in SQL Server Analysis Services

We’ll begin this discussion of the tools you’ll use to design, create, populate, secure, and manage OLAP cubes by taking an inventory. That is, we’ll first list all the tools that are part of SQL Server 2008. Later in this chapter, we’ll look at useful utilities and other tools you can get for free or at low cost that are not included with SQL Server 2008. We mention these because we’ve found them to be useful for production work. Before we list our inventory, we’ll talk a bit about the target audience—that is, who Microsoft thinks will use these tools. We share this information so that you can choose the tools that best fit your style, background, and expectations.

SQL Server 2008 does not install SSAS by default. When you install SSAS, several tools are installed with the SSAS engine and data storage mechanisms. Also, an SSAS installation does not require that you install SQL Server Database Engine Services. You’ll probably want to install SQL Server Database Engine Services, however, because some of the tools that install with it are useful with SSAS cubes. SQL Server 2008 installation follows the minimum-installation paradigm, so you’ll probably want to verify which components you’ve installed before exploring the tools for SSAS. To come up with this inventory list, follow these steps:

1. Run Setup.exe from the installation media.
2. On the left side of the Installation Center screen, click Installation and then select New SQL Server Stand-Alone Installation Or Add Features To An Existing Installation on the resulting screen.

3. Click OK after the system checks complete, and click the Install button on the next screen.

4. Click Next on the resulting screen. Then select the Add Features To An Existing Instance Of SQL Server 2008 option, and select the appropriate instance of SQL Server from the list. After you select the particular instance you want to verify, click Next to review the features that have been installed for this instance.

Who Is an SSAS Developer?

Understanding the answer to this question will help you to understand the broad variety of tools available with SSAS OLAP cubes in SQL Server 2008. Unlike classic .NET developers, SSAS developers are people with a broad and varied skill set. Microsoft has provided some tools for developers who are comfortable writing code and other tools for developers who are not. In fact, the bias in SSAS development favors those who prefer to create objects by using a graphical user interface rather than by writing code. We mention this specifically because we’ve seen traditional application developers, who are looking for a code-first approach, become frustrated with the developer interface Microsoft has provided.

In addition to providing a rich graphical user interface in most of the tools, Microsoft has also included wizards to further expedite the most commonly performed tasks. In our experience, application developers who are familiar with a code-first environment often fail to take the time to understand and explore the development environments available for SSAS. This results in frustration on the part of the developers and lost productivity on business intelligence (BI) projects.

We’ll start by presenting information at a level that assumes you’ve never worked with any version of Microsoft Visual Studio or Enterprise Manager (or Management Studio) before. Even if you have experience in one or both of these environments, you might still want to read this section. Our goal is to maximize your productivity by sharing our tips, best practices, and lessons learned.

Note in Figure 6-1 that some components are shared to the SQL Server 2008 instance, but others install only when a particular component is installed. As mentioned in previous chapters, SQL Server 2008 no longer ships with sample databases. If you want to install the AdventureWorks OLTP and OLAP samples, you must download them from CodePlex. For instructions on where to locate these samples and how to install them, see Chapter 1, “Business Intelligence Basics.”
After you’ve verified that everything you expected to be installed is actually installed in the particular instance of SSAS, you’re ready to start working with the tools. A variety of tools are included; however, you’ll do the majority of your design and development work in just one tool—BIDS.

For completeness, this is the list of tools installed with the various SQL Server components:

- **Import/Export Wizard** Used to import/export data and to perform simple transformations
- **Business Intelligence Development Studio** Primary SSAS, SSIS, and SSRS development environment
- **SQL Server Management Studio** Primary SQL Server (all components) administrative environment
- **SSAS Deployment Wizard** Used to deploy SSAS metadata (*.asdatabase) from one server to another
- **SSRS Configuration Manager** Used to configure SSRS
- **SQL Server Configuration Manager** Used to configure SQL Server components, including SSAS
- **SQL Server Error and Usage Reporting** Used to configure error/usage reporting—that is, to specify whether or not to send a report to Microsoft
- **SQL Server Installation Center**  New information center, as shown in Figure 6-2, which includes hardware and software requirements, baseline security, and installed features and samples
- **SQL Server Books Online**  Product documentation
- **Database Engine Tuning Advisor**  Used to provide performance tuning recommendations for SQL Server databases
- **SQL Server Profiler**  Used to capture activity running on SQL Server components, including SSAS
- **Report Builder 2.0**  Used by nondevelopers to design SSRS reports. This is available as a separate download and is not on the SQL Server installation media.

![Figure 6-2 The SQL Server Installation Center](image)

A number of GUI tools are available with a complete SQL Server 2008 installation. By *complete*, we mean that all components of SQL Server 2008 are installed on the machine. A full installation is not required, or even recommended, for production environments. The best practice for production environments is to create a *reduced attack surface* by installing only the components and tools needed to satisfy the business requirements. In addition, you should secure access to powerful tools with appropriate security measures. We’ll talk more about security in general later in this chapter, and we’ll describe best practices for locking
down tools in production environments. For now, we'll stay in an exploratory mode by installing everything and accessing it with administrator privileges to understand the capabilities of the various tools.

Because BIDS looks like the Visual Studio interface, people often ask us if an SSAS instance installation requires a full Visual Studio install. The answer is no. If Visual Studio is not installed on a machine with SSAS, BIDS, which is subset of Visual Studio, installs. If Visual Studio is installed, the BIDS project templates install inside of the Visual Studio instance on that machine.

The core tools you'll use for development of OLAP cubes and data mining structures in SSAS are BIDS, SSMS, and SQL Server Profiler. Before we take a closer look at these GUI tools, we'll mention a couple of command-line tools that are available to you as well.

In addition to the GUI tools, several command-line tools are installed when you install SQL Server 2008 SSAS. You can also download additional free tools from CodePlex. One tool available on the CodePlex site is called BIDS Helper, which you can find at http://www.codeplex.com/bidshelper. It includes many useful features for SSAS development. You can find other useful tools on CodePlex as well. We'll list only a couple of the tools that we've used in our projects:

- **ascmd.exe** Allows you to run XMLA, DMX, or DMX scripts from the command prompt (available at http://www.codeplex.com/MSFTASProdSamples)
- **SQLPS.exe** Allows you to execute Transact-SQL via the Windows PowerShell command line—mostly used when managing SQL Server source data for BI projects.

As we mentioned, you'll also want to continue to monitor CodePlex for new community-driven tools and samples. Contributors to CodePlex include both Microsoft employees and non-Microsoft contributors.

**Baseline Service Configuration**

Now that we've seen the list of tools, we'll take a look at the configuration of SSAS. The simplest way to do this is to use SQL Server Configuration Manager. In Figure 6-3, you can see that on our demo machine, the installed instance of SSAS is named MSSQLSERVER and its current state is set to Running. You can also see that the Start Mode is set to Automatic. The service log on account is set to NT AUTHORITY\Network Service. Of course, your settings may vary from our defaults.

Although you can also see this information using the Control Panel Services item, it's recommended that you view and change any of this information using the SQL Server Configuration Manager. The reason for this is that the latter tool properly changes associated registry settings when changes to the service configuration are made. This association is not necessarily observed if configuration changes are made using the Control Panel Services item.
FIGURE 6-3 SQL Server Configuration Manager

The most important setting for the SSAS service itself is the Log On (or service) account. You have two choices for this setting. You can select one of three built-in accounts: Local System, Local Service, or Network Service. If you do not do that, you can use an account that has been created specifically for this purpose either locally or on your domain. Figure 6-4 shows the dialog box in SQL Server Configuration Manager where you set this. Which one of these choices is best and why?

Our answer depends on which environment you’re working in. If you’re exploring or setting up a development machine in an isolated domain, or as a stand-alone server, you can use any account. As we show in Figures 6-3 and 6-4, we usually just use a local account that has been added to the local administrator’s group for this purpose. We do remind you that this circumvention of security is appropriate only for nonproduction environments, however.

FIGURE 6-4 The SSAS service account uses a Log On account.

SQL Server Books Online contains lots of information about log-on accounts. You’ll want to review the topics “Setting Up Windows Service Accounts” and “Choosing the Service
Account” for details on exactly which permissions and rights are needed for your particular service (user) account.

We'll distill the SQL Server Books Online information down a bit because, in practice, we've seen only two configurations. Most typically, we see our clients use either a local or domain lower-privileged (similar to a regular user) account. Be aware that for SSAS-only installations, the ability to use a domain user account as the SSAS logon account is disabled. One important consideration specific to SSAS is that the service logon account information is used to encrypt SSAS connection strings and passwords. This is a further reason to use an isolated, monitored, unique, low-privileged account.

Service Principal Names

What is a Service Principal Name (SPN)? An SPN is a particular type of Domain Name System (DNS) record. When you associate a service account with SSAS at the time of installation, an SPN record is created. If your SSAS server is part of a domain, this record is stored in your domain DNS database. It's required for some authentication scenarios (particular client tools). If you change the service account for SSAS, you must delete the original SPN and create a new SPN record for DNS. You can do this with the setSPN.exe tool available from the Windows Server Resource Kit.

Here's further guidance from SQL Server Books Online:

> “Service SIDs are available in SQL Server 2008 on Windows Server 2008 and Windows Vista operating systems to allow service isolation. Service isolation provides services a way to access specific objects without having to either run in a high-privilege account or weaken the object’s security protection. A SQL Server service can use this identity to restrict access to its resources by other services or applications. Use of service SIDs also removes the requirement of managing different domain accounts for various SQL Server services.

A service isolates an object for its exclusive use by securing the resource with an access control entry that contains a service security ID (SID). This ID, referred to as a per-service SID, is derived from the service name and is unique to that service. After a SID has been assigned to a service, the service owner can modify the access control list for an object to allow access to the SID. For example, a registry key in HKEY_LOCAL_MACHINE\SOFTWARE would normally be accessible only to services with administrative privileges. By adding the per-service SID to the key’s ACL, the service can run in a lower-privilege account, but still have access to the key.”

Now that you’ve verified your SSAS installation and checked to make sure the service was configured correctly and is currently running, it’s time to look at some of the tools you’ll use to work with OLAP objects. For illustration, we’ve installed the AdventureWorks DW2008 sample OLAP project found on CodePlex, because we believe it’s more meaningful to explore
the various developer surfaces with information already in them. In the next chapter, we’ll build a cube from start to finish. So if you’re already familiar with SSMS and SQL Server Profiler, you might want to skip directly to that chapter.

SSAS in SSMS

Although we don’t believe that the primary audience of this book is administrators, we do choose to begin our deep dive into the GUI tools with SSMS. SQL Server Management Studio is an administrative tool for SQL Server relational databases, SSAS OLAP cubes and data mining models, SSIS packages, SSRS reports, and SQL Server Compact edition data. The reason we begin here is that we’ve found the line between SSAS developer and administrator to be quite blurry. Because of a general lack of knowledge about SSAS, we’ve seen many an SSAS developer being asked to perform administrative tasks for the OLAP cubes or data mining structures that have been developed. Figure 6-5 shows the connection dialog box for SSMS.

![SSMS Connection Dialog](image)

**FIGURE 6-5** SSMS is the unified administrative tool for all SQL Server 2008 components.

After you connect to SSAS in SSMS, you are presented with a tree-like view of all SSAS objects. The top-level object is the server, and databases are next. Figure 6-6 shows this tree view in Object Explorer. An OLAP database object is quite different than a relational database object, which is kept in SQL Server’s RDBMS storage. Rather than having relational tables, views, and stored procedures, an OLAP database consists of data sources, data source views, cubes, dimensions, mining structures, roles, and assemblies. All of these core object types are represented by folders in the Object Explorer tree view. These folders can contain child objects as well, as shown in Figure 6-6 in the Measure Groups folder that appears under a cube in the Cubes folder.

So what are all of these objects? Some should be familiar to you based on our previous discussions of OLAP concepts, including cubes, dimensions, and mining structures. These are the basic storage units for SSAS data. You can think of them as somewhat analogous to relational tables and views in that respect, although structurally, OLAP objects are not relational but multidimensional.
Figure 6-6 Object Explorer lists all SSAS objects in a tree-like structure.

Data sources represent connections to source data. We’ll be exploring them in more detail in this chapter and the next one. Data source views are conceptually similar to relational views in that they represent a view of the data from one or more defined data sources in the project. Roles are security groups for SSAS objects. Assemblies are .NET types to be used in your SSAS project—that is, they have been written in a .NET language and compiled as .dlls.

The next area to explore in SSMS is the menus. Figure 6-7 shows both the menu and standard toolbar. Note that the standard toolbar displays query types for all possible components—that is, relational (Transact-SQL) components, multidimensional OLAP cubes (MDX), data mining structures (DMX), administrative metadata for OLAP objects (XMLA), and SQL Server Compact edition.

Figure 6-7 The SSMS standard toolbar displays query options for all possible SQL Server 2008 components.

It’s important that you remember the purpose of SSMS—administration. When you think about this, the fact that it’s straightforward to view, query, and configure SSAS objects—but more complex to create them—is understandable. You primarily use BIDS to create OLAP objects. Because this is a GUI environment, you’re also provided with guidance should you
want to examine or query objects. Another consideration is that SSMS is *not* an end-user tool. Even though the viewers are sophisticated, SSMS is designed for SSAS administrators.

