Pro*C/C++™ Precompiler

Programmer's Guide

Release 8.0

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Pro*C/C++™ Precompiler Programmer's Guide

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Release 8.0

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Preface

This manual is a comprehensive user's guide and on-the-job reference to the Pro*C/C++ Precompiler. It shows you how to use the database language SQL and Oracle's procedural extension, PL/SQL, in conjunction with Pro*C/C++ to manipulate data in an Oracle8 database. It explores a full range of topics, from underlying concepts to advanced programming techniques, and uses code examples.

Support for Objects and for the Object Type Translator are available only if you have purchased the Oracle8 Enterprise Edition with the Objects Option.

Topics are:

- What This Guide Has to Offer
- Who Should Read This Guide?
- How the Pro*C/C++ Guide Is Organized
- Conventions Used in This Guide
- ANSI/ISO Compliance
- Migrating an Application
- Your Comments Are Welcome.

What This Guide Has to Offer

This Guide shows you how the Oracle Pro*C/C++ Precompiler and embedded SQL can benefit your entire applications development process. It gives you the know-how to design and develop applications that harness the power of Oracle. And, as quickly as possible, it helps you become proficient in writing embedded SQL programs.

An important feature of this Guide is its emphasis on getting the most out of Pro*C/C++ and embedded SQL. To help you master these tools, this Guide shows you all the "tricks of the trade" including ways to improve program performance. It also includes many program examples to better your understanding and demonstrate the usefulness of embedded SQL and embedded PL/SQL.

> **Note:** You will not find installation instructions or other system-specific information in this Guide; refer to your system-specific Oracle documentation.

Who Should Read This Guide?

Anyone developing new applications or converting existing applications to run in the Oracle environment will benefit from reading this Guide. Written especially for programmers, this comprehensive treatment of the Oracle Pro*C/C++ Precompiler will also be of value to systems analysts, project managers, and others interested in embedded SQL applications. To use this Guide effectively, you need a working knowledge of applications programming in C or C++. It would be helpful to have some familiarity with the SQL database language, although this book will Guide you through most of the complexities of embedded SQL programming.

How the Pro*C/C++ Guide Is Organized

Chapters 1 through 9 present the basics of Pro*C/C++ programming and tell you how to run the precompiler. For many Pro*C/C++ developers, these chapters are sufficient to enable them to write useful and powerful Pro*C/C++ applications.

Later chapters offer more detailed descriptions of Pro*C/C++. They describe some of the more complicated things that you can do with the product, such as writing Pro*C/C++ programs that use dynamic SQL.

Chapter 1, "Introduction":

This chapter introduces you to Pro*C/C++. You look at its role in developing application programs that manipulate Oracle data.

Chapter 2, "Learning the Basics":

This chapter explains how embedded SQL programs do their work. You examine the special environment in which they operate, the impact of this environment on the design of your applications, the key concepts of embedded SQL programming, and the steps you take in developing an application.

Chapter 3, "Developing a Pro*C/C++ Application":

This chapter gives you the basic information you need to develop a Pro*C/C++ application. You learn about migrating from earlier versions. You also learn about the Oracle datatypes, host variables, indicator variables, data conversion, and how to take advantage of datatype equivalencing.

Chapter 4, "Advanced Pro*C/C++ Applications":

This chapter presents advanced topics, such as National Language Support, connecting to Oracle, concurrent connections, developing multi-threaded applications, and interfacing to OCI.

Chapter 5, "Using Embedded SQL":

This chapter teaches you the essentials of embedded SQL programming. You learn how to use host variables, indicator variables, cursors, cursor variables, and the fundamental SQL commands that insert, update, select, and delete Oracle data.

Chapter 6, "Using Embedded PL/SQL":

This chapter shows you how to improve performance by embedding PL/SQL transaction processing blocks in your program. You learn how to use PL/SQL with host variables, indicator variables, cursors, stored procedures, host arrays, and dynamic SQL.

Chapter 7, "Using C++":

This chapter describes how to precompile your C++ application, and lists three sample Pro*C/C++ programs written using C++.

Chapter 8, "Object Support in Pro*C/C++":

This chapter describes object support features: associative and navigational interfaces (embedded SQL commands), precompiler options for objects, and restrictions on the use of Oracle8 types in dynamic SQL.

Chapter 9, "Running the Pro*C/C++ Precompiler":

This chapter details the requirements for running the Oracle Pro*C/C++ Precompiler. You learn what happens during precompilation, how to issue the precompiler command, and how to specify the many useful precompiler options.

Chapter 10, "Defining and Controlling Transactions":

This chapter describes transaction processing. You learn the basic techniques that safeguard the consistency of your database.

Chapter 11, "Handling Runtime Errors":

This chapter discusses error reporting and recovery. It shows you how to use the SQLSTATE and SQLCODE status variables with the WHENEVER statement to detect errors and status changes. It also shows you how to use the SQLCA and ORACA to detect error conditions and diagnose problems.

Chapter 12, "Using Host Arrays":

This chapter looks at using arrays to improve program performance. You learn how to manipulate Oracle data using arrays, how to operate on all the elements of an array with a single SQL statement, and how to limit the number of array elements processed.

Chapter 13, "Using Dynamic SQL":

This chapter shows you how to take advantage of dynamic SQL. You are taught three methods—from simple to complex—for writing flexible programs that, among other things, let users build SQL statements interactively at run time.

Chapter 14, "Using Dynamic SQL: Advanced Concepts":

This chapter gives you an in-depth explanation of Dynamic SQL Method 4—dynamic SQL using descriptors. With this technique, your application can process and execute *any* SQL statement at runtime.

Chapter 15, "Writing User Exits":

This chapter focuses on writing user exits for Oracle Tools applications. You learn about the commands that are used to interface between a forms application and a Pro*C/C++ user exit, and how to write and link a forms user exit..

Chapter 16, "Using the Object Type Translator": Discusses the Object Type Translator (OTT) which maps object types to C structures that are used in Pro*C/C++ applications. Describes the OTT options, how to use OTT, and the results.

Appendix A, "New Features": This appendix highlights the improvements and new features introduced with this release of Pro*C/C++.

Appendix B, "Oracle Reserved Words, Keywords, and Namespaces": This appendix lists words that have a special meaning to Oracle and namespaces that are reserved for Oracle libraries.

Appendix C, "Performance Tuning": This appendix shows you some simple, easy-to-apply methods for improving the performance of your applications.

Appendix D, "Syntactic and Semantic Checking": This appendix shows you how to use the SQLCHECK option to control the type and extent of syntactic and semantic checking done on embedded SQL statements and PL/SQL blocks.

Appendix E, "System-Specific References": This appendix documents the aspects of Pro*C/C++ that can be system-specific.

Appendix F, "Embedded SQL Commands and Directives": This appendix contains descriptions of precompiler directives, embedded SQL commands, and Oracle embedded SQL extensions.

Conventions Used in This Guide

Important terms being defined for the first time are *italicized*. In discussions, UPPERCASE is used for database objects and SQL keywords, and *italicized lowercase* is used for the names of C variables, constants, and parameters. C keywords are in **bold face** type

Notation

The following notation is used in this Guide:

[ ]	Square brackets enclose optional items in syntax descriptions.
< >	Angle brackets enclose the name of a syntactic element in syntax descriptions.
{ }	Braces enclose items, only one of which is required.
|	A vertical bar separates options within brackets or braces.
. .	Two dots separate the lowest and highest values in a range.
. . .	An ellipsis shows that the preceding parameter can be repeated or that statements or clauses irrelevant to the discussion were left out.

ANSI/ISO Compliance

The Pro*C/C++ Precompiler complies *fully* with the ANSI/ISO SQL standards. Compliance with these standards was certified by the National Institute of

Standards and Technology (NIST). To flag extensions to ANSI/ISO SQL, a FIPS Flagger is provided.

Requirements

ANSI standard X3.135-1992 (known informally as SQL92) provides three levels of compliance:

- Full SQL
- Intermediate SQL (a subset of Full SQL)
- Entry SQL (a subset of Intermediate SQL)

ANSI standard X3.168-1992 specifies the syntax and semantics for embedding SQL statements in application programs written in a standard programming language such as C.

A conforming SQL implementation must support at least Entry SQL. The Oracle Pro*C/C++ Precompiler does conform to Entry SQL92.

NIST standard FIPS PUB 127-1, which applies to RDBMS software acquired for federal use, also adopts the ANSI standards. In addition, it specifies minimum sizing parameters for database constructs and requires a “FIPS Flagger” to identify ANSI extensions.

For copies of the ANSI standards, write to

American National Standards Institute

1430 Broadway

New York, NY 10018

USA

Migrating an Application

To migrate applications from earlier releases of Pro*C and Pro*C/C++, see *Oracle8 Migration*.

Your Comments Are Welcome.

The Oracle Corporation technical staff values your Comments. As we write and revise, your opinions are the most important input we receive. Please use the

Reader's Comment Form in this manual to tell us what you like and dislike about this Oracle publication.

1

Introduction

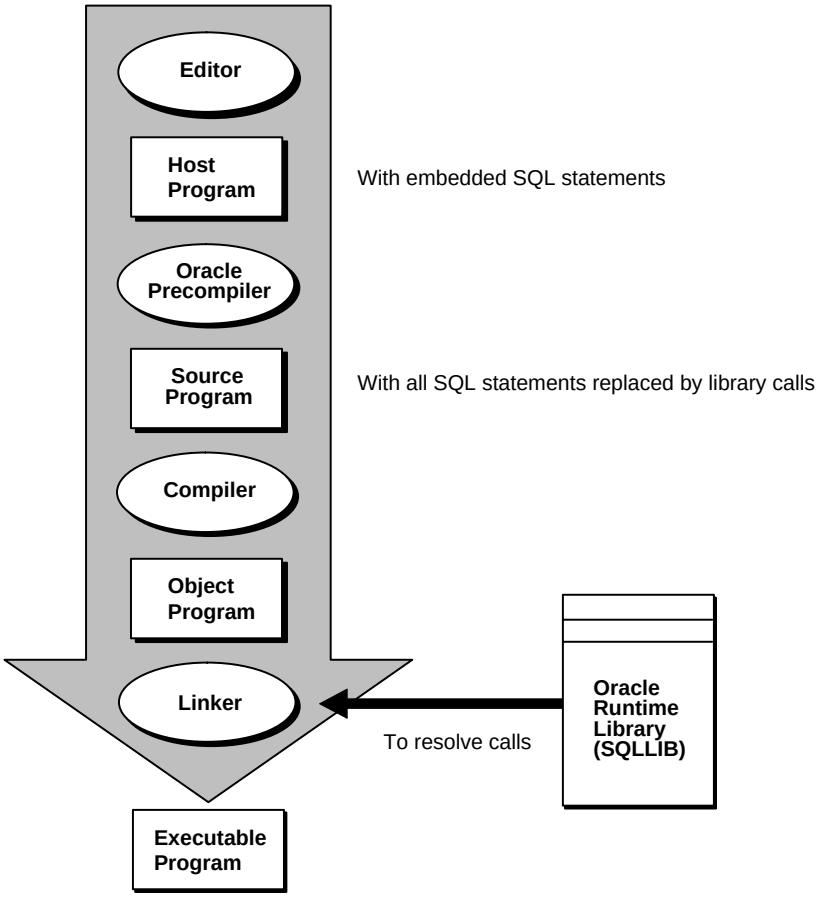
This chapter introduces you to the Pro*C/C++ Precompiler. You look at its role in developing application programs that manipulate Oracle data and find out what it allows your applications to do. This chapter answers the following questions:

- What Is an Oracle Precompiler?
- Why Use the Oracle Pro*C/C++ Precompiler?
- Why Use SQL?
- Why Use PL/SQL?
- What Does the Pro*C/C++ Precompiler Offer?
- Does the Oracle Pro*C/C++ Precompiler Meet Industry Standards?
- Migrating an Application from Earlier Releases
- Frequently Asked Questions

What Is an Oracle Precompiler?

An Oracle Precompiler is a programming tool that allows you to embed SQL statements in a high-level source program. As Figure 1–1 shows, the precompiler accepts the source program as input, translates the embedded SQL statements into standard Oracle runtime library calls, and generates a modified source program that you can compile, link, and execute in the usual way.

Figure 1–1 Embedded SQL Program Development



Why Use the Oracle Pro*C/C++ Precompiler?

The Oracle Pro*C / C++ Precompiler lets you use the power and flexibility of SQL in your application programs. A convenient, easy to use interface lets your application access Oracle directly.

Unlike many application development tools, the Pro*C / C++ Precompiler lets you create highly customized applications. For example, you can create user interfaces that incorporate the latest windowing and mouse technology. You can also create applications that run in the background without the need for user interaction.

Furthermore, Pro*C / C++ helps you fine-tune your applications. It allows close monitoring of resource use, SQL statement execution, and various runtime indicators. With this information, you can tweak program parameters for maximum performance.

Although precompiling adds a step to the application development process, it saves time because the precompiler, not you, translates each embedded SQL statement into several calls to the Oracle runtime library (SQLLIB).

Why Use SQL?

If you want to access and manipulate Oracle data, you need SQL. Whether you use SQL interactively through SQL*Plus or embedded in an application program depends on the job at hand. If the job requires the procedural processing power of C or C++, or must be done on a regular basis, use embedded SQL.

SQL has become the database language of choice because it is flexible, powerful, and easy to learn. Being non-procedural, it lets you specify what you want done without specifying how to do it. A few English-like statements make it easy to manipulate Oracle data one row or many rows at a time.

You can execute any SQL (not SQL*Plus) statement from an application program. For example, you can

- CREATE, ALTER, and DROP database tables dynamically
- SELECT, INSERT, UPDATE, and DELETE rows of data
- COMMIT or ROLLBACK transactions

Before embedding SQL statements in an application program, you can test them interactively using SQL*Plus. Usually, only minor changes are required to switch from interactive to embedded SQL.

Why Use PL/SQL?

An extension to SQL, PL/SQL is a transaction processing language that supports procedural constructs, variable declarations, and robust error handling. Within the same PL/SQL block, you can use SQL and all the PL/SQL extensions.

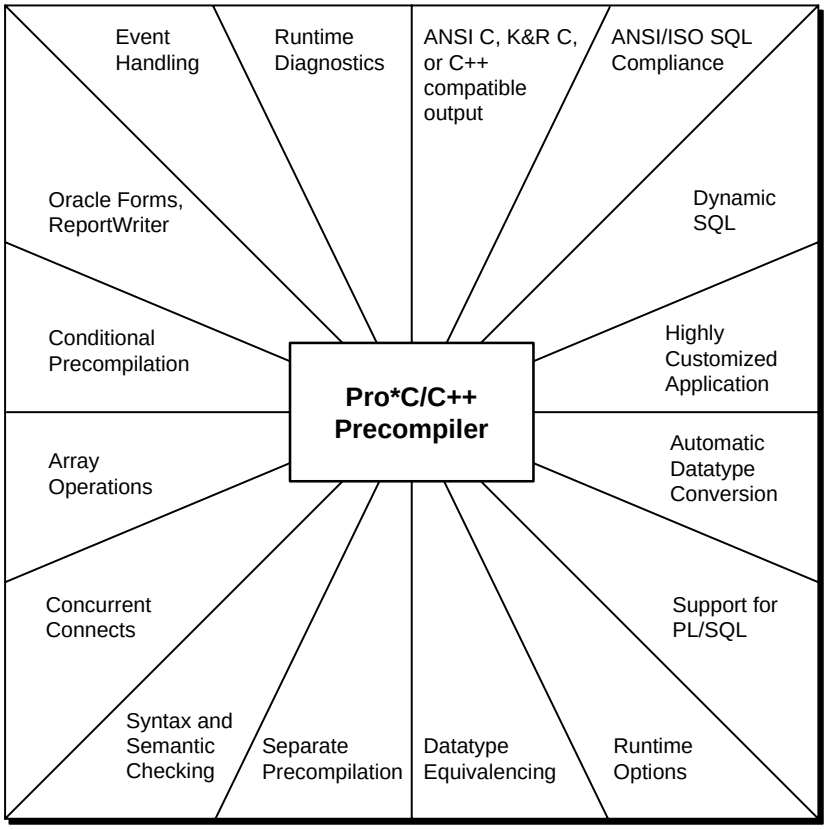
The main advantage of embedded PL/SQL is better performance. Unlike SQL, PL/SQL allows you to group SQL statements logically and send them to Oracle in a block rather than one by one. This reduces network traffic and processing overhead.

For more information about PL/SQL, including how to embed it in an application program, see Chapter 6, “Using Embedded PL/SQL”.

What Does the Pro*C/C++ Precompiler Offer?

As Figure 1–2 shows, Pro*C/C++ offers many features and benefits, which help you to develop effective, reliable applications.

Figure 1–2 Features and Benefits



For example, Pro*C/C++ allows you to

- write your application in C or C++
- follow the ANSI/ISO standards for embedding SQL statements in a high-level language
- take advantage of dynamic SQL, an advanced programming technique that lets your program accept or build any valid SQL statement at runtime
- design and develop highly customized applications

- write multi-threaded applications
- automatically convert between Oracle internal datatypes and high-level language datatypes
- improve performance by embedding PL/SQL transaction processing blocks in your application program
- specify useful precompiler options inline and on the command line and change their values during precompilation
- use datatype equivalencing to control the way Oracle interprets input data and formats output data
- separately precompile several program modules, then link them into one executable program
- completely check the syntax and semantics of embedded SQL data manipulation statements and PL/SQL blocks
- concurrently access Oracle databases on multiple nodes using SQL*Net
- use arrays as input and output program variables
- conditionally precompile sections of code in your host program so that it can run in different environments
- directly interface with SQL*Forms via user exits written in a high-level language
- handle errors and warnings with the SQL Communications Area (SQLCA) and the WHENEVER or DO statement
- use an enhanced set of diagnostics provided by the Oracle Communications Area (ORACA)
- work with object types in the database
- use National Character Set data stored in the database
- use Oracle Call Interface functions in your program

To sum it up, the Pro*C/C++ Precompiler is a full-featured tool that supports a professional approach to embedded SQL programming.

Does the Oracle Pro*C/C++ Precompiler Meet Industry Standards?

