

**Oracle Database 11g**

# PL/SQL Programming

Develop Robust, Database-Driven PL/SQL Applications

**Michael McLaughlin**

Professor of Computer Information Technology, BYU-Idaho



# Contents

Acknowledgments .....	xix
Introduction .....	xxi

## PART I PL/SQL Fundamentals

<b>1 Oracle PL/SQL Overview .....</b>	<b>3</b>
History and Background .....	4
Architecture .....	6
Basic Block Structures .....	8
Oracle 10g New Features .....	11
Built-in Packages .....	11
Compile-Time Warnings .....	11
Conditional Compilation .....	12
Number Datatype Behavior .....	13
Optimized PL/SQL Compiler .....	13
Regular Expressions .....	14
Quoting Alternative .....	14
Set Operators .....	14
Stack Tracing Errors .....	14
Wrapping PL/SQL Stored Programs .....	16
Oracle 11g New Features .....	17
Automatic Subprogram Inlining .....	17
Continue Statement .....	18
Cross-Session PL/SQL Function Result Cache .....	18
Dynamic SQL Enhancements .....	19
Mixed Name and Position Notation Calls .....	19
Multiprocess Connection Pool .....	21
PL/SQL Hierarchical Profiler .....	23
PL/SQL Native Compiler Generates Native Code .....	23
PL/Scope .....	24
Regular Expression Enhancement .....	24
SIMPLE_INTEGER Datatype .....	24
Direct Sequence Calls in SQL Statements .....	24
Summary .....	24

<b>2</b>	<b>PL/SQL Basics</b>	<b>25</b>
	Oracle PL/SQL Block Structure	26
	Variables, Assignments, and Operators	29
	Control Structures	31
	Conditional Structures	31
	Iterative Structures	33
	Stored Functions, Procedures, and Packages	36
	Stored Functions	37
	Procedures	38
	Packages	40
	Transaction Scope	40
	Single Transaction Scope	41
	Multiple Transaction Scopes	41
	Database Triggers	42
	Summary	43
<b>3</b>	<b>Language Fundamentals</b>	<b>45</b>
	Character and Lexical Units	46
	Delimiters	46
	Identifiers	51
	Literals	52
	Comments	54
	Block Structures	55
	Variable Types	60
	Scalar Datatypes	63
	Large Objects (LOBs)	79
	Composite Datatypes	82
	System Reference Cursors	87
	Variable Scope	89
	Summary	90
<b>4</b>	<b>Control Structures</b>	<b>91</b>
	Conditional Statements	92
	IF Statements	98
	CASE Statements	101
	Conditional Compilation Statements	104
	Iterative Statements	105
	Simple Loop Statements	106
	FOR Loop Statements	109
	WHILE Loop Statements	111
	Cursor Structures	113
	Implicit Cursors	113
	Explicit Cursors	116
	Bulk Statements	122
	BULK COLLECT INTO Statements	123
	FORALL Statements	127
	Summary	129
<b>5</b>	<b>Error Management</b>	<b>131</b>
	Exception Types and Scope	132
	Compilation Errors	133
	Run-Time Errors	136

Exception Management Built-in Functions	141
User-Defined Exceptions	143
Declaring User-Defined Exceptions	144
Dynamic User-Defined Exceptions	145
Exception Stack Functions	146
Exception Stack Management	146
Error Stack Formatting	150
Database Trigger Exception Management	152
Critical Error Database Triggers	153
Non-Critical Error Database Triggers	158
Summary	160

## PART II

# PL/SQL Programming

<b>6 Functions and Procedures</b>	<b>163</b>
Function and Procedure Architecture	165
Transaction Scope	172
Calling Subroutines	172
Positional Notation	173
Named Notation	173
Mixed Notation	173
Exclusionary Notation	173
SQL Call Notation	174
Functions	174
Creation Options	176
Pass-by-Value Functions	186
Pass-by-Reference Functions	192
Procedures	194
Pass-by-Value Procedures	195
Pass-by-Reference Procedures	200
Summary	206
<b>7 Collections</b>	<b>207</b>
Collection Types	210
Varrays	212
Nested Tables	225
Associative Arrays	238
Collection Set Operators	245
CARDINALITY Operator	248
EMPTY Operator	248
MEMBER OF Operator	248
MULTISET EXCEPT Operator	249
MULTISET INTERSECT Operator	249
MULTISET UNION Operator	249
SET Operator	250
SUBMULTISET Operator	251
Collection API	252
COUNT Method	255
DELETE Method	255
EXISTS Method	256