**How Do I View OLAP Objects?**

SSMS includes many object viewers. You’ll see these same viewers built into other tools designed to work with SSAS, such as BIDS. You’ll also find versions of these viewers built into client tools, such as Microsoft Office Excel 2007. The simplest and fastest way to explore cubes and mining models in SSMS is to locate the object in the tree view and then to right-click on it. For cubes, dimensions, and mining structures, the first item on the shortcut menu is Browse.

We’ll begin our exploration with the Product dimension. Figure 6-8 shows the results of browsing the Product dimension. For each dimension, we have the ability to drill down to see the member names at the defined levels—in this case, at the category, subcategory, and individual item levels. In addition to being able to view the details of the particular dimensional (rollup) hierarchy, we can also select a localization (language) and member properties that might be associated with one or more levels of a dimension. In our example, we have elected to include color and list price in our view for the AWC Logo Cap clothing item. These member properties have been associated with the item (bottom) level of the product dimension.

![Dimension Browser](image)

**Figure 6-8** The dimension browser enables you to view the data in a dimension.
The viewing options available for dimensions in SSMS include the ability to filter and implement dimension writeback. Writeback has to be enabled on the particular dimension, and the connected user needs to have dimension writeback permission to be permitted to use this action in SSMS.

In addition to being able to view the dimension information, you can also see some of the metadata properties by clicking Properties on the shortcut menu. Be aware that you’re viewing a small subset of structural properties in SSMS. As you would expect, these properties are related to administrative tasks associated with a dimension. Figure 6-9 shows the general dialog box of the Product dimension property page. Note that the only setting you can change in this view is Processing Mode. We'll examine the various processing modes for dimensions and the implications of using particular selections in Chapter 9, “Processing Cubes and Dimensions.”

![Figure 6-9](image)

The Dimension Properties dialog box in SSMS shows administrative properties associated with a dimension.

In fact, you can process OLAP dimensions, cubes, and mining structures in SSMS. You do this by right-clicking on the object and then choosing Process on the shortcut menu. Because this topic requires more explanation, we’ll cover it in Chapter 9. Suffice it to say at this point that, from a high level, SSAS object processing is the process of copying data from source locations into destination containers and performing various associated processing actions on this data as part of the loading process. As you might expect, these processes can be complex and require that you have an advanced understanding of the SSAS objects before you try to implement the objects and tune them. For this reason, we’ll explore processing in Part II of this book.

If you’re getting curious about the rest of the metadata associated with a dimension, you can view this information in SSMS as well. This task is accomplished by clicking on the shortcut menu option Script Dimension As, choosing Create To, and selecting New Query Editor Window. The results are produced as pure XMLA script. You’ll recall from earlier in the book that XMLA is a dialect of XML.
What you’re looking at is a portion of the XMLA script that is used to define the structure of the dimension. Although you can use Notepad to create SSAS objects, because they are entirely based on an XMLA script, you’ll be much more productive using the graphical user interface in BIDS to generate this metadata script. The reason you can generate XMLA in SSMS is that when you need to re-create OLAP objects, you need the XMLA to do so. So XMLA is used to copy, move, and back up SSAS objects. In fact, you can execute the XMLA query you’ve generated using SSMS. We take a closer look at querying later in this chapter.

Now that you’ve seen how to work with objects, we’ll simply repeat the pattern for OLAP cubes and data mining structures. That is, we’ll first view the cube or structure using the Browse option, review configurable administrative properties, and then take a look at the XMLA that is generated. We won’t neglect querying either. After we examine browsing, properties, and scripting for cubes and models, we’ll look at querying the objects using the appropriate language—MDX, DMX, or XMLA.

How Do I View OLAP Cubes?

The OLAP cube browser built into SSMS is identical to the one you’ll be working with in BIDS when you’re developing your cubes. It’s a sophisticated pivot table–style interface. The more familiar you become with it, the more productive you’ll be. Just click Browse on the shortcut menu after you’ve selected any cube in the Object Explorer in SSMS to get started. Doing this presents you with the starter view. This view includes the use of hint text (such as Drop Totals Of Detail Field Fields Here) in the center work area that helps you understand how best to use this browser.

On the left side of the browser, you’re presented with another object browser. This is where you select the items (or aspects) of the cube you want to view. You can select measures, dimension attributes, levels, or hierarchies. Note that you can select a particular measure as a filter from the drop-down list box at the top of this object browser. Not only will this filter the measures selected, it will also filter the associated dimensions so that you’re selecting from an appropriate subset as you build your view.

Measures can be viewed in the Totals work area. Dimension attributes, levels, or hierarchies can be viewed on the Rows, Columns, or Filters (also referred to as slicers) axis. These axes are labeled with the hint text Drop xxx Fields Here. We’ll look at Filters or Slicers axes in more detail later in this chapter.

At the top of the browser, you can select a perspective. A perspective is a defined view of an OLAP cube. You can also select a language. Directly below that is the Filter area, where you can create a filter expression (which is actually an MDX expression) by dragging and dropping a dimension level or hierarchy into that area and then completing the rest of the information—that is, configuring the Hierarchy, Operator, and Filter Expression options. We’ll be demonstrating this shortly. To get started, drag one or more measures and a couple of dimensions to the Rows and Columns axes. We’ll do this and show you our results in Figure 6-10.
To set up our first view, we filtered our list by the Internet Sales measure group in the object browser. Next we selected Internet Sales Amount and Internet Order Quantity as our measures and dragged them to that area of the workspace. We then selected the Product Categories hierarchy of the Product dimension and dragged it to the Rows axis. We also selected the Sales Territory hierarchy from the Sales Territory dimension and dragged it to the Columns axis.

We drilled down to show detail for the Accessories product category and Gloves subcategory under the Clothing product category on the Rows axis. And finally, we filtered the Sales Territory Group information to hide the Pacific region. The small blue triangle next to the Group label indicates that a filter has been applied to this data. If you want to remove any item from the work area, just click it and drag it back to the left side (list view). Your cursor will change to an X, and the item will be removed from the view.

It’s much more difficult to write the steps as we just did than to actually do them! And that is the point. OLAP cubes, when correctly designed, are quick, easy, and intuitive to query. What you’re actually doing when you’re visually manipulating the pivot table surface is generating MDX queries. The beauty of this interface is that end users can do this as well. Gone are the days that new query requests of report systems require developers to rewrite (and tune) database queries.

FIGURE 6-10 Building an OLAP cube view in SSMS
Let’s add more sophistication to our view. To do this, we’ll use the filter and slicer capabilities of the cube browser. We’ll also look at the pivot capability and use the built-in common queries. To access the latter, you can simply right-click on a measure in the measures area of the designer surface and select from a shortcut menu, which presents you with common queries, such as Show Top 10 Values and other options as well. Figure 6-11 shows our results.

![Figure 6-11 Results of building an OLAP cube view in SSMS](image)

Here are the steps we took to get there.

First we dragged the Promotions hierarchy from the Promotion dimension to the slicer (Filter Fields) area. We then set a filter by clearing the check boxes next to the Reseller promotion dimension members. This resulted in showing data associated only with the remaining members. Note that the label indicates this as well by displaying the text “Excluding: Reseller.”

We then dragged the Ship Date.Calendar Year hierarchy from the Ship Date dimension; we set the Operator area to Equal, and in the Filter Expression area we chose the years 2003 and 2004 from the available options. Another area to explore is the nested toolbar inside of the Browser subtab. Using buttons on this tab toolbar, you can connect as a different user and sort, filter, and further manipulate the data shown in the working pivot table view. Note that there is an option to show only the top or bottom values (1, 2, 5, 10, or 25 members or a percentage). Finally, if drillthrough is enabled for this cube, you can drill through using this browser by right-clicking on a data cell and selecting that option. Drillthrough allows you
to see additional columns of information that are associated with the particular fact item (or measure) that you’ve selected. You should spend some time experimenting with all the toolbar buttons so that you’re thoroughly familiar with the different built-in query options. Be aware that each time you select an option, you’re generating an MDX query to the underlying OLAP cube.

Note also that when you select cells in the grid, additional information is shown in a tooltip. You can continue to manipulate this view for any sort of testing purposes. Possible actions also include pivoting information from the rows to the column’s axis, from the slicer to the filter, and so on. Conceptually, you can think of this manipulation as somewhat similar to working with a Rubik’s cube. Of course, OLAP cubes generally contain more than three dimensions, so this analogy is just a starting point.

Viewing OLAP Cube Properties and Metadata

If you next want to view the administrative properties associated with the particular OLAP cube that you’re working with (as you did for dimensions), you simply right-click that cube in the SSMS Object Browser and then click Properties. Similar to what you saw when you performed this type of action on an OLAP dimension, you’ll then see a dialog box similar to the one shown in Figure 6-12 that allows you to view some properties. The only properties you can change in this view are those specifically associated with cube processing. As mentioned previously, we’ll look at cube processing options in more detail in Chapter 9.

FIGURE 6-12 OLAP cube properties in SSMS
By now, you can probably guess how you’d generate an XMLA metadata script for an OLAP cube in SSMS. Just right-click the cube in the object browser and click Script Cube As on the shortcut menu, choose Create To, and select New Query Editor Window. Note also that you can generate XMLA scripts from inside any object property window. You do this by clicking the Script button shown at the top of Figure 6-12.

Now that we’ve looked at both OLAP dimensions and cubes in SSMS, it’s time to look at a different type of object—SSAS data mining structures. Although conceptually different, data mining (DM) objects are accessed using methods identical to those we’ve already seen—that is, browse, properties, and script.

How Do I View DM Structures?

As we begin our tour of SSAS data mining structures, we need to remember a couple of concepts that were introduced earlier in this book. Data mining structures are containers for one or more data mining models. Each data mining model uses a particular data mining algorithm. Each data mining algorithm has one or more data mining algorithm viewers associated with it. Also, each data mining model can be viewed using a viewer as well via a lift chart. New to SQL Server 2008 is the ability to perform cross validation. Because many of these viewing options require more explanation about data mining structures, at this point we’re going to stick to the rhythm we’ve established in this chapter—that is, we’ll look at a simple view, followed by the object properties, and then the XMLA. Because the viewers are more complex for data mining objects than for OLAP objects, we’ll spend a bit more time exploring.

We’ll start by browsing the Customer Mining data mining structure. Figure 6-13 shows the result. What you’re looking at is a rendering of the Customer Clusters data mining model, which is part of the listed structure. You need to select the Cluster Profiles tab to see the same view. Note that you can make many adjustments to this browser, such as legend, number of histogram bars, and so on. At this point, some of the viewers won’t make much sense to you unless you have a background using data mining. Some viewers are more intuitive than others. We’ll focus on showing those in this section.

It’s also important for you to remember that although these viewers are quite sophisticated, SSMS is not an end-user client tool. We find ourselves using the viewers in SSMS to demonstrate proof-of-concept ideas in data mining to business decision makers (BDMs), however. If these viewers look familiar to you, you’ve retained some important information that we presented in Chapter 2, “Visualizing Business Intelligence Results.” These viewers are nearly identical to the ones that are intended for end users as part of the SQL Server 2008 Data Mining Add-ins for Office 2007. When you install the free add-ins, these data mining viewers become available as part of the Data Mining tab on the Excel 2007 Ribbon. Another consideration for you is this—similar to the OLAP cube pivot table viewer control in SSMS that we just finished looking at, these data mining controls are also part of BIDS.
In our next view, shown in Figure 6-14, we’ve selected the second mining model, Subcategory Associations, associated with the selected mining structure. Because this second model has been built using a different mining algorithm, after we make this selection the Viewer drop-down list automatically updates to list the associated viewers available for that particular algorithm. We then chose the Dependency Network tab from the three available views and did a bit of tuning of the view, using the embedded toolbar to produce the view shown (for example, sized it to fit, zoomed it, and so on).

An interesting tool that is part of this viewer is the slider control on the left side. This control allows you to dynamically adjust the strength of association shown in the view. We’ve found that this particular viewer is quite intuitive, and it has helped us to explain the power of data mining algorithms to many nontechnical users.

As you did with the OLAP pivot table viewer, you should experiment with the included data mining structure viewers. If you feel a bit frustrated because some visualizations are not yet meaningful to you, we ask that you have patience. We devote Chapter 12, “Understanding Data Mining Structures,” to a detailed explanation of the included data mining algorithms. In that chapter, we’ll provide a more detailed explanation of most included DM views.
Part II  Microsoft SQL Server 2008 Analysis Services for Developers

Figure 6-14  Data mining structure viewer in SSMS showing the Dependency Network view for the Microsoft Association algorithm

Tip  You can change any of the default color schemes for the data mining viewers in SSMS by adjusting the colors via Tools, Options, Designers, Analysis Services Designers, Data Mining Viewers.

Because the processes for viewing the data mining object administrative properties and for generating an XMLA script of the object’s metadata are identical to those used for OLAP objects, we won’t spend any more time reviewing them here.

How Do You Query SSAS Objects?

As with relational data, you have the ability to write and execute queries against multidimensional data in SSMS. This is, however, where the similarity ends. The reason is that when you work in an RDBMS, you need to write any query to the database using SQL. Even if you generate queries using tools, you’ll usually choose to perform manual tuning of those queries. Tuning steps can include rewriting the SQL, altering the indexing on the involved tables, or both.