SQL has become the standard language for relational database management systems. This section describes how the Pro*C/C++ Precompiler conforms to SQL standards established by the following organizations:

- American National Standards Institute (ANSI)
- International Standards Organization (ISO)
- U.S. National Institute of Standards and Technology (NIST)

These organizations have adopted SQL as defined in the following publications:

- ANSI standard X3.135-1992, *Database Language SQL*
- ISO/IEC standard 9075:1992, *Database Language SQL*
- ANSI standard X3.135-1989, *Database Language SQL with Integrity Enhancement*
- ANSI standard X3.168-1989, *Database Language Embedded SQL*
- ISO standard 9075-1989, *Database Language SQL with Integrity Enhancement*
- NIST standard FIPS PUB 127-1, *Database Language SQL* (FIPS is an acronym for Federal Information Processing Standards)

Requirements

ANSI standard X3.135-1992 (known informally as SQL92) provides three levels of compliance:

- Full SQL
- Intermediate SQL (a subset of Full SQL)
- Entry SQL (a subset of Intermediate SQL)

ANSI standard X3.168-1992 specifies the syntax and semantics for embedding SQL statements in application programs written in a standard programming language such as Ada, C, COBOL, FORTRAN, Pascal, or PL/I.

A conforming SQL implementation must support at least Entry SQL. The Oracle Pro*C/C++ Precompiler does conform to Entry SQL92.

NIST standard FIPS PUB 127-1, which applies to RDBMS software acquired for federal use, also adopts the ANSI standards. In addition, it specifies minimum sizing parameters for database constructs and requires a “FIPS Flagger” to identify ANSI extensions.

For copies of the ANSI standards, write to

American National Standards Institute

1430 Broadway

New York, NY 10018

USA

For a copy of the ISO standard, write to the national standards office of any ISO participant. For a copy of the NIST standard, write to

National Technical Information Service

U.S. Department of Commerce

Springfield, VA 22161

USA

Compliance

Under Oracle8, the Pro*C/C++ Precompiler complies 100% with current ANSI/ISO standards.

The Pro*C/C++ Precompiler also complies 100% with the NIST standard. It provides a FIPS Flagger and an option named FIPS, which enables the FIPS Flagger. For more information, see "FIPS Flagger" on page 1-9.

Certification

NIST tested the Pro*C/C++ Precompiler for ANSI SQL92 compliance using the *SQL Test Suite*, which consists of nearly 300 test programs. Specifically, the programs tested for conformance to the C embedded SQL standard. The result: the Oracle Pro*C/C++ Precompiler was certified 100% ANSI-compliant for Entry SQL92.

For more information about the tests, write to

National Computer Systems Laboratory

Attn: Software Standards Testing Program

National Institute of Standards and Technology

Gaithersburg, MD 20899

USA

FIPS Flagger

According to FIPS PUB 127-1, “an implementation that provides additional facilities not specified by this standard shall also provide an option to flag nonconforming SQL language or conforming SQL language that may be processed in a nonconforming manner.” To meet this requirement, the Pro*C/C++ Precompiler provides the *FIPS Flagger*, which flags ANSI extensions. An extension is any SQL element that violates ANSI format or syntax rules, except privilege enforcement rules. For a list of Oracle extensions to standard SQL, see the *Oracle8 Server SQL Reference*.

You can use the FIPS Flagger to identify

- nonconforming SQL elements that might have to be modified if you move the application to a conforming environment
- conforming SQL elements that might behave differently in another processing environment

Thus, the FIPS Flagger helps you develop portable applications.

FIPS Option

The FIPS precompiler option governs the FIPS Flagger. To enable the FIPS Flagger, specify FIPS=YES inline or on the command line. For more information about the FIPS option, see the section "Using the Precompiler Options" on page 9-10.

Migrating an Application from Earlier Releases

There are several semantic changes in database operations between Oracle7 and Oracle8. For information on how this affects Pro*C/C++ applications, see the section "Migrating From Earlier Pro*C/C++ Releases" on page 3-9, and the discussion of the DBMS precompiler option on "DBMS" on page 9-14.

Frequently Asked Questions

This section presents some questions that are frequently asked about Pro*C/C++, and about Oracle8 in relation to Pro*C/C++. The answers are more informal than the documentation in the rest of this Guide, but do provide references to places where you can find the reference material.

Question:

I’m confused by VARCHAR. What’s a VARCHAR?

Answer:

Here's a short description of VARCHARs:

VARCHAR2	A kind of column in the database that contains variable-length character data. This is what Oracle calls an "internal datatype", because it's a possible column type. See "VARCHAR2" on page 3-20.
VARCHAR	An Oracle "external datatype" (datatype code 9). You use this only if you're doing dynamic SQL Method 4, or datatype equivalencing. See "VARCHAR" on page 3-22 for datatype equivalencing, and Chapter 14, "Using Dynamic SQL: Advanced Concepts".
VARCHAR[n] varchar[n]	This is a Pro*C/C++ "pseudotype" that you can declare as a host variable in your Pro*C/C++ program. It's actually generated by Pro*C/C++ as a **struct**, with a 2-byte length element, and a [n]-byte character array. See "Declaring VARCHAR Variables" on page 3-43.

Question:

Does Pro*C/C++ generate calls to the Oracle Call Interface (OCI)?

Answer:

No. Pro*C/C++ generates data structures, and calls to its runtime library: SQLLIB (*libsql.a* in UNIX).

Question:

Then why not just code using SQLLIB calls, and not use Pro*C/C++?

Answer:

SQLLIB is not externally documented, is unsupported, and might change from release to release. Also, Pro*C/C++ is an ANSI/ISO compliant product, that follows the standard requirements for embedded SQL.

If you need to do low-level coding, use the OCI. It is supported, and Oracle is committed to supporting it.

You can also mix OCI and Pro*C/C++. See "SQLLIB Extensions for OCI Release 8 Interoperability" on page 4-55.

Question:

Can I call a PL/SQL stored procedure from a Pro*C/C++ program?

Answer:

Certainly. See Chapter 6, “Using Embedded PL/SQL”. There’s a demo program starting on "Calling a Stored Subprogram" on page 6-23.

Question:

Can I write C++ code, and precompile it using Pro*C/C++?

Answer:

Yes. Since Pro*C/C++ release 2.1, you can precompile C++ applications. See Chapter 7, “Using C++”.

Question:

Can I use bind variables anyplace in a SQL statement? For example, I’d like to be able to input the name of a table in my SQL statements at runtime. But when I use host variables, I get precompiler errors.

Answer:

In general, you can use host variables at any place in a SQL, or PL/SQL, statement where expressions are allowed. See "Referencing Host Variables" on page 3-31. The following SQL statement, where *table_name* is a host variable, is *illegal*:

```
EXEC SQL SELECT ename,sal INTO :name, :salary FROM :table_name;
```

To solve your problem, you need to use dynamic SQL. See Chapter 13, “Using Dynamic SQL”. There is a demo program that you can adapt to do this starting on "Sample Program: Dynamic SQL Method 1" on page 13-9.

Question:

I am confused by character handling in Pro*C/C++. It seems that there are many options. Can you help?

Answer:

There are many options, but we can simplify. First of all, if you need compatibility with previous V1.x precompilers, and with both Oracle V6 and Oracle7, the safest thing to do is use VARCHAR[n] host variables. See "Declaring VARCHAR Variables" on page 3-43.

The default datatype for all other character variables in Pro*C/C++ is CHARZ; see "CHARZ" on page 3-25. Briefly, this means that you must null-terminate the string on input, and it is both blank-padded and null-terminated on output.

In release 8.0, the CHAR_MAP precompiler option was introduced to specify the default mapping of char variables. See "Precompiler Option CHAR_MAP" on page 3-50.

If neither VARCHAR nor CHARZ works for your application, and you need total C-like behavior (null termination, absolutely no blank-padding), use the TYPE command and the C *typedef* statement, and use datatype equivalencing to convert your character host variables to STRING. See "User-Defined Type Equivalencing" on page 3-60. There is a sample program that shows how to use the TYPE command starting on "Sample Program: Cursor and a Host Structure" on page 3-38.

Question:

What about character pointers? Is there anything special about them?

Answer:

Yes. When Pro*C/C++ binds an input or output host variable, it must know the length. When you use VARCHAR[n], or declare a host variable of type *char[n]*, Pro*C/C++ knows the length from your declaration. But when you use a character pointer as a host variable, and use *malloc()* to define the buffer in your program, Pro*C/C++ has no way of knowing the length.

What you must do on output is not only allocate the buffer, but pad it out with some non-null characters, then null-terminate it. On input or output, Pro*C/C++ calls *strlen()* for the buffer to get the length. See "Pointer Variables" on page 3-41.

Question:

Why doesn't SPOOL work in Pro*C/C++?

Answer:

SPOOL is a special command used in SQL*Plus. It is not an embedded SQL command. See "Key Concepts of Embedded SQL Programming" on page 2-2.

Question:

Where can I find the on-line versions of the sample programs?

Answer:

Each Oracle installation should have a *demo* directory. If the directory is not there, or it does not contain the sample programs, see your system or database administrator.

Question:

How can I compile and link my application?

Answer:

Compiling and linking are very platform specific. Your system-specific Oracle documentation has instructions on how to link a Pro*C/C++ application. On UNIX systems, there is a makefile called *proc.mk* in the *demo* directory. To link, say, the demo program sample1.pc, you would enter the command line

```
make -f proc.mk sample1
```

If you need to use special precompiler options, you can run Pro*C/C++ separately, then do the make. Or, you can create your own custom makefile. For example, if your program contains embedded PL/SQL code, you can enter

```
proc cv_demo userid=scott/tiger sqlcheck=semantics
make -f proc.mk cv_demo
```

On VMS systems, there is a script called LNPROC that you use to link your Pro*C/C++ applications.

Question:

I have been told that Pro*C/C++ now supports using structures as host variables. How does this work with the array interface?

Answer:

You can use arrays inside a single structure, or an array of structures with the array interface. See "Host Structures" on page 3-34 and "Pointer Variables" on page 3-41.

Question:

Is it possible to have recursive functions in Pro*C/C++, if I use embedded SQL in the function?

Answer:

Yes. With Pro*C/C++, you can also use cursor variables in recursive functions.

Question:

Can I use any release of the Oracle Pro*C or Pro*C/C++ Precompiler with any version of the Oracle Server?

Answer:

No. You can use an older version of Pro*C or Pro*C/C++ with a newer version of the server, but you cannot use a newer version of Pro*C/C++ with an older version of the server.

For example, you can use release 2.2 of Pro*C/C++ with Oracle8, but you cannot use Pro*C/C++ release8.0 with the Oracle7 server.

Question:

When my application runs under Oracle8, I keep getting an ORA-1405 error (fetched column value is null). It worked fine under Oracle V7. What is happening?

Answer:

You are selecting a null into a host variable that does not have an associated indicator variable. This is not in compliance with the ANSI/ISO standards, and was changed beginning with Oracle7.

If possible, rewrite your program using indicator variables, and use indicators in future development. Indicator variables are described on "Indicator Variables" on page 3-32.

Alternatively, if precompiling with MODE=ORACLE and DBMS=V7 or V8, specify UNSAFE_NULL=YES on the command line (see "UNSAFE_NULL" on page 9-37 for more information) to disable the ORA-01405 message, or precompile with DBMS=V6.

Question:

Are all SQLLIB functions private?

Answer:

No. There are some SQLLIB functions that you can call to get information about your program, or its data. The SQLLIB public functions are shown here:

SQLSQLDAAlloc()	Used to allocate a SQL descriptor array (SQLDA) for dynamic SQL Method 4.See "How is the SQLDA Referenced?" on page 14-3.
SQLCDAFromResultSetCursor()	Used to convert a Pro*C/C++ cursor variable to an OCI cursor data area. See "SQLLIB Public Functions -- New Names" on page 4-36.
SQLSQLDAFree()	Used to free a SQLDA allocated using *SQLSQLDAAlloc()*. See "SQLLIB Public Functions -- New Names" on page 4-36 .
SQLCDAToResultSetCursor()	Used to convert an OCI cursor data area to a Pro*C/C++ cursor variable. See "SQLLIB Public Functions -- New Names" on page 4-36.
SQLErrorGetText()	Returns a long error message. See "sqlerrm" on page 11-20.
SQLStmtGetText)	Used to return the text of the most recently executed SQL statement. See "Obtaining the Text of SQL Statements" on page 11-32.
SQLLDAGetNamed()	Used to obtain a valid Logon Data Area for a named connection, when OCI calls are used in a Pro*C/C++ program. See "SQLLIB Public Functions -- New Names" on page 4-36.
SQLLDAGetCurrent()	Used to obtain a valid Logon Data Area for the most recent connection, when OCI calls are used in a Pro*C/C++ program. See "SQLLIB Public Functions -- New Names" on page 4-36.
SQLColumnNullCheck()	Returns an indication of null status for dynamic SQL Method 4. See "Handling Null/Not Null Datatypes" on page 14-17.
SQLNumberPrecV6()	Returns precision and scale of numbers. See "Extracting Precision and Scale" on page 14-16.
SQLNumberPrecV7()	A variant of *SQLNumberPrecV6()*. See "Extracting Precision and Scale" on page 14-16.
SQLVarcharGetLength()	Used for obtaining the padded size of a VARCHAR[n]. See "Finding the Length of the VARCHAR Array Component" on page 3-46.

In the preceding list, the functions are thread-safe SQLLIB public functions. Use these functions in multi-threaded applications. The names of the functions have been changed for release 8.0, but the old names are still supported in Pro*C/C++. For more information about these thread-safe public functions (including their old names), see the table "SQLLIB Public Functions -- New Names" on page 4-36.

Question:

How does Oracle8 support the new Object Types?

Answer:

See the chapters Chapter 8, “Object Support in Pro*C/C++” and Chapter 16, “Using the Object Type Translator” for how to use Object types in Pro*C/C++ applications.

2

Learning the Basics

This chapter explains how embedded SQL programs do their work. You examine the special environment in which they operate and the impact of this environment on the design of your applications.

After covering the key concepts of embedded SQL programming and the steps you take in developing an application, this chapter uses a simple program to illustrate the main points.

Topics are:

- Key Concepts of Embedded SQL Programming
- Steps in Developing an Embedded SQL Application
- Sample Tables
- Sample Program: A Simple Query

Key Concepts of Embedded SQL Programming

This section lays the conceptual foundation on which later chapters build. It discusses the following subjects:

- Embedded SQL Statements
- Embedded SQL Syntax
- Static Versus Dynamic SQL Statements
- Embedded PL/SQL Blocks
- Host and Indicator Variables
- Oracle Datatypes
- Arrays
- Datatype Equivalencing
- Private SQL Areas, Cursors, and Active Sets
- Transactions
- Errors and Warnings

Embedded SQL Statements

The term *embedded SQL* refers to SQL statements placed within an application program. Because it houses the SQL statements, the application program is called a *host program*, and the language in which it is written is called the *host language*. For example, the Pro*C/C++ Precompiler allows you to embed certain SQL statements in a C or C++ host program.

To manipulate and query Oracle data, you use the INSERT, UPDATE, DELETE, and SELECT statements. INSERT adds rows of data to database tables, UPDATE modifies rows, DELETE removes unwanted rows, and SELECT retrieves rows that meet your search condition.

The powerful SET ROLE statement lets you dynamically manage database privileges. A *role* is a named group of related system and/or object privileges granted to users or other roles. Role definitions are stored in the Oracle data dictionary. Your applications can use the SET ROLE statement to enable and disable roles as needed.

Only SQL statements—not SQL*Plus statements—are valid in an application program. (SQL*Plus has additional statements for setting environment parameters, editing, and report formatting.)

Executable versus Declarative Statements

Embedded SQL includes all the interactive SQL statements plus others that allow you to transfer data between Oracle and a host program. There are two types of embedded SQL statements: *executable* and *declarative*. Executable statements result in calls to the runtime library SQLLIB. You use them to connect to Oracle, to define, query, and manipulate Oracle data, to control access to Oracle data, and to process transactions. They can be placed wherever C or C++ language executable statements can be placed.

Declarative statements, on the other hand, do not result in calls to SQLLIB and do not operate on Oracle data. You use them to declare Oracle objects, communications areas, and SQL variables. They can be placed wherever C or C++ variable declarations can be placed. You treat the ALLOCATE statement, however, as an executable, not a declarative, statement.

Table 2–1 groups the various embedded SQL statements.

Table 2–1 Embedded SQL Statements

DECLARATIVE STATEMENT	**PURPOSE**
ARRAYLEN*	To use host arrays with PL/SQL
BEGIN DECLARE SECTION* END DECLARE SECTION*	To declare host variables (optional)
DECLARE*	To name Oracle schema objects
INCLUDE*	To copy in files
TYPE*	To equivalence datatypes
VAR*	To equivalence variables
WHENEVER*	To handle runtime errors
Executable SQL	
EXECUTABLE STATEMENT	**PURPOSE**
ALLOCATE*	To define and control Oracle data
ALTER ANALYZE AUDIT	

Table 2–1 Embedded SQL Statements

CLOSE	
COMMENT	
CONNECT*	
CONTEXT	
CREATE	
DROP	
ENABLE THREADS	
FREE	
GRANT	
NOAUDIT	
RENAME	
REVOKE	
TRUNCATE	
DELETE	DML
EXPLAIN PLAN	
FETCH*	
INSERT	
LOCK TABLE	
OPEN*	
SELECT	
UPDATE	
COMMIT	To process transactions
ROLLBACK	
SAVEPOINT	
SET TRANSACTION	
DESCRIBE*	To use dynamic SQL
EXECUTE*	
PREPARE*	

Table 2–1 Embedded SQL Statements

ALTER SESSION	To control sessions
SET ROLE	
*Has no interactive counterpart	

Embedded SQL Syntax

In your application program, you can freely intermix complete SQL statements with complete C statements and use C variables or structures in SQL statements. The only special requirement for building SQL statements into your host program is that you begin them with the keywords EXEC SQL and end them with a semicolon. Pro*C / C++ translates all EXEC SQL statements into calls to the runtime library SQLLIB.

Many embedded SQL statements differ from their interactive counterparts only through the addition of a new clause or the use of program variables. The following example compares interactive and embedded ROLLBACK statements:

```
ROLLBACK WORK:           -- interactive
EXEC SQL ROLLBACK WORK;  -- embedded
```

These statements have the same effect, but you would use the first in an interactive SQL environment (such as when running SQL*Plus), and the second in a Pro*C / C++ program.

Static Versus Dynamic SQL Statements

Most application programs are designed to process static SQL statements and fixed transactions. In this case, you know the makeup of each SQL statement and transaction before runtime; that is, you know which SQL commands will be issued, which database tables might be changed, which columns will be updated, and so on.

However, some applications might be required to accept and process any valid SQL statement at runtime. So, you might not know until runtime all the SQL commands, database tables, and columns involved.

Dynamic SQL is an advanced programming technique that lets your program accept or build SQL statements at run time and take explicit control over datatype conversion.