EXTEND Method	258
FIRST Method	259
LAST Method	260
LIMIT Method	260
NEXT Method	261
PRIOR Method	261
TRIM Method	262
Summary	263
<b>8 Large Objects</b>	<b>265</b>
Character Large Objects: CLOB and NCLOB Datatypes	266
PL/SQL Reading Files and Writing CLOB or NCLOB Columns	271
Uploading CLOBs to the Database	274
Binary Large Objects: BLOB Datatype	275
PL/SQL Reading Files and Writing BLOB Columns	277
Uploading BLOBs to the Database	280
SecureFiles	280
Binary Files: BFILE Datatype	282
Creating and Using Virtual Directories	282
Reading Canonical Path Names and Filenames	290
DBMS_LOB Package	298
Package Constants	298
Package Exceptions	300
Opening and Closing Methods	300
Manipulation Methods	302
Introspection Methods	306
BFILE Methods	309
Temporary LOB Methods	310
Summary	311
<b>9 Packages</b>	<b>313</b>
Package Architecture	315
Forward Referencing	315
Overloading	318
Package Specification	319
Variables	322
Types	324
Components: Functions and Procedures	327
Package Body	328
Variables	330
Types	331
Components: Functions and Procedures	332
Definer vs. Invoker Rights	335
Grants and Synonyms	336
Remote Calls	337
Managing Packages in the Database Catalog	338
Finding, Validating, and Describing Packages	338
Checking Dependencies	339
Comparing Validation Methods: Timestamp vs. Signature	340
Summary	341

<b>10</b>	<b>Triggers</b> .....	<b>343</b>
	Introduction to Triggers .....	344
	Database Trigger Architecture .....	346
	Data Definition Language Triggers .....	348
	Event Attribute Functions .....	349
	Building DDL Triggers .....	358
	Data Manipulation Language Triggers .....	360
	Statement-Level Triggers .....	361
	Row-Level Triggers .....	362
	Compound Triggers .....	365
	Instead-of Triggers .....	370
	System or Database Event Triggers .....	374
	Trigger Restrictions .....	375
	Maximum Trigger Size .....	375
	SQL Statements .....	375
	LONG and LONG RAW Datatypes .....	376
	Mutating Tables .....	376
	System Triggers .....	377
	Summary .....	378

### PART III

## PL/SQL Advanced Programming

<b>11</b>	<b>Dynamic SQL</b> .....	<b>381</b>
	Dynamic SQL Architecture .....	382
	Native Dynamic SQL (NDS) .....	383
	Dynamic Statements .....	383
	Dynamic Statements with Inputs .....	386
	Dynamic Statements with Inputs and Outputs .....	388
	Dynamic Statements with an Unknown Number of Inputs .....	391
	DBMS_SQL Package .....	393
	Dynamic Statements .....	394
	Dynamic Statements with Input Variables .....	398
	Dynamic Statements with Input and Output Variables .....	400
	DBMS_SQL Package Definition .....	403
	Summary .....	415
<b>12</b>	<b>Intersession Communication</b> .....	<b>417</b>
	Introducing Intersession Communication .....	418
	Requiring Permanent or Semipermanent Structures .....	418
	Not Requiring Permanent or Semipermanent Structures .....	418
	Comparing Intersession Communication Approaches .....	419
	The DBMS_PIPE Built-in Package .....	420
	Introducing the DBMS_PIPE Package .....	420
	Defining the DBMS_PIPE Package .....	422
	Working with the DBMS_PIPE Package .....	426
	DBMS_ALERT Built-in Package .....	436
	Introducing the DBMS_ALERT Package .....	436
	Defining the DBMS_ALERT Package .....	437
	Working with the DBMS_ALERT Package .....	439
	Summary .....	443