SSAS objects can and sometimes are queried manually. However, the extent to which you’ll choose to write manual queries will be considerably less than the extent to which you’ll query relational sources. What are the reasons for this? There are several:

- MDX and DMX language expertise is rare among the developer community. With less experienced developers, the time to write and optimize queries manually can be prohibitive.
OLAP cube data is often delivered to end users via pivot table–type interfaces (that is, Excel, or some manual client that uses a pivot table control). These interfaces include the ability to generate MDX queries by dragging and dropping members of the cube on the designer surface—in other words, by visual query generation.

SSMS and BIDS have many interfaces that also support the idea of visual query generation for both MDX and DMX. This feature is quite important to developer productivity.

What we’re saying here is that although you can create manual queries, and SSMS is the place to do this, you’ll need to do this significantly less frequently while working with SSAS objects (compared to what you have been used to with RDBMS systems). It’s very important for you to understand and embrace this difference. Visual development does not mean lack of sophistication or power in the world of SSAS.

As you move toward understanding MDX and DMX, we suggest that you first monitor the queries that SSMS generates via the graphical user interface. SQL Server Profiler is an excellent tool to use when doing this.

**What Is SQL Server Profiler?**

SQL Server Profiler is an activity capture tool for the database engine and SSAS that ships with SQL Server 2008. SQL Server Profiler broadly serves two purposes. The first is to monitor activity for auditing or security purposes. To that end, SQL Server Profiler can be easily configured to capture login attempts, access specific objects, and so on. The other main use of the tool is to monitor activity for performance analysis. SQL Server Profiler is a powerful tool—when used properly, it’s one of the keys to understanding SSAS activity. We caution you, however, that SQL Server Profiler can cause significant overhead on production servers. When you’re using it, you should run it on a development server or capture only essential information.

SQL Server Profiler captures are called *traces*. Appropriately capturing only events (and associated data) that you’re interested in takes a bit of practice. There are many items you can capture! The great news is that after you’ve determined the important events for your particular business scenario, you can save your defined capture for reuse as a trace template.

If you’re familiar with SQL Server Profiler from using it to monitor RDBMS data, you’ll note that when you set the connection to SSAS for a new trace, SQL Server Profiler presents you with a set of events that is specific to SSAS to select from. See the SQL Server Books Online topics “Introduction to Monitoring Analysis Services with SQL Server Profiler” and “Analysis Services Event Classes” for more detailed information. Figure 6-15 shows some of the events that you can choose to capture for SSAS objects. Note that in this view, we’ve selected Show All Events in the dialog box. This switch is off by default.

After you’ve selected which events (and what associated data) you want to capture, you can run your trace live, or you can save the results either to a file or to a relational table for you
to rerun and analyze later. The latter option is helpful if you want to capture the event on a production server and then replace the trace on a development server for analysis and testing of queries.

At this point, we're really just going to use SQL Server Profiler to view MDX queries that are generated when you manipulate the dimension and cube browsers in SSMS. The reason we're doing this is to introduce you to the MDX query language. You can also use SQL Server Profiler to capture generated DMX queries for data mining structures that you manipulate using the included browsers in SSMS.

To see how query capture works, just start a trace in SQL Server Profiler, using all of the default capture settings, by clicking Run on the bottom right of the Trace Properties dialog box. With the trace running, switch to SSMS, right-click on the Adventure Works sample cube in the object browsers, click Browse, and then drag a measure to the pivot table design area.

We dragged the Internet Sales Amount measure for our demo. After you've done that, switch back to SQL Server Profiler and then click on the pause trace button on the toolbar. Scroll through the trace to the end, where you should see a line with the EventClass showing Query End and EventSubclass showing 0 - MDXQuery. Then click that line in the trace. Your results should look similar to Figure 6-16.

Note that you can see the MDX query that was generated by your drag action on the pivot table design interface in SSMS. This query probably doesn't seem very daunting to you, particularly if you've worked with Transact-SQL before. Don't be fooled, however; this is just the tip of the iceberg.
Chapter 6  Understanding SSAS in SSMS and SQL Server Profiler

Figure 6-16 SQL Server Profiler allows you to view MDX query text details.

Now let’s get a bit more complicated. Click the Play button in SQL Server Profiler to start the trace again. After that, return to the SSMS OLAP cube pivot table browse area and then drag and drop some dimension information (hierarchies or members) to the rows, columns, slicer, and filter areas. After you have completed this, return to SQL Server Profiler and again pause your trace and then examine the MDX query that has been generated. Your results might look similar to what we show in Figure 6-17. You can see if you scroll through the trace that each action you performed by dragging and dropping generated at least one MDX query.

Figure 6-17 Detail of a complex MDX query

We find SQL Server Profiler to be an invaluable tool in helping us to understand exactly what type of MDX query is being generated by the various tools (whether developer, administrator, or end user) that we use. Also, SQL Server Profiler does support tracing data mining activity. To test this, you can use the SSMS Object Browser to browse any data mining model while a SQL Server Profiler trace is active. In the case of data mining, however, you’re not presented with the DMX query syntax. Rather, what you see in SQL Server Profiler is the text of the call to a data mining stored procedure. So the results in SQL Server Profiler look something like this:

```
```

These results are also strangely categorized as 0 - MDXQuery type queries in the EventSubclass column of the trace. You can also capture data mining queries using SQL Server Profiler. These queries are represented by the EventSubclass type 1 – DMXQuery in SQL Server Profiler.
We'll return to SQL Server Profiler later in this book, when we discuss auditing and compliance. Also, we'll take another look at this tool in Chapters 10 and 11, which we devote to sharing more information about manual query and expression writing using the MDX language. Speaking of queries, before we leave our tour of SSMS, we'll review the methods you can use to generate and execute manual queries in this environment.

Using SSAS Query Templates

Another powerful capability included in SSMS is that of being able to write and execute queries to SSAS objects. These queries can be written in three languages: MDX, DMX, and XMLA. At this point, we're not yet ready to do a deep dive into the syntax of any of these three languages; that will come later in this book. Rather, here we'd like to understand the query execution process. To that end, we'll work with the included query templates for these three languages. To do this, we need to choose Template Explorer from the View menu, and then click the Analysis Services (cube) icon to show the three folders with templated MDX, DMX, and XMLA queries. The Template Explorer is shown in Figure 6-18.
You can see that the queries are further categorized into functionality type in child folders under the various languages—such as Model Content and Model Management under DMX. You can also create your own folders and templates in the Template Explorer by right-clicking and then clicking New. After you do this, you’re actually saving the information to this location on disk: C:\Users\Administrator\AppData\Roaming\Microsoft\Microsoft SQL Server\100\Tools\Shell\Templates\AnalysisServices.

Using MDX Templates

Now that you’ve opened the templates, you’ll see that for MDX there are two types of queries: expressions and queries. Expressions use the syntax With Member and create a calculated member as part of a sample query. You can think of a calculated member as somewhat analogous to a calculated cell or set of cells in an Excel workbook, with the difference being that calculated members are created in $n$-dimensional OLAP space. We’ll talk in greater depth about when, why, and how you choose to use calculated members in Chapter 9.

Queries retrieve some subset of an OLAP cube as an ADO.MD CellSet result, and they do not contain calculated members. To execute a basic MDX query, simply double-click the Basic Query template in the Template Explorer and then connect to SSAS. You can optionally write queries in a disconnected state and then, when ready, connect and execute the query. This option is available to reduce resource consumption on production servers.

You need to fill the query parameters with actual cube values before you execute the query. Notice that the query window opens yet another metadata explorer in addition to the default Object Explorer. You’ll probably want to close Object Explorer when executing SSAS queries in SSMS. Figure 6-19 shows the initial cluttered, cramped screen that results if you leave all the windows open. It also shows the MDX parser error that results if you execute a query with errors. (See the bottom window, in the center of the screen, with text underlined with a squiggly line.)

Now we’ll make this a bit more usable by hiding the Object Explorer and Template Explorer views. A subtle point to note is that the SSAS query metadata browser includes two filters: a Cube filter and, below it, a Measure Group filter. The reason for this is that SSAS OLAP cubes can contain hundreds or even thousands of measure groups.

Figure 6-20 shows a cleaned-up interface. We’ve left the Cube filter set at the default, Adventure Works, but we’ve set the Measure Group filter to Internet Sales. This reduces the number of items in the viewer, as it shows only items that have a relationship to measures associated with the selected measure group. Also note that in addition to a list of metadata, this browser includes a second nested tab called Functions. As you’d expect, this tab contains an MDX function language reference list.
You might be wondering why you’re being presented with yet another metadata interface, particularly because you’re inside of a query-writing tool. Aren’t you supposed to be writing the code manually here? Nope, not yet. Here’s the reason why—MDX object naming is not as straightforward as it looks. For example, depending on uniqueness of member names in a dimension, you sometimes need to list the ordinal position of a member name; at other times, you need to actually list the name. Sound complex? It is. Dragging and dropping metadata onto the query surface can make you more productive if you’re working with manual queries.

To run the basic query, you need to replace the items shown in the sample query between angle brackets—that is, <some value>—with actual cube metadata. Another way to understand this is to select Specify Values For Template Parameters on the Query menu. You can either type the information into the Template Parameters dialog box that appears, or you can click on any of the metadata from the tree view in the left pane and then drag it and drop it onto the designer surface template areas.
We'll use the latter approach to build our first query. We'll start by dragging the cube name to the From clause. Next we'll drag the Customers.Customer Geography hierarchy from the Customer dimension to the On Columns clause. We'll finish by dragging the Date.Calendar Year member from the Date hierarchy and Calendar hierarchy to the On Rows clause. We'll ignore the Where clause for now. As with Transact-SQL queries, if you want to execute only a portion of a query, just select the portion of interest and press F5. The results are shown in Figure 6-21.

![SSMS SSAS query screen with fewer items in the viewer](image1)

**FIGURE 6-20** The SSMS SSAS query screen with fewer items in the viewer

![SSMS SSAS query using simple query syntax](image2)

**FIGURE 6-21** SSMS SSAS query using simple query syntax
Do the results seem curious to you? Are you wondering which measure is being shown? Are you wondering why only the top-level member of each of the selected hierarchies is shown on columns and rows? As we’ve said, MDX is a deceptively simple language. If you’ve worked with Transact-SQL, which bears some structural relationship but is not very closely related at all, you’ll find yourself confounded by MDX. We do plan to provide you with a thorough grounding in MDX. However, we won’t be doing so until much later in this book—we’ll use Chapters 10 and 11 to unravel the mysteries of this multidimensional query language.

At this point in our journey, it’s our goal to give you an understanding of how to view and run prewritten MDX queries. Remember that you can also re-execute any queries that you’ve captured via SQL Server Profiler traces in the SSMS SSAS query environment as well.

Because we know that you’re probably interested in just a bit more about MDX, we’ll add a couple of items to our basic query. Notably, we’ll include the MDX Members function so that we can display more than the default member of a particular hierarchy on an axis. We’ll also implement the Where clause so that you can see the result of filtering. The results are shown in Figure 6-22.

We changed the dimension member information on Columns to a specific level (Country), and then we filtered in the Where clause to the United States only. The second part of the Where clause is an example of the cryptic nature of MDX. The segment [Product].[Product Categories].[Category].&[1] refers to the category named Bikes. We used the drag (metadata) and drop method to determine when to use names and when to use ordinals in the query. This is a time-saving technique you’ll want to use as well.

![MDX Query](image)

**FIGURE 6-22** MDX query showing filtering via the Where clause
Using DMX Templates

Next we’ll move to the world of DM query syntax. Again, we’ll start by taking a look at the included templates in the Template Explorer. They fall into four categories: Model Content, Model Management, Prediction Queries, and Structure Content.

When you double-click on a DMX query template, you’ll see that the information in the Metadata browser reflects a particular mining model. You can select different mining model metadata in the pick list at the top left of the browser. Also, the functions shown now include those specific to data mining. The Function browser includes folders for each data mining algorithm, with associated functions in the appropriate folder. Because understanding how to query data mining models requires a more complete understanding of the included algorithms, we’ll simply focus on the mechanics of DMX query execution in SSMS at this point.

To do this, we’ll double-click the Model Attributes sample DMX query in the Model Content folder that you access under DMX in the Template Explorer. Then we’ll work with the templated query in the workspace. As with templated MDX queries, the DMX templates indicate parameters with the <value to replace> syntax. You can also click the Query menu and select Specify Values For Template Parameters as you can with MDX templates. We’ll just drag the [Customer Clusters] mining model to the template replacement area. Note that you must include both the square brackets and the single quotes, as shown in Figure 6-23, for the query to execute successfully.

FIGURE 6-23 A DMX query showing mining model attributes
If you click on the Messages tab in the results area (at the bottom of the screen), you’ll see that some DMX queries return an object of type Microsoft.AnalysisServices.AdomdClient. AdomdDataReader. Other DMX query types return scalar values—that is, DMX prediction queries.

For more information, see the SQL Server Books Online topic “Data Mining Extensions (DMX) Reference.”

Using XMLA Templates

As with the previous two types of templates, SSMS is designed to be an XMLA query viewing and execution environment. The SSMS Template Explorer also includes a couple of types of XMLA sample queries. These are Management, Schema Rowsets, and Server Status. The XMLA language is an XML dialect, so structurally it looks like XML rather than a data structure query language, such as MDX or DMX (which look rather Transact-SQL-like at first glance). One important difference between MDX and XMLA is that XMLA is case-sensitive and space-sensitive, following the rules of XML in general.