Embedded PL/SQL Blocks

The Pro*C/C++ Precompiler treats a PL/SQL block like a single embedded SQL statement. So, you can place a PL/SQL block anywhere in an application program that you can place a SQL statement. To embed PL/SQL in your host program, you simply declare the variables to be shared with PL/SQL and bracket the PL/SQL block with the keywords EXEC SQL EXECUTE and END-EXEC.

From embedded PL/SQL blocks, you can manipulate Oracle data flexibly and safely because PL/SQL supports all SQL data manipulation and transaction processing commands. For more information about PL/SQL, see Chapter 6, "Using Embedded PL/SQL".

Host and Indicator Variables

Host variables are the key to communication between Oracle and your program. A *host variable* is a scalar or aggregate variable declared in C and shared with Oracle, meaning that both your program and Oracle can reference its value.

Your program uses *input* host variables to pass data to Oracle. Oracle uses *output* host variables to pass data and status information to your program. The program assigns values to input host variables; Oracle assigns values to output host variables.

Host variables can be used anywhere a SQL expression can be used. In SQL statements, host variables must be prefixed with a colon (:) to set them apart from Oracle objects.

You can also use a C *struct* to contain a number of host variables. When you name the structure in an embedded SQL statement, prefixed with a colon, Oracle uses each of the components of the struct as a host variable.

You can associate any host variable with an optional indicator variable. An *indicator variable* is a short integer variable that "indicates" the value or condition of its host variable. You use indicator variables to assign nulls to input host variables and to detect nulls or truncated values in output host variables. A *null* is a missing, unknown, or inapplicable value.

In SQL statements, an indicator variable must be prefixed with a colon and immediately follow its associated host variable. The keyword INDICATOR can be placed between the host variable and its indicator for additional clarity.

If the host variables are packaged in a struct, and you want to use indicator variables, you simply create a struct that has an indicator variable for each host variable in the host structure, and name the indicator struct in the SQL statement, immediately following the host variable struct, and prefixed with a colon. You can

also use the INDICATOR keyword to separate a host structure and its associated indicator structure.

Oracle Datatypes

Typically, a host program inputs data to Oracle, and Oracle outputs data to the program. Oracle stores input data in database tables and stores output data in program host variables. To store a data item, Oracle must know its *datatype*, which specifies a storage format and valid range of values.

Oracle recognizes two kinds of datatypes: *internal* and *external*. Internal datatypes specify how Oracle stores data in database columns. Oracle also uses internal datatypes to represent database pseudocolumns, which return specific data items but are not actual columns in a table.

External datatypes specify how data is stored in host variables. When your host program inputs data to Oracle, if necessary, Oracle converts between the external datatype of the input host variable and the internal datatype of the target database column. When Oracle outputs data to your host program, if necessary, Oracle converts between the internal datatype of the source database column and the external datatype of the output host variable.

Arrays

Pro*C/C++ lets you define array host variables (called *host arrays)* and arrays of structures; then operate on them with a single SQL statement. Using the array SELECT, FETCH, DELETE, INSERT, and UPDATE statements, you can query and manipulate large volumes of data with ease. You can also use host arrays inside a host variable **struct**.

Datatype Equivalencing

Pro*C/C++ adds flexibility to your applications by letting you *equivalence* datatypes. That means you can customize the way Oracle interprets input data and formats output data.

On a variable-by-variable basis, you can equivalence supported C datatypes to the Oracle external datatypes. You can also equivalence user-defined datatypes to Oracle external datatypes.

Private SQL Areas, Cursors, and Active Sets

To process a SQL statement, Oracle opens a work area called a *private SQL area*. The private SQL area stores information needed to execute the SQL statement. An

identifier called a *cursor* lets you name a SQL statement, access the information in its private SQL area, and, to some extent, control its processing.

For static SQL statements, there are two types of cursors: *implicit* and *explicit*. Oracle implicitly declares a cursor for all data definition and data manipulation statements, including SELECT statements (queries) that return only one row. However, for queries that return more than one row, to process beyond the first row, you must explicitly declare a cursor (or use host arrays).

The set of rows returned is called the *active set*; its size depends on how many rows meet the query search condition. You use an explicit cursor to identify the row currently being processed, called the *current row*.

Imagine the set of rows being returned to a terminal screen. A screen cursor can point to the first row to be processed, then the next row, and so on. In the same way, an explicit cursor "points" to the current row in the active set. This allows your program to process the rows one at a time.

Transactions

A *transaction* is a series of logically related SQL statements (two UPDATEs that credit one bank account and debit another, for example) that Oracle treats as a unit, so that all changes brought about by the statements are made permanent or undone at the same time.

All the data manipulation statements executed since the last data definition, COMMIT, or ROLLBACK statement was executed make up the current transaction.

To help ensure the consistency of your database, Pro*C/C++ lets you define transactions using the COMMIT, ROLLBACK, and SAVEPOINT statements.

COMMIT makes permanent any changes made during the current transaction. ROLLBACK ends the current transaction and undoes any changes made since the transaction began. SAVEPOINT marks the current point in the processing of a transaction; used with ROLLBACK, it undoes part of a transaction.

Errors and Warnings

When you execute an embedded SQL statement, it either succeeds or fails, and might result in an error or warning. You need a way to handle these results. Pro*C/C++ provides two error handling mechanisms: the SQL Communications Area (SQLCA) and the WHENEVER statement.

The SQLCA is a data structure that you include (or hard code) in your host program. It defines program variables used by Oracle to pass runtime status

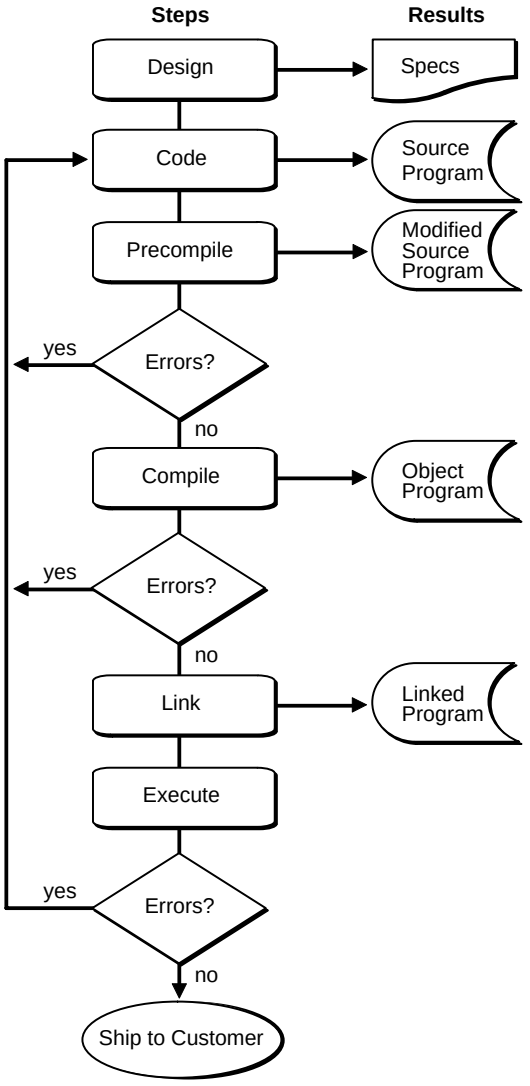
information to the program. With the SQLCA, you can take different actions based on feedback from Oracle about work just attempted. For example, you can check to see if a DELETE statement succeeded and, if so, how many rows were deleted.

With the WHENEVER statement, you can specify actions to be taken automatically when Oracle detects an error or warning condition. These actions are: continuing with the next statement, calling a function, branching to a labeled statement, or stopping.

Steps in Developing an Embedded SQL Application

Figure 2–1 shows the embedded SQL application development process.

Figure 2–1 Embedded SQL Application Development Process



As you can see, precompiling results in a modified source file that can be compiled normally. Though precompiling adds a step to the traditional development process, that step lets you write very flexible applications.

Sample Tables

Most programming examples in this guide use two sample database tables: DEPT and EMP. Their definitions follow:

```
CREATE TABLE DEPT
    (DEPTNO    NUMBER(2) NOT NULL,
     DNAME     VARCHAR2(14),
     LOC       VARCHAR2(13))

CREATE TABLE EMP
    (EMPNO     NUMBER(4) NOT NULL,
     ENAME     VARCHAR2(10),
     JOB       VARCHAR2(9),
     MGR       NUMBER(4),
     HIREDATE  DATE,
     SAL       NUMBER(7,2),
     COMM      NUMBER(7,2),
     DEPTNO    NUMBER(2))
```

Sample Data

Respectively, the DEPT and EMP tables contain the following rows of data:

```
DEPTNO  DNAME      LOC
------- ---------- ---------
10      ACCOUNTING NEW YORK
20      RESEARCH   DALLAS
30      SALES      CHICAGO
40      OPERATIONS BOSTON
```

```
EMPNO ENAME   JOB          MGR  HIREDATE    SAL   COMM  DEPTNO
----- ------- --------- ------ --------- ------ ------ -------
 7369 SMITH   CLERK       7902 17-DEC-80    800             20
 7499 ALLEN   SALESMAN    7698 20-FEB-81   1600    300      30
 7521 WARD    SALESMAN    7698 22-FEB-81   1250    500      30
 7566 JONES   MANAGER     7839 02-APR-81   2975             20
 7654 MARTIN  SALESMAN    7698 28-SEP-81   1250   1400      30
 7698 BLAKE   MANAGER     7839 01-MAY-81   2850             30
 7782 CLARK   MANAGER     7839 09-JUN-81   2450             10
 7788 SCOTT   ANALYST     7566 19-APR-87   3000             20
 7839 KING    PRESIDENT        17-NOV-81   5000             10
 7844 TURNER  SALESMAN    7698 08-SEP-81   1500             30
```

```
 7876 ADAMS   CLERK       7788 23-MAY-87   1100            20
 7900 JAMES   CLERK       7698 03-DEC-81    950            30
 7902 FORD    ANALYST     7566 03-DEC-81   3000            20
 7934 MILLER  CLERK       7782 23-JAN-82   1300            10
```

Sample Program: A Simple Query

One way to get acquainted with Pro*C/C++ and embedded SQL is to study a program example. The program listed below is also available on-line in the file *sample1.pc* in your Pro*C/C++ *demo* directory.

The program connects to Oracle, then loops, prompting the user for an employee number. It queries the database for the employee's name, salary, and commission, displays the information, and then continues the loop. The information is returned to a host structure. There is also a parallel indicator structure to signal whether any of the output values SELECTed might be null.

You should precompile sample programs using the precompiler option MODE=ORACLE.

```
/*
 *  sample1.pc
 *
 *  Prompts the user for an employee number,
 *  then queries the emp table for the employee's
 *  name, salary and commission.  Uses indicator
 *  variables (in an indicator struct) to determine
 *  if the commission is NULL.
 *
 */

#include <stdio.h>
#include <string.h>


/* Define constants for VARCHAR lengths. */
#define     UNAME_LEN      20
#define     PWD_LEN        40

/* Declare variables.No declare section is needed if MODE=ORACLE.*/
VARCHAR     username[UNAME_LEN];
/* VARCHAR is an Oracle-supplied struct */
varchar     password[PWD_LEN];
/* varchar can be in lower case also. */
```

```
/*
Define a host structure for the output values of a SELECT statement.
*/
struct {
    VARCHAR   emp_name[UNAME_LEN];
    float     salary;
    float     commission;
} emprec;
/*
Define an indicator struct to correspond to the host output struct. */
struct
{
    short     emp_name_ind;
    short     sal_ind;
    short     comm_ind;
} emprec_ind;

/*  Input host variable. */
int         emp_number;
int         total_queried;
/* Include the SQL Communications Area.
   You can use #include or EXEC SQL INCLUDE. */
#include <sqlca.h>

/* Declare error handling function. */
void sql_error();

main()
{
    char temp_char[32];

/* Connect to ORACLE--
 * Copy the username into the VARCHAR.
 */
    strncpy((char *) username.arr, "SCOTT", UNAME_LEN);
/* Set the length component of the VARCHAR. */
    username.len = strlen((char *) username.arr);
/* Copy the password. */
    strncpy((char *) password.arr, "TIGER", PWD_LEN);
    password.len = strlen((char *) password.arr);
/* Register sql_error() as the error handler. */
    EXEC SQL WHENEVER SQLERROR DO sql_error("ORACLE error--\n");

/* Connect to ORACLE.  Program will call sql_error()
 * if an error occurs when connecting to the default database.
```

```
 */
    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    printf("\nConnected to ORACLE as user: %s\n", username.arr);
/* Loop, selecting individual employee's results */
    total_queried = 0;
    for (;;)
    {
/* Break out of the inner loop when a
 * 1403 ("No data found") condition occurs.
 */
        EXEC SQL WHENEVER NOT FOUND DO break;
        for (;;)
        {
            emp_number = 0;
            printf("\nEnter employee number (0 to quit): ");
            gets(temp_char);
            emp_number = atoi(temp_char);
            if (emp_number == 0)
                break;
            EXEC SQL SELECT ename, sal, comm
                INTO :emprec INDICATOR :emprec_ind
                FROM EMP
                WHERE EMPNO = :emp_number;
/* Print data. */
            printf("\n\nEmployee\tSalary\t\tCommission\n");
            printf("--------\t------\t\t----------\n");
/* Null-terminate the output string data. */
            emprec.emp_name.arr[emprec.emp_name.len] = '\0';
            printf("%-8s\t%6.2f\t\t",
                emprec.emp_name.arr, emprec.salary);
            if (emprec_ind.comm_ind == -1)
                printf("NULL\n");
            else
                printf("%6.2f\n", emprec.commission);

            total_queried++;
        }  /* end inner for (;;) */
        if (emp_number == 0) break;
        printf("\nNot a valid employee number - try again.\n");
    } /* end outer for(;;) */

    printf("\n\nTotal rows returned was %d.\n", total_queried);
    printf("\nG'day.\n\n\n");

/* Disconnect from ORACLE. */
```

```
    EXEC SQL COMMIT WORK RELEASE;
    exit(0);
}
void sql_error(msg)
char *msg;
{
    char err_msg[128];
    int buf_len, msg_len;

    EXEC SQL WHENEVER SQLERROR CONTINUE;
    printf("\n%s\n", msg);
    buf_len = sizeof (err_msg);
    sqlglm(err_msg, &buf_len, &msg_len);
    printf("%.*s\n", msg_len, err_msg);
    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

3

Developing a Pro*C/C++ Application

This chapter provides the basic information you need to write a Pro*C/C++ program. This chapter covers the following topics:

- Support for the C Preprocessor
- Migrating From Earlier Pro*C/C++ Releases
- Programming Guidelines
- Precompile-time Evaluation of Numeric Constants
- Oracle Datatypes
- Host Variables
- Indicator Variables
- Host Structures
- Pointer Variables
- VARCHAR Variables
- Handling Character Data
- Datatype Conversion
- Datatype Equivalencing

This chapter also includes several complete demonstration programs that you can study. These programs illustrate the techniques described. They are available on-line in your *demo* directory, so you can compile and run them, and modify them for your own uses.

Support for the C Preprocessor

Pro*C/C++ supports most C preprocessor directives. Some of the things that you can do using the Pro*C/C++ preprocessor are:

- define constants and macros using the **#define** directive, and use the defined entities to parameterize Pro*C/C++ datatype declarations, such as VARCHAR
- read files required by the precompiler, such as *sqlca.h*, using the **#include** directive
- define constants and macros in a separate file, and have the precompiler read this file using the **#include** directive

How the Pro*C/C++ Preprocessor Works

The Pro*C/C++ preprocessor recognizes most C preprocessor commands, and effectively performs the required macro substitutions, file inclusions, and conditional source text inclusions or exclusions. The Pro*C/C++ preprocessor uses the values obtained from preprocessing, and alters the source output text (the generated *.c* output file).

An example should clarify this point. Consider the following program fragment:

```
#include "my_header.h"
...
VARCHAR name[VC_LEN];              /* a Pro*C-supplied datatype */
char    another_name[VC_LEN];             /* a pure C datatype */
...
```

Suppose the file *my_header.h* in the current directory contains, among other things, the line

```
#define VC_LEN   20
```

The precompiler reads the file *my_header.h*, and uses the defined value of VC_LEN (i.e., 20), declares the structure of *name* as VARCHAR[20].

char is a native type. The precompiler does not substitute 20 in the declaration of another_name[VC_LEN].

This does not matter, since the precompiler does not need to process declarations of C datatypes, even when they are used as host variables. It is left up to the C compiler's preprocessor to physically include the file *my_header.h*, and perform the substitution of 20 for VC_LEN in the declaration of *another_name*.

Preprocessor Directives

The preprocessor directives that Pro*C/C++ supports are:

- **#define**, to write macros for use by the precompiler and the C or C++ compiler
- **#include**, to read other source files for use by the precompiler
- **#if**, to precompile and compile source text based on evaluation of a constant expression to 0
- **#ifdef**, to precompile and compile source text conditionally, depending on the existence of a defined constant
- **#ifndef**, to exclude source text conditionally
- **#endif**, to end an **#if** or **#ifdef** or **#ifndef** command
- **#else**, to select an alternative body of source text to be precompiled and compiled, in case an **#if** or **#ifdef** or **#ifndef** condition is not satisfied
- **#elif**, to select an alternative body of source text to be precompiled and compiled, depending on the value of a constant or a macro argument

Directives Ignored

Some C preprocessor directives are not used by the Pro*C/C++ preprocessor. Most of these directives are not relevant for the precompiler. For example, **#pragma** is a directive for the C compiler—the precompiler does not process it. The C preprocessor directives not processed by the precompiler are:

- **#**, to convert a preprocessor macro parameter to a string constant
- **##**, to merge two preprocessor tokens in a macro definition
- **#error**, to produce a compile-time error message
- **#pragma**, to pass implementation-dependent information to the C compiler
- **#line**, to supply a line number for C compiler messages

While your C compiler preprocessor may support these directives, Pro*C/C++ does not use them. Most of these directives are not used by the precompiler. You can use these directives in your Pro*C/C++ program if your compiler supports them, but only in C or C++ code, not in embedded SQL statements or declarations of variables using datatypes supplied by the precompiler, such as VARCHAR.

ORA_PROC Macro

Pro*C/C++ predefines a C preprocessor macro called ORA_PROC that you can use to avoid having the precompiler process unnecessary or irrelevant sections of code. Some applications include large header files, which provide information that is unnecessary when precompiling. By conditionally including such header files based on the ORA_PROC macro, the precompiler never reads the file.

The following example uses the ORA_PROC macro to *ex*clude the *irrelevant.h* file:

```
#ifndef  ORA_PROC
#include <irrelevant.h>
#endif
```

Because ORA_PROC is defined during precompilation, the *irrelevant.h* file is never included.

The ORA_PROC macro is available only for C preprocessor directives, such as **#ifdef** or **#ifndef**. The EXEC ORACLE conditional statements do *not* share the same namespaces as the C preprocessor macros. Therefore, the condition in the following example does *not* use the predefined ORA_PROC macro:

```
EXEC ORACLE IFNDEF ORA_PROC;
   <section of code to be ignored>
EXEC ORACLE ENDIF;
```

ORA_PROC, in this case, must be set using either the DEFINE option or an EXEC ORACLE DEFINE statement for this conditional code fragment to work properly.

Specifying the Location of Header Files

The Pro*C/C++ Precompiler for each system assumes a standard location for header files to be read by the preprocessor, such as *sqlca.h*, *oraca.h*, and *sqlda.h*. For example, on most UNIX systems, the standard location is *$ORACLE_HOME/proc/lib*. For the default location on your system, see your system-specific Oracle documentation. If header files that you need to include are not in the default location, you must use the INCLUDE= option, on the command line or as an EXEC ORACLE option. See Chapter 9, “Running the Pro*C/C++ Precompiler”, for more information about the precompiler options, and about the EXEC ORACLE options.

To specify the location of system header files, such as *stdio.h* or *iostream.h*, where the location might be different from that hard-coded into Pro*C/C++ use the SYS_INCLUDE precompiler option. See Chapter 9, “Running the Pro*C/C++ Precompiler”, for more information.

Some Preprocessor Examples

You can use the **#define** command to create named constants, and use them in place of "magic numbers" in your source code. You can use **#define**d constants for declarations that the precompiler requires, such as VARCHAR[const]. For example, instead of potentially buggy code such as:

```
...
VARCHAR  emp_name[10];
VARCHAR  dept_loc[14];
...
...
/* much later in the code ... */
f42()
{
    /* did you remember the correct size? */
    VARCHAR new_dept_loc[10];
   ...
}
```

you can code:

```
#define ENAME_LEN     10
#define LOCATION_LEN  14
VARCHAR  new_emp_name[ENAME_LEN];
   ...
/* much later in the code ... */
f42()
{
    VARCHAR new_dept_loc[LOCATION_LEN];
   ...
}
```

You can use preprocessor macros with arguments for objects that the precompiler must process, just as you can for C objects. For example:

```
#define ENAME_LEN    10
#define LOCATION_LEN 14
#define MAX(A,B)  ((A) > (B) ? (A) : (B))


   ...
f43()
{
    /* need to declare a temporary variable to hold either an
       employee name or a department location */
    VARCHAR  name_loc_temp[MAX(ENAME_LEN, LOCATION_LEN)];
```

```
    ...
}
```

You can use the **#include**, **#ifdef** and **#endif** preprocessor directives to conditionally include a file that the precompiler requires. For example:

```
#ifdef ORACLE_MODE
#   include <sqlca.h>
#else
    long SQLCODE;
#endif
```

Using #define

There are restrictions on the use of the **#define** preprocessor directive in Pro*C/C++ You cannot use the **#define** directive to create symbolic constants for use in *executable* SQL statements. The following *invalid* example demonstrates this:

```
#define RESEARCH_DEPT   40
...
EXEC SQL SELECT empno, sal
    INTO :emp_number, :salary /* host arrays */
    FROM emp
    WHERE deptno = RESEARCH_DEPT;  /* INVALID! */
```

The only declarative SQL statements where you can legally use a **#define**d macro are TYPE and VAR statements. So, for example, the following uses of a macro are legal in Pro*C/C++

```
#define STR_LEN      40
...
typedef char asciiz[STR_LEN];
...
EXEC SQL TYPE asciiz IS STRING(STR_LEN) REFERENCE;
...
EXEC SQL VAR password IS STRING(STR_LEN) REFERENCE;
```

Other Preprocessor Restrictions

The preprocessor ignores directives **#** and **##** to create tokens that the precompiler must recognize. You can, of course, use these commands (if your C compiler's preprocessor supports them) in pure C code, that the precompiler does not have to process. Using the preprocessor command **##** is *not* valid in this example:

```
#define MAKE_COL_NAME(A)    col ## A
...
EXEC SQL SELECT MAKE_COL_NAME(1), MAKE_COL_NAME(2)
    INTO :x, :y
    FROM table1;
```

The example is incorrect because the precompiler ignores **##**.

SQL Statements Not Allowed in #include

Because of the way the Pro*C/C++ preprocessor handles the **#include** directive, as described in the previous section, you cannot use the **#include** directive to include files that contain embedded SQL statements. You use **#include** to include files that contain purely declarative statements and directives; for example, **#define**s, and declarations of variables and structures required by the precompiler, such as in *sqlca.h*.

Including the SQLCA, ORACA, and SQLDA

You can include the *sqlca.h*, *oraca.h*, and *sqlda.h* declaration header files in your Pro*C/C++ program using either the C/C++ preprocessor **#include** command, or the precompiler EXEC SQL INCLUDE command. For complete information on the contents of these header files, see Chapter 11, "Handling Runtime Errors". For example, you use the following statement to include the SQL Communications Area structure (SQLCA) in your program with the EXEC SQL option:

```
EXEC SQL INCLUDE sqlca;
```

To include the SQLCA using the C/C++ preprocessor directive, add the following code:

```
#include <sqlca.h>
```

When you use the preprocessor **#include** directive, you must specify the file extension (such as *.h*).

> **Note:** If you need to include the SQLCA in multiple places, using the **#include** directive, you should precede the **#include** with the directive **#undef** SQLCA. This is because *sqlca.h* starts with the lines
>
> ```
> #ifndef SQLCA
> #define SQLCA 1
> ```
>
> and then declares the SQLCA struct only in the case that SQLCA is not defined.

When you precompile a file that contains a **#include** directive or an EXEC SQL INCLUDE statement, you have to tell the precompiler the location of all files to be included. You can use the INCLUDE= option, either in the command line, or in the system configuration file, or in the user configuration file. See Chapter 9, "Running the Pro*C/C++ Precompiler", for more information about the INCLUDE precompiler option , the precedence of searches for included files, and configuration files.

The default location for standard preprocessor header files, such as *sqlca.h*, *oraca.h*, and *sqlda.h*, is built into the precompiler. The location varies from system to system. See your system-specific Oracle documentation for the default location on your system.

When you compile the *.c* output file that Pro*C/C++ generates, you must use the option provided by your compiler and operating system to identify the location of included files.

For example, on most UNIX systems, you can compile the generated C source file using the command

```
cc -o progname -I$ORACLE_HOME/sqllib/public ... filename.c ...
```

On VAX/OPENVMS systems, you pre-pend the include directory path to the value in the logical VAXC$INCLUDE.

EXEC SQL INCLUDE and #include Summary

When you use an EXEC SQL INCLUDE statement in your program, the precompiler includes the source text in the output (*.c*) file. Therefore, you can have declarative and executable embedded SQL statements in a file that is included using EXEC SQL INCLUDE.

When you include a file using **#include**, the precompiler merely reads the file, and keeps track of **#define**d macros.

> **Warning:** VARCHAR declarations and SQL statements are NOT allowed in #**included** files. For this reason, you cannot have SQL statements in files that are included using the Pro*C/C++ preprocessor **#include** directive.

Defined Macros

If you define macros on the C compiler's command line, you might also have to define these macros on the precompiler command line, depending on the requirements of your application. For example, if you compile with a UNIX command line such as

```
cc -DDEBUG ...
```

you should precompile using the DEFINE= option, namely

```
proc DEFINE=DEBUG ...
```

Migrating From Earlier Pro*C/C++ Releases

Release 8.0 of the Pro*C/C++ Precompiler is compatible with earlier Pro*C and Pro*C/C++ releases. However, there are several things that you should consider when you migrate your application from earlier Pro*C/C++ releases. This section discusses some of these issues.

Character Strings

Many applications have been written under the assumption that character strings are of varying length (such as VARCHAR2). By default, Oracle8 uses fixed-length, blank-padded, 0-terminated character strings (CHARZ), to conform to the current SQL standards.

If your application assumes that character strings are varying in length (and this is especially important in the string comparison semantics), then you should precompile your application using the options DBMS=V8 and CHAR_MAP=VARCHAR2. See "National Language Support" on page 4-2 for details.

DBMS=V6 provides Oracle V6 semantics in several areas, not just character string semantics.

> **Note:** The DBMS option partially replaces the MODE option of the release 1.5 and 1.6 1 Precompilers.

See the description of the DBMS options on "DBMS" on page 9-14 for a complete list of the effects of the DBMS options.

Deprecated Precompiler Option

In release 8.0, the option value DBMS=V6_CHAR is deprecated (an ANSI term meaning that it will become obsolete in the next release) and is replaced by the option CHAR_MAP=VARCHAR2 (see "Precompiler Option CHAR_MAP" on page 3-50).

Error Message Codes

Error and warning codes (PCC errors) are different between earlier releases of Pro*C/C++ and the current release. See *Oracle8 Error Messages* for a complete list of PCC codes and messages.

The runtime messages issued by SQLLIB now have the prefix SQL-, rather than the RTL- prefix used in earlier Pro*C/C++ and Pro*C releases. The message codes remain the same as those of earlier releases.

When precompiling with SQLCHECK=FULL, PLS is the prefix used by the PL/SQL compiler. Such errors are not from Pro*C/C++.

Include Files

The location of all included files that need to be precompiled must be specified on the command line, or in a configuration file. (See Chapter 9, "Running the Pro*C/C++ Precompiler" for complete information about precompiler options and configuration files.)

For example, if you are developing under UNIX, and your application includes files in the directory */home/project42/include*, you must specify this directory both on the Pro*C/C++ command line and on the *cc* command line. You use commands like these:

```
proc iname=my_app.pc include=/home/project42/include . . .
cc -I/home/project42/include . . . my_app.c
```

or you include the appropriate macros in a *makefile*. For complete information about compiling and linking your Pro*C/C++ release 8.0 application, see your system-specific Oracle documentation.

Output Files

The output file (.c) is generated in the same directory as the input file.To generate an output file in a different directory from the input file, use the ONAME option to explicitly specify the desired location of your output file. For more information, see "ONAME" on page 9-30.

Indicator Variables

If you are migrating an application from Pro*C release 1.3 or release 1.4, used since Oracle V6, to Oracle8, there is a major change in behavior if you do not use indicator variables. Oracle V6 does not return an error if you SELECT or FETCH a NULL into a host variable that has no associated indicator variable. With Oracle7,

the normal behavior is that SELECTing or FETCHing a NULL into a host variable that has no associated indicator variable does cause an error.

The error code is ORA-01405 in SQLCODE and "22002" in SQLSTATE.

To avoid this error without re-coding your application, you can specify DBMS=V6, or you can specify UNSAFE_NULL=YES (as described on "UNSAFE_NULL" on page 9-37) with DBMS=V7 or V8 and MODE=ORACLE. See the description of the DBMS option on "DBMS" on page 9-14 for complete information.

However, Oracle recommends that you *always* use indicator variables in new Pro*C/C++ applications.

Programming Guidelines

This section deals with embedded SQL syntax, coding conventions, and C-specific features and restrictions. Topics are arranged alphabetically for quick reference.

C++ Support

The Pro*C/C++ Precompiler can optionally generate code that can be compiled using supported C++ compilers. See Chapter 7, “Using C++”, for a complete explanation of this capability.

Comments

You can place C-style Comments (/* ... */) in a SQL statement wherever blanks can be placed (except between the keywords EXEC SQL). Also, you can place ANSI-style Comments (- - ...) *within* SQL statements at the end of a line, as the following example shows:

```
EXEC SQL SELECT ENAME, SAL
    INTO :emp_name, :salary  -- output host variables
    FROM EMP
    WHERE DEPTNO = :dept_number;
```

You can use C++ style Comments (//) in your Pro*C/C++ source if you precompile using the CODE=CPP precompiler option.

Constants

An *L* or *l* suffix specifies a **long** integer constant, a *U* or *u* suffix specifies an **unsigned** integer constant, a *0X* or *0x* prefix specifies a hexadecimal integer constant, and an *F* or *f* suffix specifies a **float** floating-point constant. These forms are *not* allowed in SQL statements.

Delimiters

While C uses single quotes to delimit single characters, as in

```
ch = getchar();
switch (ch)
{
case 'U': update();  break;
case 'I': insert();  break;
...
```

SQL uses single quotes to delimit character strings, as in

```
EXEC SQL SELECT ENAME, SAL FROM EMP WHERE JOB = 'MANAGER';
```

While C uses double quotes to delimit character strings, as in

```
printf("\nG'Day, mate!");
```

SQL uses double quotes to delimit identifiers containing special or lowercase characters, as in

```
EXEC SQL CREATE TABLE "Emp2" (empno  number(4), ...);
```

File Length

The Pro*C/C++ Precompiler cannot process arbitrarily long source files. Some of the variables used internally limit the size of the generated file. There is a limit to the number of lines allowed; the following aspects of the source file are contributing factors to the file-size constraint:

- complexity of the embedded SQL statements (for example, the number of bind and define variables)
- whether a database name is used (for example, connecting to a database with an AT clause)
- number of embedded SQL statements

To prevent problems related to this limitation, use multiple program units to sufficiently reduce the size of the source files.

Function Prototyping

The ANSI C standard (X3.159-1989) provides for function prototyping. A *function prototype* declares a function and the datatypes of its arguments, so that the C compiler can detect missing or mismatched arguments.

The CODE option, which you can enter on the command line or in a configuration file, determines the way that the precompiler generates C or C++ code.

When you precompile your program with CODE=ANSI_C, the precompiler generates fully prototyped function declarations. For example:

```
extern void sqlora(long *, void *);
```

When you precompile with the option CODE=KR_C (KR for "Kernighan and Ritchie"), the precompiler generates function prototypes in the same way that it does for ANSI_C, except that function parameter lists are commented out. For example:

```
extern void sqlora(/*_ long *, void *  _*/);
```

So, make sure to set the precompiler option CODE to KR_C if you use a C compiler that does not support ANSI C. When the CODE option is set to ANSI_C, the precompiler can also generate other ANSI-specific constructs; for example, the **const** type qualifier.

Host Variable Names

Host variable names can consist of upper or lowercase letters, digits, and underscores, but must begin with a letter. They can be any length, but only the first 31 characters are significant to the Pro*C/C++ Precompiler. Your C compiler or linker might require a shorter maximum length, so check your C compiler user's guide.

For SQL92 standards conformance, restrict the length of host variable names to 18 or fewer characters.

Line Continuation

You can continue SQL statements from one line to the next. You must use a backslash (\) to continue a string literal from one line to the next, as the following example shows:

```
EXEC SQL INSERT INTO dept (deptno, dname) VALUES (50, 'PURCHAS\
ING');
```

In this context, the precompiler treats the backslash as a continuation character.

MAXLITERAL Default Value

The precompiler option MAXLITERAL lets you specify the maximum length of string literals generated by the precompiler. The MAXLITERAL default value is 1024. Specify a smaller value if required. For example, if your C compiler cannot

handle string literals longer than 512 characters, you then specify MAXLITERAL=512. Check your C compiler user's guide.

Operators

The logical operators and the "equal to" relational operator are different in C and SQL, as the list below shows. These C operators are *not* allowed in SQL statements.:

SQL Operator	*C Operator*
NOT	!
AND	&&
OR	||
=	==

Operators also *not* allowed are:

Type	*C Operator*
address	&
bitwise	&, |, ^, ~
compound assignment	+=, -=, *=, etc.
conditional	?:
decrement	--
increment	++
indirection	*
modulus	%
shift	>>,<<

Statement Labels

You can associate standard C statement labels (*label_name*:) with SQL statements, as this example shows:

```
EXEC SQL WHENEVER SQLERROR GOTO connect_error;
...
connect_error:
    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL ROLLBACK RELEASE;
```

```
printf("\nInvalid username/password\n");
exit(1);
```

Label names can be any length, but only the first 31 characters are significant. Your C compiler might require a different maximum length. Check your C compiler user's guide.

Statement Terminator

Embedded SQL statements are always terminated by a semicolon, as the following example shows:

```
EXEC SQL DELETE FROM emp WHERE deptno = :dept_number;
```

Precompile-time Evaluation of Numeric Constants

Currently, Pro*C/C++ allows numeric literals and simple constant expressions involving numeric literals to be used when declaring the sizes of host variables (such as **char** or **VARCHAR**), as in the following examples:

```
#define LENGTH 10
VARCHAR v[LENGTH];
char c[LENGTH + 1];
```

You can use numeric constant declarations such as:

```
const int length = 10;
VARCHAR v[length];
char c[length + 1];
```

This is highly desirable, especially for programmers who use ANSI or C++ compilers that support such constant declarations.

Pro*C/C++ has always done constant folding of precompile-time evaluable constant expressions, but it has never allowed the use of a numeric constant declaration in any constant expression.

Pro*C/C++ supports the use of numeric constant declarations anywhere that an ordinary numeric literal or macro is used, provided that the macro expands to some numeric literal.

This is used primarily for declaring the sizes of arrays for bind variables to be used in a SQL statement.

Using Numeric Constants in Pro*C/C++

In Pro*C/C++, normal C scoping rules are used to find and locate the declaration of a numeric constant declaration.

```
const int g = 30;    /* Global declaration to both function_1()
                        and function_2() */
void function_1()
{
  const int a = 10;  /* Local declaration only to function_1() */
  char x[a];
  exec sql select ename into :x from emp where job = 'PRESIDENT';
}

void function_2()
{
  const int a = 20;  /* Local declaration only to function_2() */
  VARCHAR v[a];
  exec sql select ename into :v from emp where job = 'PRESIDENT';
}

void main()
{
  char m[g];         /* The global g */
  exec sql select ename into :m from emp where job = 'PRESIDENT';
}
```

Numeric Constant Rules and Examples

Variables which are of specific static types need to be defined with **static** and initialized. The following rules must be kept in mind when declaring numeric constants in Pro*C/C++:

- The `const` qualifier must be used when declaring the constant
- An initializer must be used to initialize the value of the constant. This initializer must be precompile-time evaluable.

Any attempt to use an identifier that does not resolve to a constant declaration with a valid initializer is considered an error.

The following shows examples of what is not permitted and why.