<b>13</b>	<b>External Procedures</b>	<b>445</b>
	Introducing External Procedures	446
	Working with External Procedures	447
	Defining the extproc Architecture	447
	Defining extproc Oracle Net Services Configuration	449
	Defining the Multithreaded External Procedure Agent	456
	Working with a C Shared Library	459
	Working with a Java Shared Library	465
	Troubleshooting the Shared Library	470
	Configuration of the Listener or Environment	470
	Configuration of the Shared Library or PL/SQL Library Wrapper	473
	Summary	474
<b>14</b>	<b>Object Types</b>	<b>475</b>
	Objects Basics	478
	Declaring Objects	479
	Implementing Object Bodies	481
	Getters and Setters	483
	Static Member Methods	485
	Comparing Objects	487
	Inheritance and Polymorphism	494
	Declaring Subclasses	495
	Implementing Subclasses	497
	Type Evolution	500
	Implementing Collection Object Bodies	500
	Declaring Object Type Collections	500
	Implementing Object Type Collections	501
	Summary	504
<b>15</b>	<b>Java Libraries</b>	<b>505</b>
	Oracle 11g JVM New Features	506
	Java Architecture	507
	Java Execution Control	509
	Java Resource Storage	509
	Java Class Names	509
	Java Resolvers	510
	Java Security and Permissions	510
	Java Threading	510
	Oracle Java Connection Types	510
	The Client-Side Driver, or JDBC Thin Driver	510
	The Oracle Call Interface Driver, or Middle-Tier Thick Driver	511
	The Oracle Server-Side Internal Driver, or Server-Tier Thick Driver	511
	Building Java Class Libraries in Oracle	512
	Building Internal Server Java Functions	513
	Building Internal Server Java Procedures	518
	Building Internal Server Java Objects	521
	Troubleshooting Java Class Libraries	526
	Mapping Oracle Types	530
	Summary	532

<b>16</b>	<b>Web Application Development</b>	<b>533</b>
	PL/SQL Web Server Architecture	535
	Oracle HTTP Server Architecture	536
	Oracle XML Database Server Architecture	537
	Configuring the Standalone Oracle HTTP Server	539
	Describing mod_plsql Cartridge	540
	Configuring the Oracle HTTP Server	541
	Configuring the XML DB Server	543
	Configuring Static Authentication	546
	Configuring Dynamic Authentication	547
	Configuring Anonymous Authentication	548
	Comparing Web-Enabled PL/SQL Procedures and PSPs	550
	Creating Web-Enabled PL/SQL Stored Procedures	550
	Developing Procedures Without Formal Parameters	553
	Developing Procedures with Formal Parameters	553
	Understanding Advantages and Limitations	559
	Building and Accessing PL/SQL Server Pages (PSPs)	559
	Developing and Running No Formal Parameter PSP Procedures	562
	Developing Formal Parameter PSP Procedures	564
	Understanding Advantages and Limitations	567
	Summary	568

## PART IV Appendixes

<b>A</b>	<b>Oracle Database Administration Primer</b>	<b>571</b>
	Oracle Database Architecture	572
	Starting and Stopping the Oracle Database	578
	Unix or Linux Operations	578
	Microsoft Windows Operations	582
	Starting and Stopping the Oracle Listener	585
	Oracle Roles and Privileges	590
	Accessing and Using the SQL*Plus Interface	590
	SQL Command-Line Interface	592
	Bind Variables	597
	Summary	598
<b>B</b>	<b>Oracle Database SQL Primer</b>	<b>599</b>
	Oracle SQL*Plus Datatypes	601
	Data Definition Language (DDL)	604
	Managing Tables and Constraints	605
	Managing Views	609
	Managing Stored Programs	612
	Managing Sequences	612
	Managing User-Defined Types	616
	Data Query Language (DQL)	617
	Queries	618
	Data Manipulation Language (DML)	624
	INSERT Statements	624