Another important difference is that the Metadata and Function browsers are not available when you perform an XMLA query. Also, the results returned are in an XML format. In Figure 6-24, we show the results of executing the default Connections template. This shows detailed information about who is currently connected to your SSAS instance.

Be reminded that metadata for all SSAS objects—that is, OLAP dimensions, cubes, data mining models, and so on—can easily be generated in SSMS by simply right-clicking the object in the Object Browser and then clicking Script As. This is a great way to begin to understand the capabilities of XMLA. In production environments, you’ll choose to automate many administrative tasks using XMLA scripting.

The templates in SSMS represent a very small subset of the XMLA commands that are available in SSAS. For a more complete reference, see the SQL Server Books Online topic “Using XMLA for Analysis in Analysis Services (XMLA).” Another technical note: certain commands used in XMLA are associated with a superset of commands in the Analysis Services Scripting Language (ASSL). The MSDN documentation points out that ASSL commands include both data definition language (DDL) commands, which define and describe instances of SSAS and the particular SSAS database, and also XMLA action commands such as Create, which are then sent to the particular object named by the ASSL. ASSL information is also referred to as binding information in SQL Server Books Online.
Although our primary audience is developers, as discussed, we’ve found that many SSAS developers are also tasked with performing SSAS administrative tasks. For this reason, we spent an entire chapter exploring the SSMS SSAS interface. Also, we find that using SSMS to explore built objects is a gentle way to introduce OLAP and DM concepts to many interested people. We’ve used SSMS to demonstrate these concepts to audiences ranging from .NET developers to business analysts. Finally, we’d like to note that we’re continually amazed at the richness of the interface. Even after having spent many years with SSAS, we still frequently find little time-savers in SSMS.
Summary

In this chapter, we took a close look at the installation of SSAS. We then discussed some tools you’ll be using to work with SSAS objects. We took a particularly detailed look at SSMS because we’ve found ourselves using it time and time again on BI projects where we were tasked with being developers. Our real-world experience has been that SSAS developers must often also perform administrative tasks. So knowledge of SSMS can be a real time-saver. We included an introduction to SQL Server Profiler because we’ve found that many clients don’t use this powerful tool correctly or at all because of a lack of understanding of it.

By now, we’re sure you’re more than ready to get started developing your first OLAP cube using BIDS. That’s exactly what we’ll be doing starting in the next chapter and then continuing on through several additional chapters—being sure to hit all the important nooks and crannies along the way.
AccessMode property, 449
account intelligence, configuring in Business Intelligence Wizard, 243, 246–247
AcquireConnections method, 581
actions, SSAS
defined, 149, 233
drillthrough, 233, 236–238
regular, 233, 234–235
reporting, 233, 235–236
Add SourceSafe Database Wizard, 541–542
AddRow method, 582
administrative scripting, SSRS, 667–669
ADO.NET connection manager, 473
ADO.NET data flow destination, 485, 486
ADO.NET data flow source, 483, 497–498, 597
Agent. See SQL Server Agent
Aggregate data flow transformation, 486, 487, 488
Aggregation Design Wizard, 271–273
aggregations
Aggregation Design Wizard, 271–273
built-in types, 147
configuring, 262–263
creating designs manually, 277–278
defined, 9
and fact tables, 261
implementing, 270–278
key points, 271
main reason to add, 271
overview, 261–263
and query processing, 262
question of need for, 270–271
role of SQL Server Profiler, 275–277
in SQL Server cube store vs. Transact-SQL, 9
Usage-Based Optimization Wizard, 274–275
using with date functions, 324–326
viewing and refining, 262–263
Agile Software Development. See MSF (Microsoft Solution Framework) for Agile Software Development
Algorithm Parameters dialog box, 367, 376–377, 378, 710
algorithms, data mining
association category, 359
classification category, 358
clustering category, 359
configuring parameters, 367, 378
in data mining models, 45, 46, 46–47, 358
forecasting and regression category, 359
Microsoft Association algorithm, 391–393
Microsoft Clustering algorithm, 386–389
Microsoft Decision Trees algorithm, 381–383
Microsoft Linear Regression algorithm, 383
Microsoft Logistic Regression algorithm, 395–396
Microsoft Naïve Bayes algorithm, 376–381, 518
Microsoft Neural Network algorithm, 394–395
Microsoft Sequence Clustering algorithm, 389–390
Microsoft Time Series algorithm, 383–386
sequence analysis and prediction category, 359
supervised vs. unsupervised, 376
viewer types for, 369–370
ALTER MINING STRUCTURE (DMX) syntax, 366
Analysis Management Objects (AMOs), 31
Analysis Services. See SQL Server Analysis Services (SSAS)
Analysis Services Processing task, 430, 530
analytical activities. See OLAP
(online analytical processing)
Ancestors MDX function, 319–320
Application class, 596, 599
applications, custom, integrating SSIS packages in, 596–600
ascmd.exe tool, 157
ASMX files, 732
assemblies
compiled, using with SSAS objects, 196–197
custom, adding to SSRS reports, 647–649
custom, creating, 197
default, in SSAS, 197
association algorithms, 359
Association Wizard, 48
asynchronous data flow outputs, 459
asynchronous transformation, 583–586
attribute hierarchies, in OLAP cube design, 206–207
attribute ordering, specifying in Business Intelligence Wizard, 244, 250
attribute relationships, in BIDS, 139, 205, 207–209, 223
Audit transformation, 524
auditing. See also SQL Server Profiler
added features in SQL Server 2008, 111
using SQL Server Profiler, 109–110
authentication
credential flow in SSRS reports, 103
requesting access to Report Server, 610–611
AverageOfChildren aggregate function, 147
background processing, for reports and subscriptions, 612
backups and restores
overview, 106
for SQL Server Analysis Services, 106–107
for SQL Server Integration Services, 107–108, 112
for SQL Server Reporting Services, 108
Barnes and Noble, 28
BI solutions. See also Business Intelligence Development Studio (BIDS)
case studies, 27–33
common challenges, 54–56
common terminology, 11–15
complete solution components, 50–54
customizing data display in SQL Server 2008, 3
defined, 3
development productivity tips, 70
in law enforcement, 29
localization of data, 29
measuring solution ROIs, 56–58
MSF project phases, 65–71
multiple servers for solutions, 4
and Office SharePoint Server, 723–745
process and people issues, 61–83
project implementation scope, 28
query language options, 23–25
relational and non-relational data sources, 22–23
reporting interfaces, 3
role of Microsoft Excel, 36–37, 43–50
sales and marketing, 29
schema-first vs. data-first approaches to design phase, 130
security requirements for solutions, 95–106
skills necessary for projects, 72–76
software life cycle, 28
solution core components, 16–20
solution optional components, 21–23
testing project results, 70–71
top 10 scoping questions, 30
visualizing solutions, 34–36
Business Intelligence Development Studio (BIDS). See also SQL Server Analysis Services (SSAS)
BIDS Helper tool, 255, 490, 494, 510
BizTalk Server, 22
Boolean data type, 363
BottomCount MDX statement, 311
breakpoints, inserting, 505–506
build, defined, 259
building phase, MSF, 68–70
business intelligence (BI). See also Business Intelligence Development Studio (BIDS)
case studies, 27–33
common challenges, 54–56
common terminology, 11–15
defining, 3
development productivity tips, 70
in law enforcement, 29
localization of data, 29
measuring solution ROIs, 56–58
MSF project phases, 65–71
multiple servers for solutions, 4
and Office SharePoint Server, 723–745
process and people issues, 61–83
project implementation scope, 28
query language options, 23–25
relational and non-relational data sources, 22–23
reporting interfaces, 3
role of Microsoft Excel, 36–37, 43–50
sales and marketing, 29
/schema-first vs. data-first approaches to design phase, 130
security requirements for solutions, 95–106
skills necessary for projects, 72–76
software life cycle, 28
solution core components, 16–20
solution optional components, 21–23
testing project results, 70–71
top 10 scoping questions, 30
visualizing solutions, 34–36
Business Intelligence Wizard
accessing, 243
Create A Custom Member Formula, 244, 251
Define Account Intelligence, 243, 246–247
Define Currency Conversion, 244, 251–254
Define Dimension Intelligence, 243, 250
Define Semiadditive Behavior, 244, 250
Define Time Intelligence, 243, 245
Specify A Unary Operator, 244, 248–250
Specify Attribute Ordering, 244, 250
ByAccount aggregate function, 147
Cache scopes, for queries, 326
CacheMode property, 364
Calculated Columns sample package, 487
calculated measures, 148
calculated members
creating in Business Intelligence Wizard, 318, 320
creating in cube designer, 239–241
creating in query designer, 631
creating using WITH MEMBER statement, 307
defined, 175, 307
global vs. local, 631
permanent, creating using BIDS interface, 334–335
permanent, creating using MDX scripts, 335–336
pros and cons, 241
vs. stored measures, 298
Calculations tab, cube designer, 201, 239–242, 334–335
Capability Maturity Model Integration (CMMI), 65
CAS (code access security), 648–649
Cash Transform data flow transformation, 486
change data capture (CDC), 524, 531
Chart control, 638, 643
checkpoints, in SSIS packages configuring, 506
defined, 506
writing, 507
child tables, relationship to parent table, 5
Children MDX function, 300, 316, 321
Choose Toolbox Items dialog box, 591
classification algorithms, 358
classification matrix, 415–416
Clean Data Wizard, 705, 706–707
cloud-hosted data mining, 720–721
Cluster DMX function, 425
Cluster Wizard, Microsoft Visio, 717–718
ClusterDistance DMX function, 425
clustering algorithms, 359
ClusterProbability DMX function, 425
CMMI (Capability Maturity Model Integration), 65
code access security (CAS), 648–649
CodePlex Web site, 37–38, 86, 157
columns
in dimension tables, 121–122
in fact tables, 118–119, 146
variable-width, in data flow metadata, 456–457
command-line tools
ascmd.exe tool, 157
DTEEXEC utility, 440
DTEEXECUI utility, 440–441
DTUTIL utility, 441
installed with SQL Server 2008, 157
rsconfig.exe tool, 604
rs.exe tool, 609
SQLPS.exe tool, 157
CommandText property, 598
community technology preview (CTP) version, SQL Server 2008, 40
ComponentMetaData property, 580
components. See also Script component
compared with tasks, 444, 567–568
custom, in SSIS, 587–588
destination, 485–486, 586–587
in SSIS package data flows, 444
transformation, 486–488
Configuration Manager, Reporting Services, 102, 108, 155, 607, 609, 737
Configuration Manager, SQL Server, 94, 155, 157–158
Configuration Manager, SSRS.
    See Configuration Manager, Reporting Services
confusion matrix. See classification matrix
connection managers
    adding to packages, 473
ADO.NET, 473
custom, 588, 594
defined, 468
Flat File, 474
inclusion in Visual Studio package designers, 468
ODBC, 473
OLE DB, 473
overview, 448–450
Raw File, 474
specifying for log providers, 502
types, 473–474
using in Script components, 580–581
using within Visual Studio, 473–474
Connections property, 571, 580
ConnectionString property, 581
constraints. See precedence constraints
containers
default error handling behavior, 499
generic group, 479
SSIS control flow, 478–479
content types
Continuous, 362
Cyclical, 362
defined, 361
detecting in Data Mining Wizard, 402
Discrete, 361
Discretized, 362
Key, 362
Key Sequence, 362, 363
Key Time, 362, 363
Ordered, 362
support for data types, 363
Table, 362
Continuous content type, 362
control flow designer
Connection Manager window in, 468
Data Flow task, 476, 477–478
Data Profiling task, 476
defined, 468
event handling, 500–501
Execute Process sample, 476–478
Execute Process task, 476, 477
Execute SQL tasks, 476, 476–477, 494
Foreach Loop containers, 476, 478
For Loop containers, 478
Sequence containers, 478
Task Host containers, 478
task overview, 476–478
Toolbox window in, 469
control flow, in SSIS packages
building custom tasks, 591–593
configuring task precedence, 480–481
container types, 478–479
Data Profiling task, 510–513
event handling, 450–451
logging events, 504
Lookup sample, 528
overview, 442–444
Script task, 567–568
copying SSIS packages to deploy, 552–553
Count aggregate function, 147
counters. See performance counters
Create A Custom Member Formula, Business Intelligence Wizard, 244, 251
CREATE KPI statement, 348
CreateNewOutputRows method