```
int a;
int b = 10;
volatile c;
```

```
volatile d = 10;
const e;
const f = b;

VARCHAR v1[a]; /* No const qualifier, missing initializer */
VARCHAR v2[b];                      /* No const qualifier */
VARCHAR v3[c];     /* Not a constant, missing initializer */
VARCHAR v4[d];                         /* Not a constant */
VARCHAR v5[e];                     /* Missing initializer */
VARCHAR v6[f];   /* Bad initializer.. b is not a constant */
```

Oracle Datatypes

Oracle recognizes two kinds of datatypes: *internal* and *external*. Internal datatypes specify how Oracle stores column values in database tables, as well as the formats used to represent pseudocolumn (values such as NULL, SYSDATE, USER, etc.) values. External datatypes specify the formats used to store values in input and output host variables. For descriptions of the Oracle datatypes, see *PL/SQL User's Guide and Reference*.

Internal Datatypes

For values stored in database columns, Oracle uses the internal datatypes shown in Table 3–1

Table 3–1 Oracle Internal Datatypes

Name	Description
VARCHAR2	variable-length character string, <= 4000 bytes
NVARCHAR2 or NCHAR VARYING	variable-length single-byte or fixed-width multi-byte string,<= 4000 bytes
NUMBER	numeric value, represented in a binary coded decimal format
LONG	variable-length character string <=2**31-1 bytes
ROWID	binary value
DATE	fixed-length date + time value, 7 bytes
RAW	variable-length binary data, <=255 bytes
LONG RAW	variable-length binary data, <= 2**31-1 bytes
CHAR	fixed-length character string, <= 2000 bytes

Table 3–1 Oracle Internal Datatypes

Name	Description
NCHAR	fixed-length single-byte or fixed-width multi-byte string, <= 2000 bytes
MLSLABEL	tag for operating system label, 2-5 bytes
BFILE	external file binary data, <= 4 Gbytes
BLOB	binary data, <= 4 Gbytes
CLOB	character data, <= 4 Gbytes
NCLOB	multi-byte character data, <= 4 Gbytes

These internal datatypes can be quite different from C datatypes. For example, C has no datatype that is equivalent to the Oracle NUMBER datatype. However, NUMBERs can be converted between C datatypes such as *float* and *double*, with some restrictions. For example, the Oracle NUMBER datatype allows up to 38 decimal digits of precision, while no current C implementations can represent *doubles* with that degree of precision.

The Oracle NUMBER datatype represents values exactly (within the precision limits), while floating-point formats cannot represent values such as 10.0 exactly.

Use the LOB datatypes to store unstructured data (text, graphic images, video clips, and sound waveforms). BFILE data is stored in an operating system file outside the database. LOB types store *locators* that specify the location of the data. For more information, see “Handling LOB Types” on page 4 - 8.

NCHAR and NVARCHAR2 are used to store NLS (NATIONAL Language Support) character data. See "National Language Support" on page 4-2 for a discussion of these datatypes.

External Datatypes

As shown in Table 3–2, the external datatypes include all the internal datatypes plus several datatypes that closely match C constructs. For example, the STRING external datatype refers to a C null-terminated string.

Table 3–2 Oracle External Datatypes

Name	Description
VARCHAR2	variable-length character string, <=64Kbytes
NUMBER	decimal number, represented using a binary-coded floating-point format
INTEGER	signed integer
FLOAT	real number
STRING	null-terminated variable length character string
VARNUM	decimal number, like NUMBER, but includes representation length component
LONG	fixed-length character string, up to 2**31-1 bytes
VARCHAR	variable-length character string, <= 65533 bytes
ROWID	binary value, external length is system dependent
DATE	fixed-length date/time value, 7 bytes
VARRAW	variable-length binary data, <= 65533 bytes
RAW	fixed-length binary data, <= 65533 bytes
LONG RAW	fixed-length binary data, <= 2**31-1 bytes
UNSIGNED	unsigned integer
LONG VARCHAR	variable-length character string, <= 2**31-5 bytes
LONG VARRAW	variable-length binary data, <= 2**31-5 bytes
CHAR	fixed-length character string, <= 255 bytes
CHARZ	fixed-length, null-terminated character string, <= 65534 bytes
CHARF	used in TYPE or VAR statements to force CHAR to default to CHAR, instead of VARCHAR2 or CHARZ
MLSLABEL	tag for operating system label, 2-5 bytes (Trusted Oracle only)

Brief descriptions of the Oracle datatypes follow.

VARCHAR2

You use the VARCHAR2 datatype to store variable-length character strings. The maximum length of a VARCHAR2 value is 64K bytes.

You specify the maximum length of a VARCHAR2(*n*) value in bytes, not characters. So, if a VARCHAR2(*n*) variable stores multi-byte characters, its maximum length can be less than *n* characters.

When you precompile using the options DBMS=V6 or CHAR_MAP=VARCHAR2, Oracle assigns the VARCHAR2 datatype to all host variables that you declare as **char[n]** or **char.**

On Input Oracle reads the number of bytes specified for the input host variable, strips any trailing blanks, then stores the input value in the target database column. Be careful. An uninitialized host variable can contain nulls. So, always blank-pad a character input host variable to its declared length, and do not null-terminate it.

If the input value is longer than the defined width of the database column, Oracle generates an error. If the input value contains nothing but blanks, Oracle treats it like a null.

Oracle can convert a character value to a NUMBER column value if the character value represents a valid number. Otherwise, Oracle generates an error.

On Output Oracle returns the number of bytes specified for the output host variable, blank-padding if necessary, then assigns the output value to the target host variable. If a null is returned, Oracle fills the host variable with blanks.

If the output value is longer than the declared length of the host variable, Oracle truncates the value before assigning it to the host variable. If there is an indicator variable associated with the host variable, Oracle sets it to the original length of the output value.

Oracle can convert NUMBER column values to character values. The length of the character host variable determines precision. If the host variable is too short for the number, scientific notation is used. For example, if you SELECT the column value 123456789 into a character host variable of length 6, Oracle returns the value '1.2E08'.

NUMBER

You use the NUMBER datatype to store fixed or floating-point Oracle numbers. You can specify precision and scale. The maximum precision of a NUMBER value is 38; the magnitude range is 1.0E-129 to 9.99E125. Scale can range from -84 to 127.

NUMBER values are stored in a variable-length format, starting with an exponent byte and followed by 19 mantissa bytes. The high-order bit of the exponent byte is a sign bit, which is set for positive numbers. The low-order 7 bits represent the magnitude.

The mantissa forms a 38-digit number with each byte representing 2 of the digits in a base-100 format. The sign of the mantissa is specified by the value of the first (leftmost) byte. If greater than 101 then the mantissa is negative and and the first digit of the mantissa is equal to the leftmost byte minus 101.

On output, the host variable contains the number as represented internally by Oracle. To accommodate the largest possible number, the output host variable must be 21 bytes long. Only the bytes used to represent the number are returned. Oracle does not blank-pad or null-terminate the output value. If you need to know the length of the returned value, use the VARNUM datatype instead.

There is seldom a need to use this external datatype.

INTEGER

You use the INTEGER datatype to store numbers that have no fractional part. An integer is a signed, 2-byte or 4-byte binary number. The order of the bytes in a word is system dependent. You must specify a length for input and output host variables. On output, if the column value is a real number, Oracle truncates any fractional part.

FLOAT

You use the FLOAT datatype to store numbers that have a fractional part or that exceed the capacity of the INTEGER datatype. The number is represented using the floating-point format of your computer and typically requires 4 or 8 bytes of storage. You must specify a length for input and output host variables.

Oracle can represent numbers with greater precision than most floating-point implementations because the internal format of Oracle numbers is decimal. This can cause a loss of precision when fetching into a FLOAT variable.

STRING

The STRING datatype is like the VARCHAR2 datatype, except that a STRING value is always null-terminated. When you precompile using the option CHAR_MAP=STRING, Oracle assigns the STRING datatype to all host variables that you declare as char[n] or char.

On Input Oracle uses the specified length to limit the scan for the null terminator. If a null terminator is not found, Oracle generates an error. If you do not specify a length, Oracle assumes the maximum length of 2000 bytes. The minimum length of a STRING value is 2 bytes. If the first character is a null terminator and the specified length is 2, Oracle inserts a null unless the column is defined as NOT NULL; if the column is defined as NOT NULL, an error occurs. An all-blank value is stored intact.

On Output Oracle appends a null byte to the last character returned. If the string length exceeds the specified length, Oracle truncates the output value and appends a null byte. If a NULL is SELECTed, Oracle returns a null byte in the first character position.

VARNUM

The VARNUM datatype is like the NUMBER datatype, except that the first byte of a VARNUM variable stores the length of the representation.

On input, you must set the first byte of the host variable to the length of the value. On output, the host variable contains the length followed by the number as represented internally by Oracle. To accommodate the largest possible number, the host variable must be 22 bytes long. After SELECTing a column value into a VARNUM host variable, you can check the first byte to get the length of the value.

Normally, there is little reason to use this datatype.

LONG

You use the LONG datatype to store fixed-length character strings.

The LONG datatype is like the VARCHAR2 datatype, except that the maximum length of a LONG value is 2147483647 bytes or two gigabytes.

VARCHAR

You use the VARCHAR datatype to store variable-length character strings. VARCHAR variables have a 2-byte length field followed by a <=65533-byte string field. However, for VARCHAR array elements, the maximum length of the string field is 65530 bytes. When you specify the length of a VARCHAR variable, be sure to include 2 bytes for the length field. For longer strings, use the LONG VARCHAR datatype.

ROWID

You can use the ROWID datatype to store binary rowids in (typically 13-byte) fixed-length fields. The field size is port specific. Check your system-specific Oracle documentation.

You can use character host variables to store rowids in a readable format. When you SELECT or FETCH a rowid into a character host variable, Oracle converts the binary value to an 18-byte character string and returns it in the format

```
BBBBBBBB.RRRR.FFFF
```

where BBBBBBBB is the block in the database file, RRRR is the row in the block (the first row is 0), and FFFF is the database file. These numbers are hexadecimal. For example, the rowid

```
0000000E.000A.0007
```

points to the 11th row in the 15th block in the 7th database file.

Typically, you FETCH a rowid into a character host variable, then compare the host variable to the ROWID pseudocolumn in the WHERE clause of an UPDATE or DELETE statement. That way, you can identify the latest row fetched by a cursor. For an example, see "Mimicking CURRENT OF" on page 12-27.

> **Note:** If you need full portability or your application communicates with a non-Oracle database using Oracle Open Gateway technology, specify a maximum length of 256 (not 18) bytes when declaring the host variable. Though you can assume nothing about the host variable's contents, the host variable will behave normally in SQL statements.

DATE

You use the DATE datatype to store dates and times in 7-byte, fixed-length fields. As Table 3–3 shows, the century, year, month, day, hour (in 24-hour format), minute, and second are stored in that order from left to right.

Table 3–3 DATE Format

Byte	1	2	3	4	5	6	7
Meaning	Century	Year	Month	Day	Hour	Minute	Second
Example **17-OCT-1994** **at 1:23:12 PM**	119	194	10	17	14	24	13

The century and year bytes are in excess-100 notation. The hour, minute, and second are in excess-1 notation. Dates before the Common Era (B.C.E.) are less than 100. The epoch is January 1, 4712 B.C.E. For this date, the century byte is 53 and the year byte is 88. The hour byte ranges from 1 to 24. The minute and second bytes range from 1 to 60. The time defaults to midnight (1, 1, 1).

Normally, there is little reason to use this datatype.

VARRAW

You use the VARRAW datatype to store variable-length binary data or byte strings. The VARRAW datatype is like the RAW datatype, except that VARRAW variables have a 2-byte length field followed by a <=65533-byte data field. For longer strings, use the LONG VARRAW datatype.

When you specify the length of a VARRAW variable, be sure to include 2 bytes for the length field. The first two bytes of the variable must be interpretable as an integer.

To get the length of a VARRAW variable, simply refer to its length field.

RAW

You use the RAW datatype to store binary data or byte strings. The maximum length of a RAW value is 255 bytes.

RAW data is like CHARACTER data, except that Oracle assumes nothing about the meaning of RAW data and does no character set conversions when you transmit RAW data from one system to another.

LONG RAW

You use the LONG RAW datatype to store binary data or byte strings. The maximum length of a LONG RAW value is 2147483647 bytes or two gigabytes.

LONG RAW data is like LONG data, except that Oracle assumes nothing about the meaning of LONG RAW data and does no character set conversions when you transmit LONG RAW data from one system to another.

UNSIGNED

You use the UNSIGNED datatype to store unsigned integers. An unsigned integer is a binary number of 2 or 4 bytes. The order of the bytes in a word is system dependent. You must specify a length for input and output host variables. On output, if the column value is a floating-point number, Oracle truncates the fractional part.

LONG VARCHAR

You use the LONG VARCHAR datatype to store variable-length character strings. LONG VARCHAR variables have a 4-byte length field followed by a string field. The maximum length of the string field is 2147483643 (2**31 - 5) bytes. When you specify the length of a LONG VARCHAR for use in a VAR or TYPE statement, do not include the 4 length bytes.

LONG VARRAW

You use the LONG VARRAW datatype to store variable-length binary data or byte strings. LONG VARRAW variables have a 4-byte length field followed by a data field. The maximum length of the data field is 2147483643 bytes. . When you specify the length of a LONG VARRAW for use in a VAR or TYPE statement, do not include the 4 length bytes.

CHAR

You use the CHAR datatype to store fixed-length character strings. The maximum length of a CHAR value is 255 bytes.

On Input Oracle reads the number of bytes specified for the input host variable, does *not* strip trailing blanks, then stores the input value in the target database column.

If the input value is longer than the defined width of the database column, Oracle generates an error. If the input value is all-blank, Oracle treats it like a character value.

On Output Oracle returns the number of bytes specified for the output host variable, doing blank-padding if necessary, then assigns the output value to the target host variable. If a NULL is returned, Oracle fills the host variable with blanks.

If the output value is longer than the declared length of the host variable, Oracle truncates the value before assigning it to the host variable. If an indicator variable is available, Oracle sets it to the original length of the output value.

CHARZ

When DBMS=V7 or V8, Oracle, by default, assigns the CHARZ datatype to all character host variables in a Pro*C/C++ program. The CHARZ datatype indicates fixed-length, null-terminated character strings. The maximum length of a CHARZ value is 255 bytes.

On input, the CHARZ and STRING datatypes work the same way. You must null-terminate the input value. The null terminator serves only to delimit the string; it does not become part of the stored data.

On output, CHARZ host variables are blank-padded if necessary, then null-terminated. The output value is always null-terminated, even if data must be truncated.

CHARF

The CHARF datatype is used in EXEC SQL TYPE and EXEC SQL VAR statements. When you precompile with the DBMS option set to V7 or V8, specifying the external datatype CHAR in a TYPE or VAR statement equivalences the C type or variable to the fixed-length, null-terminated datatype CHARZ. When you precompile with DBMS=V6, the C type or variable is equivalenced to VARCHAR2.

However, you might not want either of these type equivalences, but rather an equivalence to the fixed-length external type CHAR. If you use the external type CHARF, the C type or variable is *always* equivalenced to the fixed-length ANSI datatype CHAR, regardless of the DBMS value. CHARF never allows the C type to be equivalenced to VARCHAR2 or CHARZ. Alternatively, when you set the option CHAR_MAP=CHARF, all host variables declared as char[n] or char are equivalenced to a CHAR string.

MLSLABEL

You use the MLSLABEL datatype to store variable-length, binary operating system labels. Trusted Oracle uses labels to control access to data. For more information, see the *Trusted Oracle7 Administrator's Guide*.

You can use the MLSLABEL datatype to define a column. However, with standard Oracle, such columns can store NULLs only. With Trusted Oracle, you can insert any valid operating system label into a column of type MLSLABEL.

On Input Trusted Oracle translates the input value into a binary label, which must be a valid operating system label. If it is not, Trusted Oracle issues an error message. If the label is valid, Trusted Oracle stores it in the target database column

On Output Trusted Oracle converts the binary label to a character string, which can be of type CHAR, CHARZ, STRING, VARCHAR, or VARCHAR2.

Host Variables

Host variables are the key to communication between your host program and Oracle. Typically, a precompiler program inputs data from a host variable to Oracle, and Oracle outputs data to a host variable in the program. Oracle stores input data in database columns, and stores output data in program host variables.

A host variable can be any arbitrary C expression that resolves to a scalar type. But, a host variable must also be an *lvalue*. Host arrays of most host variables are also supported. See "Pointer Variables" on page 3-41 for more information.

Declaring Host Variables

You declare a host variable according to the rules of C, specifying a C datatype supported by the Oracle program interface. You do not have to declare host variables in a special Declare Section. However, if you do not use a Declare Section, the FIPS flagger warns you about this, as the Declare Section is part of the SQL Standard.

The C datatype must be compatible with that of the source or target database column. Table 3–4 shows the C datatypes and the pseudotypes that you can use when declaring host variables. Only these datatypes can be used for host variables. Table 3–5 shows the compatible Oracle internal datatypes.

Table 3–4 C Datatypes for Host Variables

C Datatype or Pseudotype	Description
char	single character
char[n]	n-character array (string)
int	integer
short	small integer
long	large integer
float	floating-point number (usually single precision)
double	floating-point number (always double precision)
VARCHAR[n]	variable-length string

Table 3–5 C-Oracle Datatype Compatibility

Internal Type	C Type	Description
VARCHAR2(Y) (Note 1)	char	single character
CHAR(X) (Note 1)	char[n] VARCHAR[n] int short long float double	n-byte character array n-byte variable-length character array integer small integer large integer floating-point number double-precision floating-point number
NUMBER	int	integer
NUMBER(P,S) (Note 2)	short long float double char char[n] VARCHAR[n]	small integer large integer floating-point number double-precision floating-point number single character n-byte character array n-byte variable-length character array
DATE	char[n] VARCHAR[n]	n-byte character array n-byte variable-length character array
LONG	char[n] VARCHAR[n]	n-byte character array n-byte variable-length character array
RAW(X) (Note 1)	unsigned char[n] VARCHAR[n]	n-byte character array n-byte variable-length character array

Table 3–5 C-Oracle Datatype Compatibility

Internal Type	C Type	Description
LONG RAW	unsigned char[n]	n-byte character array
	VARCHAR[n]	n-byte variable-length character array
ROWID	unsigned char[n]	n-byte character array
	VARCHAR[n]	n-byte variable-length character array
MLSLABEL	unsigned char[n]	n-byte character array
	VARCHAR[n]	n-byte variable-length character array
Notes:		
1. X ranges from 1 to 255. 1 is the default value. Y ranges from 1 to 4000.		
2. P ranges from 2 to 38. S ranges from -84 to 127.		

For a description of the Oracle datatypes, see "Datatype Conversion" on page 3-58.

One-dimensional arrays of simple C types can also serve as host variables. For char[n] and VARCHAR[n], *n* specifies the maximum string length, *not* the number of strings in the array. Two-dimensional arrays are allowed only for char[m][n] and VARCHAR[m][n], where *m* specifies the number of strings in the array and *n* specifies the maximum string length.

Pointers to simple C types are supported. Pointers to char[n] and VARCHAR[n] variables should be declared as pointer to char or VARCHAR (with no length specification). Arrays of pointers, however, are not supported.

Storage-Class Specifiers

Pro*C/C++ lets you use the **auto**, **extern**, and **static** storage-class specifiers when you declare host variables. However, you cannot use the **register** storage-class specifier to store host variables, since the precompiler takes the address of host variables by placing an ampersand (&) before them. Following the rules of C, you can use the **auto** storage class specifier only within a block.

To comply with the ANSI C standard, the Pro*C/C++ Precompiler allows you to declare an **extern char[n]** host variable with or without a maximum length, as the following examples shows:

```
extern char  protocol[15];
extern char  msg[];
```

However, you should always specify the maximum length. In the last example, if *msg* is an output host variable declared in one precompilation unit but defined in another, the precompiler has no way of knowing its maximum length. If you have not allocated enough storage for *msg* in the second precompilation unit, you might corrupt memory. (Usually, "enough" is the number of bytes in the longest column value that might be SELECTed or FETCHed into the host variable, plus one byte for a possible null terminator.)

If you neglect to specify the maximum length for an **extern char[ ]** host variable, the precompiler issues a warning message. Also, it assumes that the host variable will store a CHARACTER column value, which cannot exceed 255 characters in length. So, if you want to SELECT or FETCH a VARCHAR2 or a LONG column value of length greater than 255 characters into the host variable, you *must* specify a maximum length.

Type Qualifiers

You can also use the **const** and **volatile** type qualifiers when you declare host variables.

A **const** host variable must have a constant value, that is, your program cannot change its initial value. A **volatile** host variable can have its value changed in ways unknown to your program (by a device attached to the system, for instance).

Referencing Host Variables

You use host variables in SQL data manipulation statements. A host variable must be prefixed with a colon (:) in SQL statements but must not be prefixed with a colon in C statements, as the following example shows:

```
char    buf[15];
int     emp_number;
float   salary;
...
gets(buf);
emp_number = atoi(buf);

EXEC SQL SELECT sal INTO :salary FROM emp
     WHERE empno = :emp_number;
```

Though it might be confusing, you can give a host variable the same name as an Oracle table or column, as this example shows:

```
int     empno;
char    ename[10];
```

```
float   sal;
...
EXEC SQL SELECT ename, sal INTO :ename, :sal FROM emp
     WHERE empno = :empno;
```

Restrictions

A host variable name is a C identifier, hence it must be declared and referenced in the same upper/lower case format. It cannot substitute for a column, table, or other Oracle object in a SQL statement, and must not be an Oracle reserved word. See Appendix B, "Oracle Reserved Words, Keywords, and Namespaces".

A host variable must resolve to an address in the program. For this reason, function calls and numeric expressions cannot serve as host variables. The following code is *invalid*:

```
#define MAX_EMP_NUM    9000
...
int get_dept();
...
EXEC SQL INSERT INTO emp (empno, ename, deptno) VALUES
    (:MAX_EMP_NUM + 10, 'CHEN', :get_dept());
```

Indicator Variables

You can associate every host variable with an optional indicator variable. An indicator variable must be defined as a 2-byte integer and, in SQL statements, must be prefixed with a colon and immediately follow its host variable (unless you use the keyword INDICATOR). If you are using Declare Sections, you must also declare indicator variables inside the Declare Sections.

Note: This applies to relational columns, not object types, which are discussed in Chapter 8, "Object Support in Pro*C/C++".

Using the Keyword INDICATOR

To improve readability, you can precede any indicator variable with the optional keyword INDICATOR. You must still prefix the indicator variable with a colon. The correct syntax is :

```
:host_variable INDICATOR :indicator_variable
```

which is equivalent to

```
:host_variable:indicator_variable
```

You can use both forms of expression in your host program.

Possible indicator values, and their meanings, are:

0	The operation was successful
-1	A NULL was returned, inserted, or updated.
-2	Output to a character host variable from a "long" type was truncated, but the original column length cannot be determined.
>0	The result of a SELECT or FETCH into a character host variable was truncated. In this case, if the host variable is an NLS multi-byte variable, the indicator value is the original column length in characters. If the host variable is not an NLS variable, then the indicator length is the original column length in bytes.

An Example

Typically, you use indicator variables to assign nulls to input host variables and detect nulls or truncated values in output host variables. In the example below, you declare three host variables and one indicator variable, then use a SELECT statement to search the database for an employee number matching the value of host variable *emp_number*. When a matching row is found, Oracle sets output host variables *salary* and *commission* to the values of columns SAL and COMM in that row and stores a return code in indicator variable *ind_comm*. The next statements use *ind_comm* to select a course of action.

```
EXEC SQL BEGIN DECLARE SECTION;
    int    emp_number;
    float  salary, commission;
    short comm_ind;  /* indicator variable  */
EXEC SQL END DECLARE SECTION;
    char temp[16];
    float  pay;      /* not used in a SQL statement */
...
printf("Employee number? ");
gets(temp);
emp_number = atof(temp);
EXEC SQL SELECT SAL, COMM
    INTO :salary, :commission:ind_comm
    FROM EMP
    WHERE EMPNO = :emp_number;
```

```
if(ind_comm == -1)    /* commission is null */
    pay = salary;
else
    pay = salary + commission;
```

For more information about using indicator variables, see "Using Indicator Variables" on page 5-3.

Guidelines

The following guidelines apply to declaring and referencing indicator variables. An indicator variable must

- be declared explicitly (in the Declare Section if present) as a 2-byte integer
- be prefixed with a colon (:) in SQL statements
- immediately follow its host variable in SQL statements and PL/SQL blocks (unless preceded by the keyword INDICATOR)

An indicator variable must *not*

- be prefixed with a colon in host language statements
- follow its host variable in host language statements
- be an Oracle reserved word

Oracle Restrictions

When DBMS=V6, Oracle does not issue an error if you SELECT or FETCH a null into a host variable that is not associated with an indicator variable. However, when DBMS=V7 or V8, if you SELECT or FETCH a null into a host variable that has no indicator, Oracle issues the following error message:

```
ORA-01405: fetched column value is NULL
```

When precompiling with MODE=ORACLE and DBMS=V7 or V8 specified, you can specify UNSAFE_NULL=YES to disable the ORA-01405 message. For more information, see "UNSAFE_NULL" on page 9-37.

Host Structures

You can use a C structure to contain host variables. You reference a structure containing host variables in the INTO clause of a SELECT or a FETCH statement, and in the VALUES list of an INSERT statement. Every component of the host structure must be a legal Pro*C/C++ host variable, as defined in Table 3–4.

When a structure is used as a host variable, only the name of the structure is used in the SQL statement. However, each of the members of the structure sends data to Oracle, or receives data from Oracle on a query. The following example shows a host structure that is used to add an employee to the EMP table:

```
typedef struct
{
    char  emp_name[11]; /* one greater than column length */
    int   emp_number;
    int   dept_number;
    float salary;
} emp_record;
...
/* define a new structure of type "emp_record" */
emp_record new_employee;

strcpy(new_employee.emp_name, "CHEN");
new_employee.emp_number = 9876;
new_employee.dept_number = 20;
new_employee.salary = 4250.00;

EXEC SQL INSERT INTO emp (ename, empno, deptno, sal)
    VALUES (:new_employee);
```

The order that the members are declared in the structure must match the order that the associated columns occur in the SQL statement, or in the database table if the column list in the INSERT statement is omitted.

For example, the following use of a host structure is *invalid*, and causes a runtime error:

```
struct
{
    int empno;
    float salary;          /* struct components in wrong order */
    char emp_name[10];
} emp_record;

...
SELECT empno, ename, sal
   INTO :emp_record FROM emp;
```

The example is wrong because the components of the structure are not declared in the same order as the associated columns in the select list. The correct form of the SELECT statement is

```
SELECT empno, sal, ename   /* reverse order of sal and ename */
    INTO :emp_record FROM emp;
```

Host Structures and Arrays

An *array* is a collection of related data items, called *elements*, associated with a single variable name. When declared as a host variable, the array is called a *host array*. Likewise, an indicator variable declared as an array is called an *indicator array*. An indicator array can be associated with any host array.

Host arrays can increase performance by letting you manipulate an entire collection of data items with a single SQL statement. With few exceptions, you can use host arrays wherever scalar host variables are allowed. Also, you can associate an indicator array with any host array.

For a complete discussion of host arrays, see Chapter 12, “Using Host Arrays”.

You can use host arrays as components of host structures. In the following example, a structure containing arrays is used to INSERT three new entries into the EMP table:

```
struct
{
    char emp_name[3][10];
    int emp_number[3];
    int dept_number[3];
} emp_rec;
...
strcpy(emp_rec.emp_name[0], "ANQUETIL");
strcpy(emp_rec.emp_name[1], "MERCKX");
strcpy(emp_rec.emp_name[2], "HINAULT");
emp_rec.emp_number[0] = 1964; emp_rec.dept_number[0] = 5;
emp_rec.emp_number[1] = 1974; emp_rec.dept_number[1] = 5;
emp_rec.emp_number[2] = 1985; emp_rec.dept_number[2] = 5;

EXEC SQL INSERT INTO emp (ename, empno, deptno)
    VALUES (:emp_rec);
```

PL/SQL Records

You cannot use a C **struct** as a host variable for a PL/SQL RECORD variable.

Nested Structures and Unions

You cannot nest host structures. The following example is *invalid*:

```
struct
{
    int emp_number;
    struct
    {
        float salary;
        float commission;
    } sal_info;            /* INVALID */
    int dept_number;
} emp_record;
...
EXEC SQL SELECT empno, sal, comm, deptno
    INTO :emp_record
    FROM emp;
```

Also, you cannot use a C **union** as a host structure, nor can you nest a **union** in a structure that is to be used as a host structure.

Host Indicator Structures

When you need to use indicator variables, but your host variables are contained in a host structure, you set up a second structure that contains an indicator variable for each host variable in the host structure.

For example, suppose you declare a host structure *student_record* as follows:

```
struct
{
    char s_name[32];
    int s_id;
    char grad_date[9];
} student_record;
```

If you want to use the host structure in a query such as

```
EXEC SQL SELECT student_name, student_idno, graduation_date
    INTO :student_record
    FROM college_enrollment
    WHERE student_idno = 7200;
```

and you need to know if the graduation date can be NULL, then you must declare a separate host indicator structure. You declare this as

```
struct
{
    short s_name_ind;  /* indicator variables must be shorts */
    short s_id_ind;
    short grad_date_ind;
} student_record_ind;
```

Reference the indicator structure in the SQL statement in the same way that you reference a host indicator variable:

```
EXEC SQL SELECT student_name, student_idno, graduation_date
    INTO :student_record INDICATOR :student_record_ind
    FROM college_enrollment
    WHERE student_idno = 7200;
```

When the query completes, the NULL / NOT NULL status of each selected component is available in the host indicator structure.

> **Note:** This Guide conventionally names indicator variables and indicator structures by appending *_ind* to the host variable or structure name. However, the names of indicator variables are completely arbitrary. You can adopt a different convention, or use no convention at all.

Sample Program: Cursor and a Host Structure

The demonstration program in this section shows a query that uses an explicit cursor, selecting data into a host structure. This program is available inthe file *sample2.pc* in your *demo* directory.

```
/*
 *  sample2.pc
 *
 *  This program connects to ORACLE, declares and opens a cursor,
 *  fetches the names, salaries, and commissions of all
 *  salespeople, displays the results, then closes the cursor.
 */

#include <stdio.h>
#include <sqlca.h>

#define UNAME_LEN      20
#define PWD_LEN        40

/*
 * Use the precompiler typedef'ing capability to create
```

```
 * null-terminated strings for the authentication host
 * variables. (This isn't really necessary--plain char *'s
 * does work as well. This is just for illustration.)
 */
typedef char asciiz[PWD_LEN];

EXEC SQL TYPE asciiz IS STRING(PWD_LEN) REFERENCE;
asciiz     username;
asciiz     password;

struct emp_info
{
    asciiz     emp_name;
    float      salary;
    float      commission;
};


/* Declare function to handle unrecoverable errors. */
void sql_error();


main()
{
    struct emp_info *emp_rec_ptr;

/* Allocate memory for emp_info struct. */
    if ((emp_rec_ptr =
        (struct emp_info *) malloc(sizeof(struct emp_info))) == 0)
    {
        fprintf(stderr, "Memory allocation error.\n");
        exit(1);
    }

/* Connect to ORACLE. */
    strcpy(username, "SCOTT");
    strcpy(password, "TIGER");

    EXEC SQL WHENEVER SQLERROR DO sql_error("ORACLE error--");

    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    printf("\nConnected to ORACLE as user: %s\n", username);

/* Declare the cursor. All static SQL explicit cursors
 * contain SELECT commands. 'salespeople' is a SQL identifier,
```

```
 * not a (C) host variable.
 */
    EXEC SQL DECLARE salespeople CURSOR FOR
        SELECT ENAME, SAL, COMM
            FROM EMP
            WHERE JOB LIKE 'SALES%';

/* Open the cursor. */
    EXEC SQL OPEN salespeople;

/* Get ready to print results. */
    printf("\n\nThe company's salespeople are--\n\n");
    printf("Salesperson   Salary   Commission\n");
    printf("-----------   ------   ----------\n");

/* Loop, fetching all salesperson's statistics.
 * Cause the program to break the loop when no more
 * data can be retrieved on the cursor.
 */
    EXEC SQL WHENEVER NOT FOUND DO break;

    for (;;)
    {
        EXEC SQL FETCH salespeople INTO :emp_rec_ptr;
        printf("%-11s%9.2f%13.2f\n", emp_rec_ptr->emp_name,
                emp_rec_ptr->salary, emp_rec_ptr->commission);
    }

/* Close the cursor. */
    EXEC SQL CLOSE salespeople;

    printf("\nArrivederci.\n\n");

    EXEC SQL COMMIT WORK RELEASE;
    exit(0);
}



void
sql_error(msg)
char *msg;
{
    char err_msg[512];
    int buf_len, msg_len;
```

```
    EXEC SQL WHENEVER SQLERROR CONTINUE;

    printf("\n%s\n", msg);

/* Call sqlglm() to get the complete text of the
 * error message.
 */
    buf_len = sizeof (err_msg);
    sqlglm(err_msg, &buf_len, &msg_len);
    printf("%.*s\n", msg_len, err_msg);

    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

Pointer Variables

C supports *pointers*, which "point" to other variables. A pointer holds the address (storage location) of a variable, not its value.

Declaring Pointer Variables

You define pointers as host variables following the normal C practice, as the next example shows:

```
int   *int_ptr;
char  *char_ptr;
```

Referencing Pointer Variables

In SQL statements, prefix pointers with a colon, as shown in the following example:

```
EXEC SQL SELECT intcol INTO :int_ptr FROM ...
```

Except for pointers to character strings, the size of the referenced value is given by the size of the base type specified in the declaration. For pointers to character strings, the referenced value is assumed to be a null-terminated (also known as 0-terminated) string. Its size is determined at run time by calling the *strlen()* function. For details, see the section "Handling Character Data" on page 3-50.

You can use pointers to reference the members of a **struct**. First, declare a pointer host variable, then set the pointer to the address of the desired member, as shown in the example below. The datatypes of the **struct** member and the pointer variable must be the same. Most compilers will warn you of a mismatch.

```
struct
{
    int  i;
    char c;
} structvar;
int   *i_ptr;
char  *c_ptr;
...
main()
{
    i_ptr = &structvar.i;
    c_ptr = &structvar.c;
/* Use i_ptr and c_ptr in SQL statements. */
...
```

Structure Pointers

You can use a pointer to a structure as a host variable. The following example

- declares a structure
- declares a pointer to the structure
- allocates memory for the structure
- uses the struct pointer as a host variable in a query
- dereferences the struct components to print the results

```
struct EMP_REC
{
    int emp_number;
    float salary;
};
char *name = "HINAULT";
...
struct EMP_REC *sal_rec;
sal_rec = (struct EMP_REC *) malloc(sizeof (struct EMP_REC));
...
EXEC SQL SELECT empno, sal INTO :sal_rec
    FROM emp
```

```
    WHERE ename = :name;

printf("Employee number and salary for %s: ", name);
printf("%d, %g\n", sal_rec->emp_number, sal_rec->salary);
```

In the SQL statement, pointers to host structures are referred to in exactly the same way as a host structure. The ‘‘address of” notation (**&**) is not required; in fact, it is an error to use it.

VARCHAR Variables

You can use the VARCHAR pseudotype to declare variable-length character strings. When your program deals with strings that are output from, or input to, VARCHAR2 or LONG columns, you might find it more convenient to use VARCHAR host variables instead of standard C strings. The datatype name VARCHAR can be uppercase or lowercase, but it *cannot* be mixed case. In this Guide, uppercase is used to emphasize that VARCHAR is not a native C datatype.

Declaring VARCHAR Variables

Think of a VARCHAR as an extended C type or pre-declared **struct**. For example, the precompiler expands the VARCHAR declaration

```
VARCHAR   username[20];
```

into the following **struct** with array and length members:

```
struct
{
     unsigned short  len;
     unsigned char   arr[20];
} username;
```

The advantage of using VARCHAR variables is that you can explicitly reference the length member of the VARCHAR structure after a SELECT or FETCH. Oracle puts the length of the selected character string in the length member. You can then use this member to do things such as adding the null (i.e. ’\0’) terminator

```
username.arr[username.len] = '\0';
```

or using the length in a *strncpy* or *printf* statement; for example:

```
printf("Username is %.*s\n", username.len, username.arr);
```

You specify the maximum length of a VARCHAR variable in its declaration. The length must lie in the range 1..65,533. For example, the following declaration is *invalid* because no length is specified:

```
VARCHAR   null_string[];    /* invalid */
```

The length member holds the current length of the value stored in the array member.

You can declare multiple VARCHARs on a single line; for example:

```
VARCHAR emp_name[ENAME_LEN], dept_loc[DEPT_NAME_LEN];
```

The length specifier for a VARCHAR can be a **#define**d macro, or any complex expression that can be resolved to an integer at precompile time.

You can also declare pointers to VARCHAR datatypes. See the section "Handling Character Data" on page 3-50.

Do not attempt to use a typedef statement such as :

```
typedef VARCHAR buf[64];
```

This causes errors during the C compilation.