UPDATE Statements .....	626
DELETE Statements .....	627
Data Control Language (DCL) .....	628
Summary .....	628
<b>C PHP Primer .....</b>	<b>629</b>
History and Background .....	631
What Is PHP? .....	631
What Is Zend? .....	631
Developing Web Programming Solutions .....	632
What Goes Where and Why? .....	632
What Does Oracle Contribute to PHP? .....	633
Why Is PHP 5 Important? .....	633
How to Use PHP .....	633
How to Use PHP and OCI8 to Access the Oracle Database .....	658
Summary .....	684
<b>D Oracle Database Java Primer .....</b>	<b>685</b>
Java and JDBC Architecture .....	686
Configuring the Oracle Java Environment .....	687
Java Programming Language Primer .....	689
Java Basics .....	689
Java Assignment Operators .....	692
Java Conditional and Iterative Structures .....	693
Java Method Definitions .....	695
Java try-catch Blocks .....	696
Testing a Client-Side or Thin-Driver JDBC Connection .....	697
Accessing Scalar Variables .....	702
Writing and Accessing Large Objects .....	709
Writing and Accessing a CLOB Column .....	710
Accessing a BFILE Column .....	718
Summary .....	727
<b>E Regular Expression Primer .....</b>	<b>729</b>
Introduction to Regular Expressions .....	730
Character Classes .....	730
Collation Classes .....	732
Metacharacters .....	732
Metasequences .....	734
Literals .....	735
Oracle 11g Regular Expression Implementation .....	736
REGEXP_COUNT Function .....	736
REGEXP_INSTR Function .....	737
REGEXP_LIKE Function .....	739
REGEXP_REPLACE Function .....	740
REGEXP_SUBSTR Function .....	740
Using Regular Expressions .....	741
REGEXP_COUNT Function .....	742
REGEXP_INSTR Function .....	743
REGEXP_LIKE Function .....	744
REGEXP_REPLACE Function .....	744

	REGEXP_SUBSTR Function .....	745
	Summary .....	746
<b>F</b>	<b>Wrapping PL/SQL Code Primer .....</b>	<b>747</b>
	Limitations of Wrapping PL/SQL .....	748
	Limitations of the PL/SQL Wrap Utility .....	748
	Limitations of the DBMS_DDL.WRAP Function .....	749
	Using the Wrap Command-Line Utility .....	749
	Using the DBMS_DDL Command-Line Utility .....	749
	The WRAP Function .....	749
	The CREATE_WRAPPED Procedure .....	751
	Summary .....	752
<b>G</b>	<b>PL/SQL Hierarchical Profiler Primer .....</b>	<b>753</b>
	Configuring the Schema .....	754
	Collecting Profiler Data .....	756
	Understanding Profiler Data .....	758
	Reading the Raw Output .....	759
	Defining the PL/SQL Profiler Tables .....	760
	Querying the Analyzed Data .....	762
	Using the plshprof Command-Line Utility .....	763
	Summary .....	764
<b>H</b>	<b>PL/Scope .....</b>	<b>765</b>
	Configuring PL/Scope Data Collection .....	766
	Viewing PL/Scope Collected Data .....	766
	Summary .....	768
<b>I</b>	<b>PL/SQL Reserved Words and Keywords .....</b>	<b>769</b>
	Summary .....	775
<b>J</b>	<b>PL/SQL Built-in Functions .....</b>	<b>777</b>
	Character Functions .....	778
	ASCII Function .....	778
	ASCIISTR Function .....	779
	CHR Function .....	779
	CONCAT Function .....	779
	INITCAP Function .....	780
	INSTR Function .....	780
	LENGTH Function .....	781
	LOWER Function .....	782
	LPAD Function .....	782
	LTRIM Function .....	782
	REPLACE Function .....	783
	RPAD Function .....	783
	RTRIM Function .....	784
	UPPER Function .....	784
	Datatype Conversion .....	785
	CAST Function .....	785
	CONVERT Function .....	787
	TO_CHAR Function .....	788
	TO_CLOB Function .....	790

TO_DATE Function	790
TO_LOB Function	791
TO_NCHAR Function	792
TO_NCLOB Function	792
TO_NUMBER Function	793
TO_TIMESTAMP Function	794
Error Reporting	794
SQLCODE Function	795
SQLERRM Function	795
Miscellaneous	797
BFILENAME Function	797
COALESCE Function	799
DECODE Function	800
DUMP Function	801
EMPTY_BLOB Function	801
EMPTY_CLOB Function	804
GREATEST Function	805
LEAST Function	806
NANVL Function	808
NULLIF Function	809
NVL Function	809
SYS_CONTEXT Function	810
USERENV Function	813
VSIZE Function	814
Number	815
CEIL Function	815
FLOOR Function	815
MOD Function	816
POWER Function	816
REMAINDER Function	818
Summary	819
<b>Index</b>	<b>821</b>