CreateNewOutputRows method, 582
CRISP-DM life cycle model,
399–400, 409
cross validation, 417–418
CTP (community technology
preview) version, SQL Server
2008, 40
cube browser, 41–42, 201
cube designer
accessing Business Intelligence
Wizard, 243
Actions tab, 201, 233–239
Aggregations tab, 201, 262–263,
275
Browser tab, 41–42, 201
Calculations tab, 201, 239–242,
334–335
Cube Structure tab, 201, 201–203
description, 201
Dimension Usage tab, 126–128,
134–135, 211–212, 215
KPIs tab, 201, 228, 345
opening dimension editor,
203–204
Partitions tab, 201, 264, 278
Perspectives tab, 201, 227
tool for building OLAP cubes,
198–204
Translations tab, 201
cube partitions
defined, 263
defining, 265–266
enabling writeback, 285–286
overview, 263–264
for relational data, 268–269
remote, 270
specifying local vs. remote, 270
in star schema source tables,
268–269
storage modes, 270
and updates, 532
Cube Wizard
building first OLAP cube, 218–223
Create An Empty Cube option,
199
Generate Tables In The Data
Source option, 199, 200
launching from Solution Explorer,
218
populating Dimension Usage tab,
128
Use Existing Tables option,
198–199, 200
CUBEPKIMEMBER OLAP function,
683
CUBEMEMBER OLAP function, 683
CUBEMEMBERPROPERTY OLAP
function, 683
CUBERANKEDMEMBER OLAP
function, 683
CUBESET OLAP function, 683
CUBESETCOUNT OLAP function, 683
CUBEVALUE OLAP function, 683
currency conversions, configuring
in Business Intelligence Wizard,
244, 251–254
CurrentMember MDX function, 232,
313
custom applications, integrating
SSIS packages in, 596–600
custom foreach enumerators,
594–595
custom member formulas, creating
in Business Intelligence Wizard,
244, 251
custom SSIS objects
control flow tasks, 591–593
data flow components, 588–591,
593–594
deploying, 589–591
implementing user interfaces,
593, 594
overview, 587–588
registering assemblies in GAC, 590
signing assemblies, 589
customer relationship management
(CRM) projects, skills needed for
reporting, 75
Cyclical content type, 362
D
Data Connection Wizard, 672
data dictionaries, 67
data flow designer
advanced edit mode, 484
Calculated Columns sample
package, 487
Connection Manager sample
package, 487
debugging Script window in,
468
Data Connection Wizard, 672
data dictionaries, 67
data flow designer
advanced edit mode, 484
Calculated Columns sample
package, 487
debugging Script window in,
468
Data Connection Wizard, 672
data dictionaries, 67
data flow designer
advanced edit mode, 484
Calculated Columns sample
package, 487
debugging Script window in,
468
destination components, 485–486
error handling, 497–498
Execute Process sample, 482
overview, 482–483
paths, defined, 484
separate from control flow
designer, 478
source components, 483–485
specifying Script components,
573–581
and SSIS data viewer capability,
488–489
Toolbox window in, 469
transformation components,
486–488
data flow engine, in SSIS asynchronous outputs, 459
basic tasks, 453–454
memory buffers, 454
metadata characteristics, 454–458
overview, 453–454
synchronous outputs, 458, 459
variable-width column issue, 456–457

data flow, in SSIS packages. See also
data flow engine, in SSIS
asynchronous component outputs, 459
custom components, 588–591, 593–594
error handling, 451–452
logging events, 504
Lookup sample, 529–530
overview, 444
Script component, 567–568
synchronous component outputs, 458, 459
data flow maps, 525
Data Flow task, 476, 477–478, 482
data lineage, 524
data marts, 13
data mining
adding data mining models to structures using BIDS, 404–406
algorithms. See algorithms, data mining
ALTER MINING STRUCTURE syntax, 366
Attribute Characteristics view, 378, 379
Attribute Discrimination view, 378, 380
Attribute Profiles view, 378
background, 14
BIDS model visualizers, 46–47
BIDS visualizer for, 18
building objects, 407
building prototype model, 50
building structures using BIDS, 401–404
cloud-hosted, 720–721
compared with OLAP cubes, 14, 396
content types, 361–363
core tools for development, 157
creating structures by opening new Analysis Services project in BIDS, 401–404
creating structures using SSAS, 18
data types, 361–363
defined, 14
Dependency Network view, 370–371, 378
Distribution property, 363
DMX query language, 24, 179–180
end-user client applications, 431
feature selection, 377–381
future for client visualization controls, 720
Generic Content Tree viewer, 371–372
getting started, 396
implementing structures, 399–431
importance of including functionality, 53–54
initial loading of structures and models, 533–534
installing add-ins to Microsoft Office 2007, 687–688
Microsoft Cluster viewer, 372
Microsoft Excel and end-user viewer, 356
Microsoft Office 2007 as client, 687–721
model viewers in BIDS, 46
Modeling Accuracy Chart tab, 360, 373–375, 417
Modeling Model Prediction tab, 360, 375, 419, 424
Modeling Model Viewer tab, 360, 427–428, 536
Modeling Query transformation component, 487, 536–537
data mining structure designer choosing data mining model, 365–368
handling nested tables, 364, 366
Mining Accuracy Chart tab, 360, 373–375, 417
Mining Model Prediction tab, 360, 375, 419, 424
Mining Model Viewer tab, 360, 427–428, 536
Mining Models tab, 360, 365–368, 404, 404–405
Mining Structure tab, 360, 364–365, 404
viewing source data, 364
Data Mining tab, Microsoft Excel Accuracy And Validation group, 712
comparison with Table Tools
Analyze tab, 700–701
Data Modeling group, 708–712
Data Preparation group, 705–708
Management group, 701–702
Model Usage group, 702–705
Data Mining Wizard, 401–404, 405–406
Data Profiling task
defined, 510
limitations, 512
list of available profiles, 512–513
new in SQL Server 2008, 478
profiling multiple tables, 513
viewing output file, 513
when to use, 510
data regions, SSRS, defined, 638–655
Tablix data region, defined, 639–642
Data Source Properties dialog box

Data Source Properties dialog box, 614–616
data source views (DSVs) compared with relational views, 161
creating, 199, 201
defined, 190
examining, 190–192
getting started, 195
making changes to existing tables, 193–194
making changes to metadata, 192–193
overview, 190–191
as quick way to assess data quality, 518
required for building OLAP cubes, 199
in SSIS, 466, 467
data storage containers, skills for building, 72
data stores, OLAP. See also cubes, OLAP
denormalized, 8
as source for decision support systems, 13–14
data stores, OLTP
query challenges, 6–7
reasons for normalizing, 5–6
relational vs. non-relational, 5
Data Transformation Services (DTS) comparison with SSIS, 446, 463–464
relationship to SSIS, 437–438
in SQL Server 2000, 546
data types
Boolean, 363
content types supported, 363
date, 363
defined, 361
detecting in Data Mining Wizard, 403
double, 363
long, 363
text, 363
data viewers, SSIS, 488–489, 506
data visualization group, Microsoft Research, 34, 83, 720
data vs. metadata, 258
data warehouses
background, 12
compared with OLAP, 12
data marts as subset, 13
defined, 11
Microsoft internal, case study, 28
database snapshots, 507
DatabaseIntegratedSecurity property, 668
data-first approach to BI design, 130
DataReader destination, 485
DataReader object, 598
dataset designer, 618
Dataset Properties dialog box, 618
date data type, 363
date functions, 321–326
debugging
SSIS packages, 471–472, 505–506
SSIS script tasks, 572
using data viewers, 488–489, 506
decision support systems, 13–14
decision tables
fast load technique, 528
loading source data into, 525–526
Decision Tree view, Microsoft Visio, 716
Declarative Management Framework (DMF) policies, 95
DefaultEvents class, 596
Define Account Intelligence, Business Intelligence Wizard, 243, 246–247
Define Currency Conversion, Business Intelligence Wizard, 244, 251–254
Define Dimension Intelligence, Business Intelligence Wizard, 243, 250
Define Relationships dialog box, 212–213, 215–216, 216
Define Semiadditive Behavior, Business Intelligence Wizard, 244, 250
Define Time Intelligence, Business Intelligence Wizard, 243, 245
degenerate dimension, in fact tables, 119
denormalization and OLAP cube structure, 125
in OLAP data stores, 8
Dependency Network view, Microsoft Visio, 714–715
Deploy option, BIDS Solution Explorer, 260
deploying
code for custom objects, 589–591
reports to SSRS, 623–624
role and responsibility of release/operations managers, 83
SSIS packages, 441, 461–462, 546–558
Deployment Progress window, 41
Deployment Utility, 556–558
Deployment Wizard, 155
derived measures, 148
Descendants MDX function, 318–319, 321
Description SSIS variable property, 491
destination components
data flow designer, 485–486
Script-type, 586–587
developers
IT administrators vs. traditional developers, 81
keeping role separate from tester role, 81
manager’s role and responsibility on development teams, 79–81
responsibility for performing administrative tasks, 160, 181
SSAS graphical user interface for creating objects, 154
types needed for BI projects, 80
development teams
forming for BI projects, 76–83
optional project skills, 74–76
required project skills, 72–74
role and responsibility of developer manager, 79–81
role and responsibility of product manager, 78
role and responsibility of program manager, 79
role and responsibility of project architect, 78–79
role and responsibility of release/operations manager, 83
role and responsibility of test manager, 81–82
role and responsibility of user experience manager, 82–83
roles and responsibilities for working with MSF, 76–83
source control considerations, 111–113
development tools, conducting baseline survey, 86
deviation analysis, 360
DimCustomer dimension table example, 122, 123
DimCustomer snowflake schema example, 134
dimension designer
accessing Business Intelligence Wizard, 243
Attribute Relationships tab, 141
Dimension Structure tab, 139
dimension editor
Attribute Relationships tab, 205, 207–209, 223
Browser tab, 205
Dimension Structure tab, 205–207
opening from cube designer, 203–204
overview, 205
Translations tab, 205, 209
dimension intelligence, configuring in Business Intelligence Wizard, 243, 250
Dimension Processing destination, 485
dimension structures, defined, 139
dimension tables
data vs. metadata, 258
DimCustomer example, 122, 123
exploring source table data, 123
as first design step in OLAP modeling, 131
generating new keys, 122, 146
pivot table view, 123
rapidly changing dimensions, 144
slowly changing dimensions, 142–144
space issue, 124
for star schema, 117–118, 121–125, 194
table view, 123
types of columns, 121–122
updating, 532–533
Dimension Usage tab, in cube designer
options, 211–212
for snowflake schema, 135, 215
for star schema, 126–127, 134–135
using Cube Wizard to populate, 128
dimensions
adding attributes, 222–223
adding to OLAP cube design using Cube Wizard, 220–221
combining with measures to build OLAP cubes, 210–214
configuring properties, 243–254
creating using New Dimension Wizard, 221
data vs. metadata, 258
enabling writeback for partitions, 285–286
hierarchy building, 138–139
non-star designs, 215–217
presenting in OLAP cubes, 138–142
processing options, 287–291
querying of properties, 329–332
rapidly changing, 144, 284
relationship to cubes, 257–258
role in simplifying OLAP cube complexity, 204–205
slowly changing, 142–144
as starting point for designing and building cubes, 204–205
Unified Dimensional Model, 138
writeback capability, 145
disconnected BIDS instances, 259–261
Discrete content type, 361
Discretized content type, 362
Distinct Count aggregate function, 147
Distribution property, 363
dll files, 590
DMF (Declarative Management Framework) policies, 95
DMX (Data Mining Extensions) query language
adding query parameter to designer, 634–635
ALTER MINING STRUCTURE syntax, 366
designer, defined, 627
designer, overview, 617
including query execution in SSIS packages, 535–537
Predict function, 421, 423–424, 425
PredictHistogram function, 425
prediction functions, 423–426
PREDICTION JOIN syntax, 422, 427
prediction query overview, 421–423
PredictProbability function, 425
PredictProbabilityStDev function, 425
PredictProbabilityVar function, 425
PredictStDev function, 425
PredictSupport function, 425
PredictTimeSeries function, 425
PredictVariance function, 425
queries in SSIS, 426–428
RangeMax function, 425
RangeMid function, 425
RangeMin function, 425
switching from MDX designer to DMX designer, 633
templates, 179–180
ways to implement queries, 426
domain controllers, conducting baseline survey, 85
double data type, 363
drillthrough actions, 233, 236–238, 372–373
DROP KPI statement, 348
ds files, 108
dsv files, 108
DSVs. See data source views (DSVs)
DTEXEC utility, 440
DTEXECUI utility, 440–441
DTLoggedExec tool, 600
DTS. See Data Transformation Services (DTS)
Dts object, 571–572
DtsConnection class, 597
dtsx files, 442, 540, 547
DTUTIL utility, 441, 558

E
Enable Writeback dialog box, 286
end users
decision support systems for communities, 13–14
reporting interface considerations, 51
viewing BI from their perspective, 31–50
Enterprise Manager. See SQL Server Enterprise Manager
tools, 388, 592–593
enumerators, custom, 588, 594–595
envisioning phase, MSF, 65–67
Error and Usage Reporting tool, 155
error conditions, in BIDS, 259
error handling, in SSIS, 451–452, 497–499
ETL (extract, transform, and load) systems
background, 14–15
as BI tool, 515–516
defined, 14–15
importance of SSIS, 52–53
for loading data mining models, 533–537
for loading OLAP cubes, 516–530
security considerations, 97–98
skills needed, 73, 76
SSIS as platform for, 435–462
for updating OLAP cubes, 530–533
EvaluateAsExpression SSIS variable property, 491
event handler designer
Connection Manager window in, 468
defined, 468
 Toolbox window in, 469
event handling, in SSIS, 450–451, 499–501
events, logging, 501–505
Excel. See also Excel Services
adding Data Mining tab to Ribbon, 47–48, 50
adding Table Tools Analyze tab to Ribbon, 47–48, 419
Associate sample workbook, 48–49
as client for SSAS data mining structures, 101
as client for SSAS OLAP cubes, 100–101
configuring session-specific connection information, 101
connecting to sample SSAS OLAP cubes, 43–45
creating sample PivotChart, 679–680
creating sample PivotTable, 678–679
Data Connection Wizard, 672
Data Mining add-ins, 73, 361, 368, 419
data mining integration functionality, 689–690
Data Mining tab functionality, 700–712
Dependency Network view for Microsoft Association, 48–49
extending, 683–684
Import Data dialog box, 674
Offline OLAP Wizard, 681–683
as OLAP cube client, 671–684
OLAP functions, 683
as optional component for BI solutions, 21
PivotTable interface, 675–677
PivotTables as interface for OLAP cubes, 10–11
popularity as BI client tool, 723–724
Prediction Calculator, 419
role in understanding data mining, 45–47
security for SSAS objects, 100–101
skills needed for reporting, 73, 75
trace utility, 101
viewing data mining structures, 47–50
viewing SSRS reports in, 649–650
Excel Calculation Services, 724
Excel data flow destination, 485
Excel data flow source, 483
Excel Services. See also Excel basic architecture, 724–725
complex example, 733–736
extending programatically, 732–736
immutability of Excel sheets, 726
overview, 724
publishing parameterized Excel sheets, 729–732
sample worksheets, 726–729
and Web Services API, 732–736
ExclusionGroup property, 579
Execute method, 592, 596, 597
Execute Package task, 478
Execute Process sample control flow tasks in, 476–478
data flow designer, for SSIS package, 482–483
installing, 474–475
Execute SQL tasks, 476, 476–477, 494
ExecuteReader method, 597, 598
Explore Data Wizard, 705–706
Expression And Configuration Highlighter, 494
Expression dialog box, 637
Expression SSIS variable property, 491–492
expressions
adding to constraints, 480–481
in dataset filters, 637
in SSIS, 447, 493–494
Expressions List window, 494
extracting. See ETL (extract, transform, and load) systems
extraction history, 524
FactResellerSales fact table example, 119
fast load technique
for loading initial data into dimension tables, 528
for loading initial data into fact tables, 527
for updating fact tables, 532
File deployment, for SSIS packages, 547
file servers, conducting baseline survey, 85
files-only installation, SSRS, 607
Filter MDX function, 305–307, 308
filtering
creating filters on datasets, 637
in data mining models, 366
source data for data mining models, 404–405
firewalls
conducting baseline survey, 85
security breaches inside, 97
First (Last) NonEmpty aggregate function, 147
FirstChild aggregate function, 147
Flat File connection manager, 474
Flat File data flow destination, 485
Flat File data flow source, 483
For Loop containers, SSIS, 148
foreach enumerators, custom, 594–595
Foreach Loop containers, 476, 478
ForEachEnumerator class, 594
forecasting algorithms, 359
FREEZE keyword, 342
functions, 299–307, 326
Fuzzy Grouping transformation, 517–518
Fuzzy Lookup transformation, 521
F
fact columns, in fact tables, 118–119, 146
fact dimension (schema), 216
fact modeling, 146–147
fact rows, in fact tables, 261
FactResellerSales example, 119
fact tables
in Adventure Works cube, 211
data vs. metadata, 258
degenerate dimension, 119
exploring source table data, 120, 146–147
FactResellerSales example, 119
fast load technique, 527, 528
loading initial data into, 527–530
multiple-source, 211
OLAP model design example, 131–132
pivot table view, 120
for star schema, 117–118, 118–121
storage space concern, 121
types of columns, 118
updating, 532
G
gauge control, 622, 638
GetEnumerator method, 594
global assembly cache (GAC), registering assembly files, 590
grain statements, 128–129
granularity, defined, 128
GUI (graphic user interface), SQL Server 2008
need for developers to master, 69–70
for SSAS developers, 154
### H

**Head** MDX function, 316  
Health care industry, business intelligence solutions, 27–28  
Hierarchical MDX functions, 316–320  
HOLAP (hybrid OLAP), 267, 279  
Holdout test sets, 403  
HTTP listener, 607, 607–609

### I

**IDBCommand** interface, 597  
**IDBConnection** interface, 597  
**IDBDataParameter** interface, 597  
**IIf** MDX function, 337–338  
IIS (Internet Information Services) conducting baseline survey, 86  
not an SSRS requirement, 606, 608, 610  
noting version differences, 86  
Image data region, 638–655  
Import Data dialog box, 674  
Import/Export Wizard defined, 155  
role in developing SSIS packages, 439  
Inmon, Bill, 12  
**Input0_ProcessInputRow** method, 577, 578  
Integration Services. See SQL Server Integration Services (SSIS)  
IntelliSense, 633, 637  
Internet Information Services conducting baseline survey, 86  
not an SSRS requirement, 606, 608, 610  
noting version differences, 86  
iteration in BI projects, 62  
in OLAP modeling, 132

### K

Key columns, in fact tables, 118  
Key content type, 362  
Key performance indicators (KPIs) accessing from KPIs tab in cube designer, 201, 228, 345  
client-based vs. server-based, 232  
core metrics, 229  
creating, 345–349  
customizing, 231–232  
defined, 15  
defining important metrics, 55  
metadata browser for, 229–231  
nesting, 229  
overview, 149, 228–233  
templates for, 229–232  
viewing in Adventure Works cube, 228, 229  
Key Sequence content type, 362, 363  
Key Time content type, 362, 363  
Kimball, Ralph, 12  
KPIs. See key performance indicators (KPIs)

### L

LastChild aggregate function, 147  
LastChild MDX function, 314, 324  
**LastPeriods** MDX function, 314, 324, 325  
Law enforcement, business intelligence solutions, 29  
Least-privilege security accessing source data by using, 96–97, 190  
configuring logon accounts, 98  
when to use, 70  
Life cycle. See software development life cycle  
lift charts, 410–413  
linked objects, 285  
load balancing, 270  
**Load** method, 596  
loading. See ETL (extract, transform, and load) systems  
local processing mode, 653, 657  
localization, 29  
Log Events window, 503  
log locations, 502–503  
log providers custom, 588, 594  
overview, 459–460  
specifying connection manager, 502  
logging for package execution, 501–505  
question of how much, 504–505  
SSIS log providers, 459–460, 502  
viewing results, 503  
logical modeling, OLAP design concepts, 115–150  
logical servers and services conducting baseline survey, 86  
considerations, 92–94  
service baseline considerations, 94  
long data type, 363  
Lookup data flow transformation, 486  
Lookup sample, using SSIS to load dimension and fact tables, 528–530

### M

Maintenance Plan Tasks, SSIS, 471  
Many-to-many dimension (schema), 216–217  
Matrix data region, 638–655  
Max aggregate function, 147  
MDX (Multidimensional Expressions) query language  
**Ancestors** function, 319–320  
background, 23  
**BottomCount** statement, 311  
**Children** function, 300, 316, 321  
core syntax, 296–305  
creating calculated members, 307  
creating named sets, 308, 338–340  
creating objects by using scripts, 309  
creating permanent calculated members, 333–336  
in cube designer Calculations tab, 240, 241–242  
**CurrentMember** function, 232, 313  
date functions, 321–326  
defined, 23  
**Descendants** function, 318–319, 321  
designer included in Report Builder, 644  
**Filter** function, 305–307, 308  
functions, 299–307, 326  
**Head** function, 316  
hierarchical functions, 316–320  
**IIf** function, 337–338  
Internet Sales example, 295, 297–299  
and key performance indicators, 232  
**LastChild** function, 314, 324  
**LastPeriods** function, 314, 324, 325  
**Members** function, 299–300, 308  
native vs. generated, 225  
object names, 296  
opening query designer, 628  
**OpeningPeriod** function, 322–323  
operators, 297  
**Order** function, 302–303  
**ParallelPeriod** function, 232, 322  
**Parent** function, 317–318  
**PeriodsToDate** function, 333  
query basics, 295  
query designer, 617  
query designer, defined, 627  
query designer, overview, 628–631  
query templates, 175–178  
querying dimension properties, 329–332
MDX, continued

Rank function, 312–314
SCOPE keyword, 246
scripts, 341–343
setting parameters in queries, 631–633
Siblings function, 317
Tail function, 315, 330–331
TopCount function, 310
Union function, 320
using with PerformancePoint Server 2007, 352–354
using with SQL Server Reporting Services (SSRS), 349–351
warning about deceptive simplicity, 239
working in designer manual (query) mode, 629, 630–631
working in designer visual (design) mode, 629–631
Ytd function, 294
MDX IntelliSense, 633
measure columns, in fact tables, 118–119
Measure Group Bindings dialog box, 213–214
Measure Group Storage Settings dialog box, 278–279
measure groups in Adventure Works cube, 211
creating measures, 211
defined, 211
defining relationship to dimension data, 212–213
enabling writeback for partitions, 286
how they work, 211
relationship to source fact tables, 146–147
selecting for OLAP cubes, 219
measure modeling, 146–147
measures, calculated compared with derived, 148
Members MDX function, 299–300, 308
memory management, and SSRS, 665–666
metadata, data flow characteristics, 454–458
how SSIS uses, 458
variable-width column issue, 456–457
metadata vs. data, 258
Microsoft Association algorithm, 391–393, 400
Microsoft Baseline Security Analyzer, 95
Microsoft Biztalk Server, 22
Microsoft Clustering algorithm, 386–389, 400
Microsoft Decision Trees algorithm in classification matrix example, 415
defined, 400
in lift chart example, 412–413
overview, 381–383
in profit chart example, 414
for quick assessment of source data quality, 518
viewers for, 369–370
Microsoft Distributed Transaction Coordinator (MS-DTC), 508
Microsoft Dynamics, 22, 75
Microsoft Excel. See Excel Services
Microsoft Excel Services. See Excel Services
Microsoft Linear Regression algorithm, 383, 400
Microsoft Logistic Regression algorithm, 395–396, 400
Microsoft Naïve Bayes algorithm, 376–381, 399, 518
Microsoft Neural Network algorithm, 394–395, 400
Microsoft Office 2007 as data mining client, 687–721
installing Data Mining Add-ins, 687–688
optional components for BI solutions, 21–22
Microsoft PerformancePoint Server (PPS) integration with SQL Server Analysis Services, 745
as optional component for BI solutions, 22
skills needed for reporting, 75
using MDX with, 352–354
Microsoft Project Server, 22
Microsoft Research, 34, 83, 478, 720
Microsoft Security Assessment Tool, 95
Microsoft Sequence Clustering algorithm, 389–390, 400
Microsoft Solutions Framework (MSF). See also MSF (Microsoft Solutions Framework) for Agile Software Development
Agile Software Development version, 63–65
alternatives to, 62
building phase, 68–70
defined, 62
deploying phase, 71
development team roles and responsibilities, 76–83
envisioning phase, 65–67
milestones, 62
planning phase, 67–68
project phases, 62, 65–71
role of iteration, 62
spiral method, 62, 64
stabilizing phase, 70–71
Microsoft SQL Server 2008. See SQL Server 2008
Microsoft Time Series algorithm, 383–386, 400
Microsoft Visio. See Visio
Microsoft Visual Studio. See Visual Studio
Microsoft Visual Studio Team System (VSTS) integrating MSF Agile into, 64–65
reasons to consider, 22, 546
Team Foundation Server, 111–112
Microsoft Visual Studio Tools for Applications (VSTA) debugging scripts, 572
defined, 568
writing Script component code, 577–582
writing scripts, 570–572
Microsoft Visual Studio Tools for the Microsoft Office System (VSTO), 683–684
Microsoft Word as optional component for BI solutions, 21
viewing SSRS reports in, 649–650
milestones, in Microsoft Solutions Framework (MSF), 62
Min aggregate function, 147
mining model viewers, 46, 48–49, 356, 368, 408
mining structure designer choosing data mining model, 365–368
handling nested tables, 364, 366
Mining Accuracy Chart tab, 360, 373–375, 417
Mining Model Prediction tab, 360, 375, 419, 424
Mining Model Viewer tab, 46, 360, 368–373, 408, 409
Mining Models tab, 360, 365–368, 404, 404–405
OLAP cubes

Mining Structure tab, 360, 364–365, 404
viewing source data, 364
Model Designer, SSRS, backing up files, 108
model training. See Data Mining Model Training destination
modeling
logical modeling, OLAP design concepts, 115–150
OLAP. See OLAP modeling
OLTP modeling, 115, 137–138
physical, for business intelligence solutions, 4
Modeling Flags property, 363
MOLAP (multidimensional OLAP), 267, 279
MS-DTC (Microsoft Distributed Transaction Coordinator), 508
MsDtsSrvr.ini.xml, SSIS configuration file, 112
MSF (Microsoft Solutions Framework) for Agile Software Development
background, 63–65
built into Microsoft Visual Studio Team System, 64–65
defined, 63
development team roles and responsibilities, 77
project phases, 65–71
suitability for BI projects, 64
MSF (Microsoft Solutions Framework) for Capability Maturity Model Integration (CMMI), 65
.msi files, 38
MSReportServer_ConfigurationSetting class, 668
MSReportServer_Instance class, 668
multidimensional data stores. See cubes, OLAP
Multidimensional Expressions. See MDX (Multidimensional Expressions) query language

N
Name SSIS variable property, 492
named sets, 241, 308, 338–340
Namespace SSIS variable property, 492
natural language, 67
.NET API
application comparison with SSIS projects in Visual Studio, 467
and compiled assemblies, 196–197
developer skills, 80, 81
skills needed for custom client reporting, 75
for SQL Server Integration Services, 442
using code in SSRS reports, 647–649
using to develop custom SSIS objects, 587–588, 588
network interface cards (NICs), conducting baseline survey, 85
New Cube Wizard, 134
New Table Or Matrix Wizard, 644–646
non-relational data, defined, 5
normalization implementing in relational data stores, 5
reasons for using, 6–7
view of OLTP database example, 5

Object Explorer defined, 39
viewing SSAS objects from SSMS, 160
viewing SSIS objects from SSMS, 438, 439
object viewers, 164
ODBC connection manager, 473
Office 2007 as data mining client, 687–721
installing Data Mining Add-ins, 687–688
optional components for BI solutions, 21–22
Office SharePoint Server 2007 configuration modes for working with SSRS, 737–738
integrated mode, installing SSRS add-in for, 742–743
native mode, integration of SSRS with, 740–741
as optional component for BI solutions, 21–22
Report Center, 744–745
skills needed for reporting, 75
SQL Server business intelligence and, 723–745
SSRS and, 604, 736–745
template pages, 744–745
Windows SharePoint Services, 94
Offline OLAP Wizard, 681–683
OLAP (online analytical processing) characteristics, 8
compared with data mining, 14
compared with data warehousing, 12
defined, 8
Microsoft Excel functions, 683
modeled as denormalized, 8
when to use, 8
working offline in Microsoft Excel, 681–683
OLAP cubes adding aggregations, 263
assessing source data quality, 516–518
background, 13
as BI data structure, 13
BIDS browser, 41–42, 201
building in BIDS, 198–204
building prototypes, 50
building sample using Adventure Works, 37–39
configuring properties, 243–254
connecting to sample using Microsoft Excel, 43–45
as core of SQL Server BI projects, 115
core tools for development, 157
creating empty structures, 133
as data marts, 13
data vs. metadata, 258
in data warehouses, 11
defined, 9
and denormalization concept, 125
vs. denormalized relational data stores, 10
deploying, 254–255, 260–261
designing by using BIDS, 183–223
dimensions overview, 9–10, 204–210, 257–258
fact (measure) modeling, 146–147
first, building in BIDS, 218–223
Microsoft Excel as client, 671–684
modeling logical design concepts, 115–150
vs. OLTP data sources, 54
opening sample in Business Intelligence Development Studio, 39–43
overview of source data options, 115–116
partitioning data, 263–270
as pivot tables, 10–11
pivoting in BIDS browser, 42
presenting dimensional data, 138–142
processing options, 287–291
and ROI of BI solutions, 56–58
skills needed for building, 72, 74
star schema source data models, 116–125
OLAP modeling

OLAP cubes, continued
UDM modeling, 9–10
updating, 530–533
using dimensions, 210–217
viewing by using SSMS Object Browser, 164–168
visualizing screen view, 10–11
OLAP modeling
compared with OLTP modeling, 115
comparing with OLTP sources, 137–138
as iterative process, 132
naming conventions, 150
naming objects, 132
need for source control, 132
role of grain statements, 128–129
tools for creating models, 130–132, 149–150
using Visio 2007 to create models, 130–132, 133

OLTP (online transactional processing)
defined, 5
normalizing data stores, 5
querying data stores, 6–7
OLTP modeling
compared with OLAP modeling, 115
compared with OLAP views, 137–138
OLTP table partitioning, 268–269
OnError event, 451
OnExecStatusChanged event handler, 500
OnInit method, 648
OLTP (online transactional processing)
characteristics, 6
defined, 5
normalizing data stores, 5
querying data stores, 6–7
OLTP modeling
compared with OLAP modeling, 115
compared with OLAP views, 137–138
OLTP table partitioning, 268–269
OnPostExecute event handler, 500, 500–501
OnProgress event handler, 467–469
OnVariableValueChanged event handler, 500
OpeningPeriod MDX function, 322–323
operating environment, conducting baseline survey, 86, 87–88
optional skills, for BI projects, 74–76
Oracle, 5, 19
Order MDX function, 302–303
Ordered content type, 362
Outliers Wizard, 706–707
overtraining, data model, 535

P
Package Configuration Wizard, 549–550
Package Configurations Organizer dialog box, 548–549, 551–553
package designer
adding connection managers to packages, 473
best design practices, 509–510
Connection Manager window in, 468
control flow designer, 468
data flow designer, 468
debugging packages, 471–472
event handler designer, 468
executing packages, 471–472
how they work, 470–472
navigating, 479
overview, 467–469
Toolbox window in, 469
viewing large packages, 479
Package Explorer, 468–469
Package Installation Wizard, 557–558
Package Store File deployment, for SSIS packages, 547
Package Store MSDB deployment, for SSIS packages, 547
packages, in SSIS
adding checkpoints to, 506–507
adding to custom applications, 596–600
backups and restores, 107–108
best practices for designing, 509–510
configurations, 461
configuring transactions in, 507–508
connection managers, 448–450
control flow, 442–444
control flow compared with data flow, 444–445
creating with BIDS, 463–495
data flow, 444
debugging, 505–506
default error handling behavior, 498
defined, 20
developing and managing by using DTUTIL utility, 441, 558
deployment options, 461–462, 546–558
developing in Visual Studio, 464–472
documentation standards, 525
Encrypt Sensitive With Password encryption option, 563
Encrypt Sensitive With User Key encryption option, 563
encoding, 554–556
encryption issues, 563
error handling, 451–452
event handling, 450–451, 499–501
executing by using DTExec utility, 440
executing by using DTExecUI utility, 440–441
expressions, 447
external configuration file, 548–552
file copy deployment, 552–553
handling sensitive data, 563
keeping simple, 508, 509
logical components, 442–452
physical components, 442
role of SSMS in handling, 438–439
saving results of Import/Export Wizard as, 439
scheduling execution, 558–559
security considerations, 97–98, 559–562
setting breakpoints in, 505–506
source control considerations, 112
as SSIS principal unit of work, 436, 438
and SSIS runtime, 452
tool and utilities for, 438–441
upgrading from earlier versions of SQL Server, 440
variables, 445–447
where to store, 98, 112
PacMan (SSIS Package Manager), 600
parallel processing, in SQL Server
2008, Enterprise edition, 269
ParallelPeriod MDX function, 232, 322
Parent MDX function, 317–318
parent tables, relationship to child tables, 5
Partition Processing destination, 485
Partition Wizard, 265–266
partitions, cube
defined, 263
defining, 265–266
enabling writeback, 285–286
overview, 263–264
for relational data, 268–269
remote, 270
specifying local vs. remote, 270
in star schema source tables, 268–269
storage modes, 270
and updates, 532
partitions, table, 268–269
Pasumansky, Mosha, 340, 633
performance counters
possible problems to document, 88
role in creating baseline assessment of operating environment, 87–88
Performance Visualization tool, 510
PerformancePoint Server integration with SQL Server Analysis Services, 745
as optional component for BI solutions, 22
skills needed for reporting, 75
using MDX with, 352–354
PeriodsToDate MDX function, 333
permissions, for SSRS objects, 103–104
perspectives compared with relational views, 227
defined, 149
overview, 227–228
phases, in Microsoft Solutions Framework (MSF), 62
physical infrastructure
assessing servers needed for initial BI development environment, 88
conducting baseline survey, 85–87
planning for change, 85–89
physical modeling, for business intelligence solutions, 4
physical servers
assessing number needed for initial BI development environment, 88–89
for business intelligence solutions, 4
conducting baseline survey, 85
considerations, 91–92
consolidation, 92
determining optimal number and placement for initial BI development environment, 89–94
development server vs. test server, 91
installing SQL Server, 90
installing SSAS, 90
installing SSRS, 90
target location options for deploying SSIS packages, 547–548
typical initial BI installation, 90
pie chart, adding to Microsoft Excel sheet, 729–731
PivotCharts, Microsoft Excel adding to workbooks, 679–680
creating views, 44
PivotTable Field List, 650–651, 652
PivotTables, Microsoft Excel connecting to sample cubes, 43–44
creating, 678–679
creating PivotChart views, 44
dimensional information, 678–679
formatting, 679
as interface for cubes, 10–11
overview, 675–680
ways to pivot view of data, 44
planning phase, MSF, 67–68
PostExecute method, 577, 578, 587
PostLogMessage method, 580
PPS. See Microsoft PerformancePoint Server (PPS)
precedence constraints, 480–481
Predict DMX function, 421, 423–424, 425, 427
PredictHistogram DMX function, 425
prediction algorithms, 359
Prediction Calculator, Microsoft Excel, 419
prediction functions, 423–426
PREDICTION JOIN syntax, 422, 427
predictive analytics, 148–149, 355, 366, 426
Predictive Model Markup Language (PMML), 409
PredictProbability DMX function, 425
PredictProbabilityStDev DMX function, 425
PredictProbabilityVar DMX function, 425
PredictStDev DMX function, 425
PredictSupport DMX function, 425
PredictTimeSeries DMX function, 425
PredictVariance DMX function, 425
PreExecute method, 577, 587
proactive caching
fine tuning, 283–284
notification settings, 282
overview, 279–282
Process Cube dialog box, 288–289
Process Progress dialog box, 407, 429–430
processing layer, security considerations, 97–98
processing time, 270
ProcessInput method, 583, 584–585, 585, 586
ProcessInputRow method, 584, 585, 586, 587. See also Input0_ProcessInputRow method
processors, multiple, 454, 523
ProClarity, 22
product managers
job duties, 78
role and responsibility on development teams, 78
profit charts, 413–414
program managers
job duties, 79
role and responsibility on development teams, 79
project architects, role and responsibility on development teams, 78–79
Project Real, 28
Project Server, 22
Propagate variable, 501
prototypes, building during MSF planning phase, 68
proxy accounts, 563
proxy servers, conducting baseline survey, 85
queries. See also DMX (Data Mining Extensions) query language; MDX (Multidimensional Expressions) query language cache scopes, 326
challenges in OLTP data stores, 6–7
creating in report designer, 616–618
creating named sets, 338–340
creating permanent calculated members, 333–336
manually writing, 54–55
MDX basics, 295
optimizing, 326
query browsers
Cube filter, 175
Measure Group filter, 175
query designer
multiple types, 616–618
for reports, 627–638
setting parameters in queries, 631–633
query languages, 23–25. See also DMX (Data Mining Extensions) query language; MDX (Multidimensional Expressions) query language; XMLA (XML for Analysis) query language

Query Parameters dialog box, 632

Query templates for DMX (Data Mining Extensions) query language, 179–180 execution process, 174–175 for MDX (Multidimensional Expressions) query language, 175–178 for XMLA (XML for Analysis) query language, 180

query tuning, 276

R

RaiseChangedEvent SSIS variable property, 492

RangeMax DMX function, 425

RangeMid DMX function, 425

RangeMin DMX function, 425


ReadOnlyVariables property, 577

ReadWriteVariables property, 578

Sample Data Wizard, 705, 707–708
Save Copy Of Package dialog box, 554–556
scalability, and SSRS, 662–664
schema-first approach to BI design, 130
SCOPE keyword, MDX query language, 246, 341–342
Scope SSIS variable property, 492
Script component. See also Script Transformation Editor dialog box
compared with Script task, 567–568
connection managers in, 580–581
as data source, 573
debugging, 587
destination-type, 586–587
selecting Transformation type option, 574
source-type, 582
synchronous and asynchronous transformation, 582–586
type options, 573–574
writing code, 577–581
Script task
compared with Script component, 567–568
defined, 478
using to define scripts, 568–570
Script Task Editor dialog box, 568–570
Script Transformation Editor dialog box
Connection Managers page, 580
Inputs And Outputs page, 576, 578–579, 579
Input Columns page, 574–576
opening, 574
scripting
limitations, 587
Script task compared with Script component, 567–568
for SSRS administrative tasks, 667–669
ScriptLanguage property, 568
scripts, MDX, 341–343
security. See also least-privilege security
best practices, 70, 564
BIDS, for solutions, 98–99
BIDS, when creating SSIS packages, 98
custom client considerations, 104–106
encrypting packages when deploying, 554–556
handling sensitive SSIS package data, 563
overview of SSIS package issues, 559–562
passing report credentials through ReportViewer, 657–658
proxy execution accounts for SSIS packages, 79
Security Assessment Tool, 95
security requirements in development environment, 70
overview, 95–106
Select Script Component type dialog box, 573–574
semiadditive behavior, configuring in Business Intelligence Wizard, 244, 250
sequence analysis algorithms, 359
Sequence containers, 478
servers. See logical servers and services; physical servers
service level agreements (SLAs) availability strategies, 87
conducting baseline survey, 87
reasons to create in BI projects, 87
Service Principal Name (SPN), 159
Shared Data Source Properties dialog box, 613–614
SharePoint Server. See Office SharePoint Server 2007
Siblings MDX function, 317
signing assemblies, 589
skills, for BI projects
optional, 74–76
required, 72–74
.sln files, 98
backing up, 108
Slowly Changing Dimension transformation, 533
Slowly Changing Dimension Wizard, SSIS, 143–144
slowly changing dimensions (SCD), 142–144
.smdl files, 108, 112–113
snapshots, database, 507
snowflake schema
DimCustomer example, 134
on Dimension Usage tab of cube designer, 135, 215
overview, 134
when to use, 136–137
software development life cycle, 61–71
Solution Explorer, in BIDS, 40, 46, 184, 186–188
Solution Explorer, Visual Studio configuring SSAS object properties, 243
data sources and data source views, 466, 467
SSIS Packages folder, 466–467
viewing SSIS projects in, 466–467
solutions, defined, 98, 539
SOLVE_ORDER keyword, 343–344
source code control/source control systems, 540–542
source control, 111–113, 132
source data
accessing by using least-privileged accounts, 96–97
cleaning, validating, and consolidating, 69
collecting connection information, 96–97
loading into decision tables, 525–526
non-relational, 5
performing quality checks before loading mining structures and models, 533–534
querying OLTP data stores, 6–7
relational, 5
structure names, 68
transformation issues, 519–523
source data systems, upgrading to SQL Server 2008, 89
Specify A Unary Operator, Business Intelligence Wizard, 244, 248–250
Specify Attribute Ordering, Business Intelligence Wizard, 244, 250
spiral method, 62, 64
SQL Server 2000, upgrading production servers for SSAS, SSIS, and SSRS, 90
SQL Server 2008
command-line tools installed, 157
complete installation, 156–157
as core component of Microsoft BI solutions, 16, 19
customizing data display, 3
Database Engine Tuning Advisor, 8
documenting sample use, 86
downloading and installing Data Mining Add-ins for Office 2007, 47–48
downloading and installing sample databases, 154
feature differences by edition, 37, 58
SQL Server 2008, Enterprise edition continued
installing sample databases, 37–41
installing samples in development environment, 86
minimum-installation paradigm, 153–154
new auditing features, 111
online transactional processing, 5–8
security features, 70
SQL Server 2008, Enterprise edition
installing sample databases, 37–41
installing samples in development environment, 86
minimum-installation paradigm, 153–154
new auditing features, 111
parallel processing, 269
scaling out, 666–667
SQL Server Agent, 558–564
SQL Server Analysis Services (SSAS). See also SQL Server Management Studio (SSMS);
SQL Server Profiler
aggregation types, 147
background, 16–17
backups and restores, 106–107
baseline service configuration, 157–159
BIDS as development interface, 16
BIDS as tool for developing cubes, 16
building sample OLAP cube, 37–39
considering where to install, 89
creating ETL packages, 55
in custom applications, 596–600
core tools, 153–181
deploying Adventure Works 2008
to, 41
Deployment Wizard, 155
dimension design in, 140–142
documenting service logon
account information, 94
exploring fact table data, 120
installing, 153
installing multiple instances, 90
linked objects, 285
logon permissions, 98
mastering GUI, 69–70
performance counters for, 87
providers for star schema source
data, 117
query designers, using for creating reports, 627–638
querying objects in SSMS, 170–175
reasons for installing SQL Server Database Engine Services with, 153
as requirement for OLAP BI solutions, 23
roles in, 195–196
scaling to multiple machines, 91
security considerations, 98–99
SSMS as administrative interface, 16
using compiled assemblies with objects, 196–197
using OLAP cubes vs. OLTP data sources, 54
viewing configuration options in SSMS, 93
viewing SSAS objects in Object Explorer, 160
viewing what is installed, 153–154
working on databases in BIDS in connected mode, 261
SQL Server Books Online, defined, 156
SQL Server Compact destination, 485
SQL Server Database Engine, 108
SQL Server Database Engine Tuning Advisor, 8, 156
SQL Server destination, 485
SQL Server Enterprise Manager, 463–464
SQL Server Error and Usage Reporting, defined, 155
SQL Server Installation Center, defined, 156
SQL Server Integration Services (SSIS)
architectural components, 435–462
architectural overview, 436–438
backups and restores, 107–108, 112
BIDS as development interface, 16
BIDS as tool for implementing packages, 20
comparison with Data Transformation Services, 446, 463–464
defined, 20
documenting service logon
account information, 94
error handling, 497–499
ETL skills needed, 76
event handling, 499–501
history, 437–438
as key component in Microsoft BI solutions, 20
log providers, 459–460
mastering GUI, 69–70
MsDtsSrvr.ini.xml configuration file, 112
.NET API overview, 442
object model and components, 442–452
object model, defined, 436
package as principal unit of work, 436, 438
performance counters for, 87
relationship to Data Transformation Services, 437
runtime, defined, 436
runtime, overview, 452
scaling to multiple machines, 91
scripting support, 567–587
security considerations for packages, 97–98
service, defined, 436
Slowly Changing Dimension Wizard, 143–144
solution and project structures, 539–540
source control considerations, 112
SSMS as administrative interface, 16
upgrading packages from earlier versions of SQL Server, 440
ways to check data quality, 516–518
SQL Server Management Studio (SSMS)
backups of deployed SSAS solutions, 106–107
connecting to SSAS in, 160
as core tool for developing OLAP cubes and data mining structures in SSAS, 157
data mining object processing, 431
defined, 19, 155, 160
menus in, 161
object viewers, 164
opening query editor window, 295
processing OLAP objects, 163
querying SSAS objects, 170–175
role in handling SSIS packages, 438–439
verifying Adventure Works installation, 39
viewing configuration options available for SSAS, 93
viewing data mining structures, 164, 168–170
viewing dimensions, 163
viewing OLAP cubes, 164–168
viewing OLAP objects, 162–164
working with SSIS Service, 564–565
SQL Server Profiler
as core tool for developing OLAP cubes and data mining structures in SSAS, 157
defined, 156
how query capture works, 172–174
overview, 171–172
role in designing aggregations, 275–277
using for access auditing, 109–110
SQL Server Reporting Services (SSRS)
adding custom code to reports, 647–649
architecture, 603–605
authentication credential flow for reports, 103
background, 19
backups and restores, 108
BIDS as development interface, 16
building reports for, 627–646
command-line utilities, 604
Configuration Manager, 102, 108, 155, 607, 609, 737
configuring environment for report deployment, 623–624
configuring with Office SharePoint Server, 737–738
considering where to install, 89
as core component of Microsoft BI solutions, 16
creating reports, 603–624
defined, 19
deploying reports, 623–624
documenting service logon account information, 94
feature differences by edition, 606
installing add-in for Microsoft Office SharePoint Server, 742–743
installing and configuring, 606–612
integration with Office SharePoint Server, 604
mastering GUI, 69–70
performance counters for, 73, 75
security decisions during installation and setup, 102–104
skills needed for reporting, 73, 75
source control considerations, 112–113
SSMS as administrative interface, 16
storing metadata, 604
using in SharePoint integrated mode, 742–743
using in SharePoint native mode, 740–741
using MDX with, 349–351
Web site interface, 19
Windows Management Instrumentation, 668–669
SQLPS.exe tool, 157
SSAS. See SQL Server Analysis Services (SSAS)
SSAS Deployment Wizard, 155
SSIS. See SQL Server Integration Services (SSIS)
SSIS Package Manager (PacMan), 600
SSIS Package Store, 552, 554, 564
SSIS Package Upgrade Wizard, 440
SSIS Performance Visualization tool, 510
SSIS Service, 564–565
SSMS. See SQL Server Management Studio (SSMS)
SSRS. See SQL Server Reporting Services (SSRS)
SSRS Web Services API, 658–659
stabilizing phase, MSF, 70–71
staging databases, when to use, 520–523, 524, 531
star schema
comparison with non-star designs, 215–217
conceptual view, 125
for denormalizing, 30
dimension tables, 117–118, 121–125, 194
Dimension Usage tab, in cube designer, 126–127, 134–135
fact tables, 117–118, 118–121, 194
Microsoft changes to feature, 210–211
moving source data to, 525–530
for OLAP cube modeling, 116–125
on-disk storage, 116–117
physical vs. logical structures, 116–117
reasons to create, 126, 126–127
tables vs. views, 116–117
visualization, 117–118
storage area networks, 91
Subreport data region, 638–655
Sum aggregate function, 147
Synchronize command, to back up and restore, 107
synchronous data flow outputs, 458, 459
synchronous transformation, 583–586
SynchronousInputID property, 578–579
system variables, in SSIS, 445–446, 493
T
Table content type, 362
Table data region, 638–655
table partitioning, defined, 269. See also OLTP table partitioning
tables
parent vs. child, 5
relational, for denormalizing, 8
Tablix container, defined, 622
Tablix data region, defined, 639–642
tabular report designer, 619–620
Tail MDX function, 315, 330–331
Task class, 591–592
Task Host containers, 478
tasks
compared with components, 444, 445
custom, 587–588
default error handling behavior, 499
in SSIS package control flow, 442–444
taxonomies
documenting, 67–68
role in naming of OLAP objects, 132
Team Foundation Server, 38, 540 teams. See development teams
Template Explorer, 174, 422
test managers
job duties, 81
keeping role separate from
developer role, 81
role and responsibility on
development teams, 81–82
testing. See stabilizing phase, MSF
testing plans, 70–71
text data type, 363
Textbox data region, 638–655
This function, 342
time intelligence, configuring in
Business Intelligence Wizard,
243, 245
Toolbox, SSIS
adding objects to, 591
overview, 469
Toolbox, SSRS, in BIDS, 621–622, 638
Toolbox, Visual Studio, 652, 654
tools
ascmd.exe tool, 157
BIDS Helper tool, 255, 490, 494, 510
downloading from CodePlex Web
site, 37–38, 86, 157
DTEXEC utility, 440
DTEXECUI utility, 440–441
DTUTIL utility, 441
installed with SQL Server 2008,
157
rsconfig.exe tool, 604
rs.exe tool, 609
SQLPS.exe tool, 157
TopCount MDX function, 310
Trace Properties dialog box, 276
Tracer utility, Microsoft Excel, 101
transactional activities. See
OLTP (online transactional
processing)
transactions, package, 507–508
Transact-SQL
aggregate functions, 9
queries, 54–55
transformation components, 486–488
transformations, built-in, 578
transforming. See ETL (extract,
transform, and load) systems
translations
for cube metadata, 225–226
SSAS, defined, 149

U
UDM (Unified Dimensional Model),
9–10, 138
unary operators, specifying in
Business Intelligence Wizard,
244, 248–250
Unified Dimensional Model (UDM),
9–10, 138
Union MDX function, 320
Upgrade Package Wizard, 487
upgrading SSIS packages from
earlier versions of SQL Server,
440
URLs (uniform resource locators)
enhanced arguments, 651
implementing access, 651–652
Usage-Based Optimization Wizard,
274–275
user experience managers, role and
responsibility on development teams,
82, 82–83
user interfaces (UIs)
role and responsibility of user
experience managers, 82–83
skills needed for creating, 73, 75
utilities
ascmd.exe tool, 157
BIDS Helper tool, 255, 490, 494, 510
downloading from CodePlex Web
site, 37–38, 86, 157
DTEXEC utility, 440
DTEXECUI utility, 440–441
DTUTIL utility, 441
installed with SQL Server 2008,
157
rsconfig.exe tool, 604
rs.exe tool, 609
SQLPS.exe tool, 157
TopCount MDX function, 310

V
Validate method, 592, 594
Value SSIS variable property,
492–493
ValueType SSIS variable property,
493
variables, in SSIS
adding to packages, 490
Description property, 491
differences related to SSIS
platform, 490–493
EvaluateAsExpression property,
491
Expression property, 491–492
Name property, 492
Namespace property, 492
opening Variables window, 490
overview, 445–447
properties, 491–493
RaiseChangedEvent property, 492
Scope property, 492
system, 493
Value property, 492–493
ValueType property, 493
ways to use, 494–495
variable-width columns, in data flow
metadata, 456–457
Virtual PC, setting up test
configurations, 37
virtualization, 4, 91
Visual SourceSafe (VSS)
checking files in and out, 544–545
creating and configuring VSS
database, 541–542
creating and configuring VSS user
accounts, 542
History dialog box, 545
Lock-Modify-Unlock Model
option, 541–542
overview, 540
storing solution files, 542–544
using Add SourceSafe Database
Wizard, 541–542
Visual Studio. See also Solution
Explorer, Visual Studio
Adventure Works.sln file, 38, 40
embedding custom ReportViewer
controls, 652–656
as location for SSIS package
development, 464–472
relationship to BIDS, 16–17, 22,
41, 463
relationship to SQL Server
Integration Services, 440
resemblance to BIDS interface,
157
signing custom object assemblies,
589
SSIS menu, 472
SSIS package designers, 467–472
Toolbox, 652, 654
usefulness in BI development, 86
viewing new SSIS project template
in, 465–466
VSTO (Microsoft Visual Studio
Tools for the Microsoft Office
System), 683–684
VSTS (Visual Studio Team System)
integrating MSF Agile into, 64–65
reasons to consider, 22, 546
Team Foundation Server, 111–112

W
Warnings tab, in BIDS, 259
waterfall method, 62
Web Parts, 21–22, 740–741
Web servers, conducting baseline
survey, 85
Web Services API, and Excel
Services, 732–736
Windows Communication
Foundation (WCF), 732–733
Windows Management
Instrumentation (WMI),
668–669
Windows Reliability and
Performance Monitor tool, 87
Windows Server 2003, IIS version
differences, 86
Windows Server 2008
IIS version differences, 86
Performance Monitor counters,
523
Reliability and Performance
Monitor tool, 87
virtualization improvements, 4
Web SharePoint Services and
Office SharePoint Server 2007,
94
Windows Vista, IIS version
differences, 86
Windows-on-Windows 32-bit
applications, 91
Word 2007
as optional component for BI
solutions, 21
viewing SSRS reports in, 649–650
writeback
defined, 98
overview, 145
storing changes to dimensions,
285–286

X
XML data flow source, 483
XML for Analysis. See XMLA (XML
for Analysis) query language
XMLA (XML for Analysis) query
language
background, 24
defined, 24
query templates, 180
source control considerations, 113
using for data mining object
processing, 431
viewing scripts, 164

Y
Ytd MDS function, 294
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