Referencing VARCHAR Variables

In SQL statements, you reference VARCHAR variables using the **struct** name prefixed with a colon, as the following example shows:

```
...
int       part_number;
VARCHAR   part_desc[40];
...
main()
{
    ...
    EXEC SQL SELECT pdesc INTO :part_desc
        FROM parts
        WHERE pnum = :part_number;
    ...
```

After the query is executed, *part_desc.len* holds the actual length of the character string retrieved from the database and stored in *part_desc.arr*.

In C statements, you reference VARCHAR variables using the component names, as the next example shows:

```
printf("\n\nEnter part description: ");
gets(part_desc.arr);
/* You must set the length of the string
   before using the VARCHAR in an INSERT or UPDATE */
part_desc.len = strlen(part_desc.arr);
```

Returning NULLs to a VARCHAR Variable

Oracle automatically sets the length component of a VARCHAR output host variable. If you SELECT or FETCH a NULL into a VARCHAR, the server does not change the length or array members.

> **Note:** If you select a NULL into a VARCHAR host variable, and there is no associated indicator variable, an ORA-01405 error occurs at run time. Avoid this by coding indicator variables with all host variables. (As a temporary fix, use the DBMS=V6 or UNSAFE_NULL=YES precompiler option. See "DBMS" on page 9-14).

Inserting NULLs Using VARCHAR Variables

If you set the length of a VARCHAR variable to zero before performing an UPDATE or INSERT statement, the column value is set to NULL. If the column has a NOT NULL constraint, Oracle returns an error.

Passing VARCHAR Variables to a Function

VARCHARs are structures, and most C compilers permit passing of structures to a function by value, and returning structures by copy out from functions. However, in Pro*C/C++ you must pass VARCHARs to functions by reference. The following example shows the correct way to pass a VARCHAR variable to a function:

```
VARCHAR emp_name[20];
...
emp_name.len = 20;
SELECT ename INTO :emp_name FROM emp
WHERE empno = 7499;
...
print_employee_name(&emp_name); /* pass by pointer */
...

print_employee_name(name)
VARCHAR *name;
{
    ...
```

```
    printf("name is %.*s\n", name->len, name->arr);
    ...
}
```

Finding the Length of the VARCHAR Array Component

When the precompiler processes a VARCHAR declaration, the actual length of the array element in the generated structure can be longer than that declared. For example, on a Sun Solaris system, the Pro*C/C++ declaration

```
VARCHAR my_varchar[12];
```

is expanded by the precompiler to

```
struct my_varchar
{
    unsigned short len;
    unsigned char  arr[12];
};
```

However, the precompiler or the C compiler on this system pads the length of the array component to 14 bytes. This alignment requirement pads the total length of the structure to 16 bytes: 14 for the padded array and 2 bytes for the length.

The *sqlvcp()* function—part of the SQLLIB runtime library—returns the actual (possibly padded) length of the array member.

You pass the *sqlvcp()* function the length of the data for a VARCHAR host variable or a VARCHAR pointer host variable, and *sqlvcp()* returns the total length of the array component of the VARCHAR. The total length includes any padding that might be added by your C compiler.

The syntax of *sqlvcp()* is

```
sqlvcp(size_t *datlen, size_t *totlen);
```

Put the length of the VARCHAR in the first parameter before calling *sqlvcp()*. When the function returns, the second parameter contains the total length of the array element. Both parameters are pointers to long integers, so must be passed by reference.

Sample Program: Using *sqlvcp()*

The following sample program shows how you can use the *sqlvcp()* function in a Pro*C/C++ application. (The sample also uses the *sqlgls()* function, which is described in Chapter 11, “Handling Runtime Errors”.) The sample declares a

VARCHAR pointer, then uses the *sqlvcp()* function to determine the size required for the VARCHAR buffer. The program FETCHes employee names from the EMP table and prints them. Finally, the sample uses the *sqlgls()* function to print out the SQL statement and its function code and length attributes. This program is available on-line as *sqlvcp.pc* in your *demo* directory.

```
/*
 *  The sqlvcp.pc program demonstrates how you can use the
 *  sqlvcp() function to determine the actual size of a
 *  VARCHAR struct. The size is then used as an offset to
 *  increment a pointer that steps through an array of
 *  VARCHARs.
 *
 *  This program also demonstrates the use of the sqlgls()
 *  function, to get the text of the last SQL statement executed.
 *  sqlgls() is described in the "Error Handling" chapter of
 *  _The Programmer's Guide to the Oracle Pro*C/C++ Precompiler.
 */

#include <stdio.h>
#include <sqlca.h>
#include <sqlcpr.h>

/*  Fake a VARCHAR pointer type. */

struct my_vc_ptr
{
    unsigned short len;
    unsigned char arr[32767];
};

/* Define a type for the VARCHAR pointer */
typedef struct my_vc_ptr my_vc_ptr;
my_vc_ptr *vc_ptr;


EXEC SQL BEGIN DECLARE SECTION;
VARCHAR *names;
int      limit;    /* for use in FETCH FOR clause  */
char    *username = "scott/tiger";
EXEC SQL END DECLARE SECTION;
void sql_error();
extern void sqlvcp(), sqlgls();

main()
```

```
{
    unsigned int vcplen, function_code, padlen, buflen;
    int i;
    char stmt_buf[120];

    EXEC SQL WHENEVER SQLERROR DO sql_error();

    EXEC SQL CONNECT :username;
    printf("\nConnected.\n");

/*  Find number of rows in table. */
    EXEC SQL SELECT COUNT(*) INTO :limit FROM emp;


/*  Declare a cursor for the FETCH statement. */
    EXEC SQL DECLARE emp_name_cursor CURSOR FOR
    SELECT ename FROM emp;
    EXEC SQL FOR :limit OPEN emp_name_cursor;

/*  Set the desired DATA length for the VARCHAR. */
    vcplen = 10;

/*  Use SQLVCP to help find the length to malloc. */
    sqlvcp(&vcplen, &padlen);
    printf("Actual array length of VARCHAR is %ld\n", padlen);

/*  Allocate the names buffer for names.
    Set the limit variable for the FOR clause. */
    names = (VARCHAR *) malloc((sizeof (short) +
    (int) padlen) * limit);
    if (names == 0)
    {
        printf("Memory allocation error.\n");
        exit(1);
    }
/*  Set the maximum lengths before the FETCH.
 *  Note the "trick" to get an effective VARCHAR *.
 */
    for (vc_ptr = (my_vc_ptr *) names, i = 0; i < limit; i++)
    {
        vc_ptr->len = (short) padlen;
        vc_ptr = (my_vc_ptr *)((char *) vc_ptr +
        padlen + sizeof (short));
    }
/*  Execute the FETCH. */
```

```
    EXEC SQL FOR :limit FETCH emp_name_cursor INTO :names;

/*  Print the results. */
    printf("Employee names--\n");

    for (vc_ptr = (my_vc_ptr *) names, i = 0; i < limit; i++)
    {
        printf
         ("%.*s\t(%d)\n", vc_ptr->len, vc_ptr->arr, vc_ptr->len);
        vc_ptr = (my_vc_ptr *)((char *) vc_ptr +
                  padlen + sizeof (short));
    }

/*  Get statistics about the most recent
 *  SQL statement using SQLGLS. Note that
 *  the most recent statement in this example
 *  is not a FETCH, but rather "SELECT ENAME FROM EMP"
 *  (the cursor).
 */
    buflen = (long) sizeof (stmt_buf);

/*  The returned value should be 1, indicating no error. */
    sqlgls(stmt_buf, &buflen, &function_code);
    if (buflen != 0)
    {
        /* Print out the SQL statement. */
        printf("The SQL statement was--\n%.*s\n", buflen, stmt_buf);

        /* Print the returned length. */
        printf("The statement length is %ld\n", buflen);

        /* Print the attributes. */
        printf("The function code is %ld\n", function_code);

        EXEC SQL COMMIT RELEASE;
        exit(0);
    }
    else
    {
        printf("The SQLGLS function returned an error.\n");
        EXEC SQL ROLLBACK RELEASE;
        exit(1);
    }
}
```

```
void
sql_error()
{
    char err_msg[512];
    int buf_len, msg_len;


    EXEC SQL WHENEVER SQLERROR CONTINUE;

    buf_len = sizeof (err_msg);
    sqlglm(err_msg, &buf_len, &msg_len);
    printf("%.*s\n", msg_len, err_msg);

    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

Handling Character Data

This section explains how the Pro*C/C++ Precompiler handles character host variables. There are four host variable character types:

- character arrays
- pointers to strings
- VARCHAR variables
- pointers to VARCHARs

Do not confuse VARCHAR (a host variable data structure supplied by the precompiler) with VARCHAR2 (an Oracle internal datatype for variable-length character strings).

Precompiler Option CHAR_MAP

The CHAR_MAP precompiler command line option is available to specify the default mapping of char[n] and char host variables. In Oracle V6, these host variables were mapped to VARCHAR2 by default. Oracle7 and Oracle8 map them to CHARZ. CHARZ implements the ANSI Variable Character format. Strings are fixed-length, blank-padded and 0-terminated. VARCHAR2 values (including

NULLs) are always fixed-length and blank-padded. Table 3–6 shows the possible settings of CHAR_MAP:

Table 3–6 CHAR_MAP Settings

CHAR_MAP Setting	Is Default for	Description
VARCHAR2	DBMS=V6	All values (including NULL) are fixed-length blank-padded.
CHARZ	DBMS=V7, DBMS=V8	Fixed-length blank-padded, then 0-terminated. Conforms to the ANSI Variable Character type.
STRING	New format	0-terminated. Conforms to ASCIIZ format used in C programs.
CHARF	Previously, only through VAR or TYPE declarations.	Fixed-length blank-padded. NULL is left unpadded. Conforms to the ANSI Fixed Character type.

When you specify DBMS=V6, any option you use for CHAR_MAP, other than VARCHAR2, results in an error. The default mapping is CHAR_MAP=VARCHAR2, which was the case in previous versions of Pro*C/C++.

The option DBMS=V6_CHAR, which Oracle introduced in Pro*C/C++ 2.2 to obtain default mapping of character host variables to VARCHAR2, is being deprecated (will become obsolete). Use CHAR_MAP=VARCHAR2 instead.

Inline Usage of the CHAR_MAP Option

Unless you declared a char or char[n] variable otherwise, the inline CHAR_MAP option determines its mapping. The following code fragment illustrates the results of setting this option inline in Pro*C:

```
char ch_array[5];

strncpy(ch_array, "12345", 5);
/* char_map=charz is the default in Oracle7 and Oracle8 */
EXEC ORACLE OPTION (char_map=charz);
/* Select retrieves a string "AB" from the database */
SQL SELECT ... INTO :ch_array FROM ... WHERE ... ;
/* ch_array == { 'A', 'B', ' ', ' ', '\0' } */
```

```
strncpy (ch_array, "12345", 5);
EXEC ORACLE OPTION (char_map=string) ;
/* Select retrieves a string "AB" from the database */
EXEC SQL SELECT ... INTO :ch_array FROM ... WHERE ... ;
/* ch_array == { 'A', 'B', '\0', '4', '5' } */

strcpy( ch_array, "12345", 5);
EXEC ORACLE OPTION (char_map=charf);
/* Select retrieves a string "AB" from the database */
EXEC SQL SELECT ... INTO :ch_array FROM ... WHERE ... ;
/* ch_array == { 'A', 'B', ' ', ' ', ' ' } */
```

Effect of the DBMS and CHAR_MAP Options

The DBMS and CHAR_MAP options determine how Pro*C/C++ treats data in character arrays and strings. These options allows your program to observe compatibility with ANSI fixed-length strings, or to maintain compatibility with previous releases of Oracle and Pro*C/C++ that use variable-length strings. See Chapter 9, "Running the Pro*C/C++ Precompiler" for a complete description of the DBMS and CHAR_MAP options.

The DBMS option affects character data both on input (from your host variables to the Oracle table) and on output (from an Oracle table to your host variables).

Character Array and the CHAR_MAP Option

The mapping of character arrays can also be set by the CHAR_MAP option independent of the DBMS option. By default, DBMS=V6 uses CHAR_MAP=VARCHAR2 (the only option permitted for V6), while DBMS=V7 or DBMS=V8 both use CHAR_MAP=CHARZ, which can be overridden by specifying either CHAR_MAP=VARCHAR2 or STRING or CHARF.

On Input

Character Array On input, the DBMS option determines the format that a host variable character array must have in your program. When the CHAR_MAP=VARCHAR2, (or DBMS=V6), host variable character arrays must be blank padded, and should not be 0-terminated. When the DBMS=V7 or V8, character arrays must be null-terminated ('0\').

When the CHAR_MAP option is set to VARCHAR2, or DBMS is set to V6, trailing blanks are stripped up to the first non-blank character before the value is sent to the database. Note that an uninitialized character array can contain null characters. To

make sure that the nulls are not inserted into the table, you must blank-pad the character array to its length. For example, if you execute the statements :

```
char emp_name[10];
...
strcpy(emp_name, "MILLER");     /* WRONG! Note no blank-padding */
EXEC SQL INSERT INTO emp (empno, ename, deptno) VALUES
    (1234, :emp_name, 20);
```

you will find that the string "MILLER" was inserted as "MILLER\0\0\0\0" (with four null bytes appended to it). This value does not meet the following search condition:

```
. . . WHERE ename = 'MILLER';
```

To INSERT the character array when DBMS is set to V6 or CHAR_MAP is set to VARCHAR2, you should execute the statements

```
strncpy(emp_name, "MILLER    ", 10); /* 4 trailing blanks */
EXEC SQL INSERT INTO emp (empno, ename, deptno) VALUES
    (1234, :emp_name, 20);
```

When DBMS=V7 or V8, input data in a character array must be null-terminated. So, make sure that your data ends with a null.

```
char emp_name[11];  /* Note: one greater than column size of 10 */
...
strcpy(emp_name, "MILLER");        /* No blank-padding required */
EXEC SQL INSERT INTO emp (empno, ename, deptno) VALUES
    (1234, :emp_name, 20);
```

Character Pointer The pointer must address a null-terminated buffer that is large enough to hold the input data. Your program must allocate enough memory to do this.

On Input

The following example illustrates all possible combinations of the effects of the CHAR_MAP option settings on the value retrieved from a database into a character array.

Assume a database

```
TABLE strdbase ( ..., strval VARCHAR2(6));
```

which contains the following strings in the column strval:

```
""        -- string of length 0
"AB"      -- string of length 2
"KING"    -- string of length 4
"QUEEN"   -- string of length 5
"MILLER"  -- string of length 6
```

In a Pro*C/C++ program, initialize the 5-character host array *str* with 'X' characters and use for the retrieval of all the values in column strval:

```
char  str[5] = {'X', 'X', 'X','X', 'X'} ;
short str_ind;
...
EXEC SQL SELECT strval INTO :str:str_ind WHERE ... ;
```

with the following results for the array, str, and the indicator variable, str_ind, as CHAR_MAP is set to VARCHAR2, CHARF, CHARZ and STRING:

```
strval = ""         "AB"       "KING"     "QUEEN"    "MILLER"
-------------------------------------------------------------
VARCHAR2 "     " -1 "AB   " 0  "KING "  0 "QUEEN"  0 "MILLE"  6
CHARF    "XXXXX" -1 "AB   " 0  "KING "  0 "QUEEN"  0 "MILLE"  6
CHARZ    "    0" -1 "AB  0" 0  "KING0"  0 "QUEE0"  5 "MILL0"  6
STRING   "0XXXX" -1 "AB0XX" 0  "KING0"  0 "QUEE0"  5 "MILL0"  6
```

where 0 stands for the null character, '\0'.

On Output

Character Array On output, the DBMS and CHAR_MAP options determines the format that a host variable character array will have in your program. When DBMS=V6 or CHAR_MAP=VARCHAR2, host variable character arrays are blank padded up to the length of the array, but never null-terminated. When DBMS=V7 or V8 (or CHAR_MAP=CHARZ), character arrays are blank padded, then null-terminated in the final position in the array.

Consider the following example of character output:

```
CREATE TABLE test_char (C_col CHAR(10), V_col VARCHAR2(10));

INSERT INTO test_char VALUES ('MILLER', 'KING');
```

A precompiler program to select from this table contains the following embedded SQL:

```
...
char name1[10];
char name2[10];
...
EXEC SQL SELECT C_col, V_col INTO :name1, :name2
    FROM test_char;
```

If you precompile the program with DBMS=V6 (or CHAR_MAP=VARCHAR2), *name1* will contain:

```
"MILLER####"
```

that is, the name "MILLER" followed by 4 blanks, with no null-termination. (Note that if *name1* had been declared with a size of 15, there are 9 blanks following the name.)

name2 will contain:

```
"KING######"      /* 6 trailing blanks */
```

If you precompile the program with DBMS=V7 or V8, *name1* will contain:

```
"MILLER###\0" /* 3 trailing blanks, then a null-terminator */
```

that is, a string containing the name, blank-padded to the length of the column, followed by a null terminator. *name2* will contain:

```
"KING#####\0"
```

In summary, if DBMS=V6 or DBMS=V6 (or CHAR_MAP=VARCHAR2), the output from either a CHARACTER column or a VARCHAR2 column is blank-padded to the length of the host variable array. If DBMS=V7 or V8, the output string is always null-terminated.

Character Pointer The DBMS and CHAR_MAP options do not affect the way character data are output to a pointer host variable.

When you output data to a character pointer host variable, the pointer must point to a buffer large enough to hold the output from the table, plus one extra byte to hold a null terminator.

The precompiler runtime environment calls *strlen()* to determine the size of the output buffer, so make sure that the buffer does not contain any embedded nulls

('\0'). Fill allocated buffers with some value other than '\0', then null-terminate the buffer, before fetching the data.

> **Note:** C pointers can be used in a Pro*C/C++ program that is precompiled with DBMS=V7 or V8 and MODE=ANSI. However, pointers are not legal host variable types in a SQL standard compliant program. The FIPS flagger warns you if you use pointers as host variables.

The following code fragment uses the columns and table defined in the previous section, and shows how to declare and SELECT into character pointer host variables:

```
...
char *p_name1;
char *p_name2;
...
p_name1 = (char *) malloc(11);
p_name2 = (char *) malloc(11);
strcpy(p_name1, "          ");
strcpy(p_name2, "0123456789");

EXEC SQL SELECT C_col, V_col INTO :p_name1, :p_name2
    FROM test_char;
```

When the SELECT statement above is executed with any DBMS or CHAR_MAP setting, the value fetched is:

```
"MILLER####\0"     /* 4 trailing blanks and a null terminator */

"KING######\0"    /* 6 blanks and null */
```

VARCHAR Variables and Pointers

The following example shows how VARCHAR host variables are declared:

```
VARCHAR   emp_name1[10];   /* VARCHAR variable   */
VARCHAR  *emp_name2;       /* pointer to VARCHAR */
```

On Input

VARCHAR Variables When you use a VARCHAR variable as an input host variable, your program need only place the desired string in the array member of the expanded VARCHAR declaration (*emp_name1.arr* in our example) and set the

length member (*emp_name1.len*). There is no need to blank-pad the array. Exactly *emp_name1.len* characters are sent to Oracle, counting any blanks and nulls. In the following example, you set *emp_name1.len* to 8:

```
strcpy(emp_name1.arr, "VAN HORN");
emp_name1.len = strlen(emp_name1.arr);
```

Pointer to a VARCHAR When you use a pointer to a VARCHAR as an input host variable, you must allocate enough memory for the expanded VARCHAR declaration. Then, you must place the desired string in the array member and set the length member, as shown in the following example:

```
emp_name2 = malloc(sizeof(short) + 10)   /* len + arr */
strcpy(emp_name2->arr, "MILLER");
emp_name2->len = strlen(emp_name2->arr);
```

Or, to make *emp_name2* point to an existing VARCHAR (*emp_name1* in this case), you could code the assignment

```
emp_name2 = &emp_name1;
```

then use the VARCHAR pointer in the usual way, as in

```
EXEC SQL INSERT INTO EMP (EMPNO, ENAME, DEPTNO)
     VALUES (:emp_number, :emp_name2, :dept_number);
```

On Output

VARCHAR Variables When you use a VARCHAR variable as an output host variable, the program interface sets the length member but does *not* null-terminate the array member. As with character arrays, your program can null-terminate the *arr* member of a VARCHAR variable before passing it to a function such as *printf()* or *strlen()*. An example follows:

```
emp_name1.arr[emp_name1.len] = '\0';
printf("%s", emp_name1.arr);
```

Or, you can use the length member to limit the printing of the string,

as in:

```
printf("%.*s", emp_name1.len, emp_name1.arr);
```

An advantage of VARCHAR variables over character arrays is that the length of the value returned by Oracle is available right away. With character arrays, you might

need to strip the trailing blanks yourself to get the actual length of the character string.

VARCHAR Pointers When you use a pointer to a VARCHAR as an output host variable, the program interface determines the variable's maximum length by checking the length member (*emp_name2->len* in our example). So, your program must set this member before *every* fetch. The fetch then sets the length member to the actual number of characters returned, as the following example shows:

```
emp_name2->len = 10;  /* Set maximum length of buffer. */
EXEC SQL SELECT ENAME INTO :emp_name2 WHERE EMPNO = 7934;
printf("%d characters returned to emp_name2", emp_name2->len);
```

Datatype Conversion

At precompile time, a default external datatype is assigned to each host variable. For example, the precompiler assigns the INTEGER external datatype to host variables of type *short* and *int*.

At run time, the datatype code of every host variable used in a SQL statement is passed to Oracle. Oracle uses the codes to convert between internal and external datatypes.

Before assigning a SELECTed column (or pseudocolumn) value to an output host variable, Oracle must convert the internal datatype of the source column to the datatype of the host variable. Likewise, before assigning or comparing the value of an input host variable to a column, Oracle must convert the external datatype of the host variable to the internal datatype of the target column.

Conversions between internal and external datatypes follow the usual data conversion rules. For example, you can convert a CHAR value of "1234" to a C *short* value. You cannot convert a CHAR value of "65543" (number too large) or "10F" (number not decimal) to a C *short* value. Likewise, you cannot convert a *char[n]* value that contains any alphabetic characters to a NUMBER value.

Datatype Equivalencing

Datatype equivalencing lets you control the way Oracle interprets input data, and the way Oracle formats output data. It allows you to override the default external datatypes that the precompiler assigns. On a variable-by-variable basis, you can equivalence supported C host variable datatypes to Oracle external datatypes. You can also equivalence user-defined datatypes to Oracle external datatypes.

Host Variable Equivalencing

By default, the Pro*C/C++ Precompiler assigns a specific external datatype to every host variable. Table 3–7 shows the default assignments:

Table 3–7 Default Type Assignments

C Type, or Pseudotype	Oracle External Type	
char char[n] char*	VARCHAR2 CHARZ STRING CHARF	(DBMS=V6 default or CHAR_MAP=VARCHAR2) (DBMS=V7, V8 default) (CHAR_MAP=STRING) (CHAR_MAP=CHARF)
int, int*	INTEGER	
short, short*	INTEGER	
long, long*	INTEGER	
float, float*	FLOAT	
double, double*	FLOAT	
VARCHAR*, VARCHAR[n]	VARCHAR	

With the VAR statement, you can override the default assignments by equivalencing host variables to Oracle external datatypes. The syntax you use is

```
EXEC SQL VAR host_variable IS type_name [ (length) ];
```

where *host_variable* is an input or output host variable (or host array) declared earlier, *type_name* is the name of a valid external datatype, and *length* is an integer literal specifying a valid length in bytes.

Host variable equivalencing is useful in several ways. For example, suppose you want to SELECT employee names from the EMP table, then pass them to a routine that expects null-terminated strings. You need not explicitly null-terminate the names. Simply equivalence a host variable to the STRING external datatype, as follows:

```
...
char  emp_name[11];
```

```
EXEC SQL VAR emp_name IS STRING(11);
```

The length of the ENAME column in the EMP table is 10 characters, so you allot the new *emp_name* 11 characters to accommodate the null terminator. When you SELECT a value from the ENAME column into *emp_name*, the program interface null-terminates the value for you.

You can use any of the datatypes listed in the external datatypes table on "Oracle External Datatypes" on page 3-19 except NUMBER (use VARNUM instead):

User-Defined Type Equivalencing

You can also equivalence user-defined datatypes to Oracle external datatypes. First, define a new datatype structured like the external datatype that suits your needs. Then, equivalence your new datatype to the external datatype using the TYPE statement.

With the TYPE statement, you can assign an Oracle external datatype to a whole class of host variables. The syntax you use is:

```
EXEC SQL TYPE user_type IS type_name [ (length) ] [REFERENCE];
```

Suppose you need a variable-length string datatype to hold graphics characters. First, declare a struct with a **short** length component followed by a 65533-byte data component. Second, use **typedef** to define a new datatype based on the struct. Then, equivalence your new user-defined datatype to the VARRAW external datatype, as shown in the following example:

```
struct  screen
{
    short  len;
    char   buff[4000];
};
typedef struct screen graphics;

EXEC SQL TYPE graphics IS VARRAW(4000);
graphics  crt;  — host variable of type graphics
     ...
```

You specify a length of 4000 bytes for the new *graphics* type because that is the maximum length of the data component in your struct. The precompiler allows for the *len* component (and any padding) when it sends the length to the Oracle server.

REFERENCE Clause

You can declare a user-defined type to be a pointer, either explicitly, as a pointer to a scalar or struct type, or implicitly, as an array, and use this type in an EXEC SQL TYPE statement. In this case, you must use the REFERENCE clause at the end of the statement, as shown in the following example:

```
typedef unsigned char *my_raw;

EXEC SQL TYPE my_raw IS VARRAW(4000) REFERENCE;
my_raw    graphics_buffer;
...
graphics_buffer = (my_raw) malloc(4004);
```

In this example, you allocated additional memory over and above the type length (4000). This is necessary because the precompiler also returns the length (the size of a *short*), and can add padding after the length due to word alignment restrictions on your system. If you do not know the alignment practices on your system, make sure to allocate sufficient extra bytes for the length and padding (9 should usually be sufficient).

CHARF External Datatype

Release 1.6 of the Pro*C/C++ Precompiler introduced a new external datatype named CHARF, which is a fixed-length character string. You can use this new datatype in VAR and TYPE statements to equivalence C datatypes to the fixed-length SQL standard datatype CHAR, regardless of the setting of the DBMS or CHAR_MAP option.

When DBMS=V7 or V8, specifying the external datatype CHARACTER in a VAR or TYPE statement equivalences the C datatype to the fixed-length datatype CHAR (datatype code 96). However, when DBMS=V6 or CHAR_MAP=VARCHAR2, the C datatype is equivalenced to the variable-length datatype VARCHAR2 (code 1).

Now, you can always equivalence C datatypes to the fixed-length SQL standard type CHARACTER by using the CHARF datatype in the VAR or TYPE statement. When you use CHARF, the equivalence is always made to the fixed-length character type, regardless of the setting of the DBMS or CHAR_MAP option.

Using the EXEC SQL VAR and TYPE Directives

You can code an EXEC SQL VAR ... or EXEC SQL TYPE ... statement anywhere in your program. These statements are treated as executable statements that change the datatype of any variable affected by them from the point that the TYPE or VAR statement was made to the end of the scope of the variable. If you precompile with

MODE=ANSI, you must use Declare Sections. In this case, the TYPE or VAR statement must be in a Declare Section.

Sample Program: Datatype Equivalencing

The demonstration program in this section shows you how you can use datatype equivalencing in your Pro*C/C++ programs. This program demonstrates the use of type equivalencing using the LONG RAW external datatype. In order to provide a useful example that is portable across different systems, the program inserts binary files into and retrieves them from the database. For example, suppose you have a file called 'hello' in the current directory. You can create this file by compiling the following source code:

```
#include <stdio.h>

int
main()
{
  printf("Hello World!\n");
}
```

```
When this program is run, we get:

$hello
Hello World!

Here is some sample output from a run of sample4:

$sample4
Connected.
Do you want to create (or recreate) the EXECUTABLES table (y/n)? y
EXECUTABLES table successfully dropped.  Now creating new table...
EXECUTABLES table created.

Sample 4 Menu.  Would you like to:
(I)nsert a new executable into the database
(R)etrieve an executable from the database
(L)ist the executables currently stored in the database
(Q)uit the program

Enter i, r, l, or q: l

Executables currently stored:
```

```
----------- --------- ------

Total: 0

Sample 4 Menu.  Would you like to:
(I)nsert a new executable into the database
(R)etrieve an executable from the database
(L)ist the executables currently stored in the database
(Q)uit the program

Enter i, r, l, or q: i
Enter the key under which you will insert this executable: hello
Enter the filename to insert under key 'hello'.
If the file is not in the current directory, enter the full
path: hello
Inserting file 'hello' under key 'hello'...
Inserted.

Sample 4 Menu.  Would you like to:
(I)nsert a new executable into the database
(R)etrieve an executable from the database
(L)ist the executables currently stored in the database
(Q)uit the program

Enter i, r, l, or q: l

Executables currently stored:
----------- --------- ------
hello

Total: 1

Sample 4 Menu.  Would you like to:
(I)nsert a new executable into the database
(R)etrieve an executable from the database
(L)ist the executables currently stored in the database
(Q)uit the program

Enter i, r, l, or q: r
Enter the key for the executable you wish to retrieve: hello
Enter the file to write the executable stored under key hello into.  If you
don't want the file to be in the current directory, enter the
full path: h1
Retrieving executable stored under key 'hello' to file 'h1'...
Retrieved.
```

```
Sample 4 Menu.  Would you like to:
(I)nsert a new executable into the database
(R)etrieve an executable from the database
(L)ist the executables currently stored in the database
(Q)uit the program

Enter i, r, l, or q: q

We now have the binary file 'h1' created, and we can run it:

$h1
Hello World!
```

This program is available on-line in the file *sample4.pc* in your *demo* directory.

```
/*************************************************************
sample4.pc
*************************************************************/

#include <stdio.h>
#include <sys/types.h>
#include <sys/file.h>
#include <fcntl.h>
#include <string.h>
#include <sqlca.h>

/* Oracle error code for 'table or view does not exist'. */
#define NON_EXISTENT -942

/* This is the maximum size (in bytes) of a file that
 * can be inserted and retrieved.
 * If your system cannot allocate this much contiguous
 * memory, this value might have to be lowered.
 */
#define MAX_FILE_SIZE 500000


/* This is the definition of the long varraw structure.
 * Note that the first field, len, is a long instead
 * of a short.  This is because the first 4
 * bytes contain the length, not the first 2 bytes.
 */
typedef struct
{
```

```
    long len;
    char buf[MAX_FILE_SIZE];
} long_varraw;


/* Type Equivalence long_varraw to long varraw.
 * All variables of type long_varraw from this point
 * on in the file will have external type 95 (long varraw)
 * associated with them.
 */
EXEC SQL type long_varraw is long varraw (MAX_FILE_SIZE);


/* This program's functions declared. */
void do_connect();
void create_table();
void sql_error();
void list_executables();
void print_menu();



main()
{
  char reply[20], key[20], filename[100];
  int ok = 1;

/* Connect to the database. */
  do_connect();

  printf("Do you want to create (or recreate) the EXECUTABLES table (y/n)? ");
  gets(reply);

  if ((reply[0] == 'y') || (reply[0] == 'Y'))
    create_table();

/* Print the menu, and read in the user's selection. */
  print_menu();
  gets(reply);

  while (ok)
  {
    switch(reply[0]) {
    case 'I': case 'i':
/* User selected insert - get the key and file name. */
```

```
      printf("
    Enter the key under which you will insert this executable: ");
      gets(key);
      printf(
        "Enter the filename to insert under key '%s'.\n", key);
      printf(
 "If the file is not in the current directory, enter the full\n");
      printf("path: ");
      gets(filename);
      insert(key, filename);
      break;
    case 'R': case 'r':
/* User selected retrieve - get the key and file name. */
      printf(
       "Enter the key for the executable you wish to retrieve: ");
      gets(key);
      printf(
      "Enter the file to write the executable stored under key ");
      printf("%s into.  If you\n", key);
      printf(
     "don't want the file to be in the current directory, enter the\n");
      printf("full path: ");
      gets(filename);
      retrieve(key, filename);
      break;
    case 'L': case 'l':
/* User selected list - just call the list routine. */
      list_executables();
      break;
    case 'Q': case 'q':
/* User selected quit - just end the loop. */
      ok = 0;
      break;
    default:
/* Invalid selection. */
      printf("Invalid selection.\n");
      break;
    }

    if (ok)
    {
/* Print the menu again. */
      print_menu();
      gets(reply);
    }
```

```
  }

  EXEC SQL commit work release;
}


/* Connect to the database. */
void
do_connect()
{

/* Note this declaration: uid is a char *
 * pointer, so Oracle will do a strlen() on it
 * at runtime to determine the length.
 */
  char *uid = "scott/tiger";

  EXEC SQL whenever sqlerror do sql_error("Connect");
  EXEC SQL connect :uid;

  printf("Connected.\n");
}


/* Creates the executables table. */
void
create_table()
{
/* We are going to check for errors ourselves
 * for this statement. */
  EXEC SQL whenever sqlerror continue;

  EXEC SQL drop table executables;
  if (sqlca.sqlcode == 0)
  {
    printf("EXECUTABLES table successfully dropped.  ");
    printf("Now creating new table...\n");
  }
  else if (sqlca.sqlcode == NON_EXISTENT)
  {
    printf("EXECUTABLES table does not exist.  ");
    printf("Now creating new table...\n");
  }
  else
    sql_error("create_table");
```

```
/* Reset error handler. */
  EXEC SQL whenever sqlerror do sql_error("create_table");

  EXEC SQL create table executables
    (name varchar2(20),
     binary long raw);

  printf("EXECUTABLES table created.\n");
}



/* Opens the binary file identified by 'filename' for
 * reading, and copies it into 'buf'.
 * 'bufsize' should contain the maximum size of
 * 'buf'.  Returns the actual length of the file read in,
 * or -1 if there is an error.
 */
int
read_file(filename, buf, bufsize)
char *filename, *buf;
long bufsize;
{

/* We will read in the file LOCAL_BUFFERSIZE bytes at a time. */
#define LOCAL_BUFFERSIZE 512

/* Buffer to store each section of the file. */
  char local_buffer[LOCAL_BUFFERSIZE];

/* Number of bytes read each time. */
  int number_read;

/* Total number of bytes read (the size of the file). */
  int total_size = 0;

/* File descriptor for the input file. */
  int in_fd;

/* Open the file for reading. */
  in_fd = open(filename, O_RDONLY, 0);
  if (in_fd == -1)
    return(-1);
```

```
/* While loop to actually read in the file,
 * LOCAL_BUFFERSIZE bytes at a time.
 */
  while ((number_read = read(in_fd, local_buffer,
          LOCAL_BUFFERSIZE)) > 0)
  {
    if (total_size + number_read > bufsize)
    {
/* The number of bytes we have read in so far exceeds the buffer
 * size - close the file and return an error. */
      close(in_fd);
      return(-1);
    }

/* Copy the bytes just read in from the local buffer
   into the output buffer. */
    memcpy(buf+total_size, local_buffer, number_read);

/* Increment the total number of bytes read by the number
   we just read. */
    total_size += number_read;
  }

/* Close the file, and return the total file size. */
  close(in_fd);
  return(total_size);
}


/* Generic error handler.  The 'routine' parameter
 * should contain the name of the routine executing when
 * the error occurred.  This is be specified in the
 * 'EXEC SQL whenever sqlerror do sql_error()' statement.
 */
void
sql_error(routine)
char *routine;
{
  char message_buffer[512];
  int buffer_size;
  int message_length;

/* Turn off the call to sql_error() to avoid
 * a possible infinite loop.
 */
```

```
  EXEC SQL WHENEVER SQLERROR CONTINUE;

  printf("\nOracle error while executing %s!\n", routine);

/* Use sqlglm() to get the full text of the error message. */
  buffer_size = sizeof(message_buffer);
  sqlglm(message_buffer, &buffer_size, &message_length);
  printf("%.*s\n", message_length, message_buffer);

  EXEC SQL ROLLBACK WORK RELEASE;
  exit(1);
}


/* Opens the binary file identified by 'filename' for
 * writing, and copies the contents of 'buf' into it.
 * 'bufsize' should contain the size of 'buf'.
 * Returns the number of bytes written (should be == bufsize),
 * or -1 if there is an error.
 */
int
write_file(filename, buf, bufsize)
char *filename, *buf;
long bufsize;
{
  int out_fd;        /* File descriptor for the output file. */
  int num_written;   /* Number of bytes written. */

/* Open the file for writing.  This command replaces
 * any existing version. */
  out_fd = creat(filename, 0755);
  if (out_fd == -1) {
/* Can't create the output file - return an error. */
    return(-1);
  }

/* Write the contents of buf to the file. */
  num_written = write(out_fd, buf, bufsize);

/* Close the file, and return the number of bytes written. */
  close(out_fd);
  return(num_written);
}
```

```
/* Inserts the binary file identified by file into the
 * executables table identified by key.
 */
int
insert(key, file)
char *key, *file;
{
  long_varraw lvr;

  printf("Inserting file '%s' under key '%s'...\n", file, key);
  lvr.len = read_file(file, lvr.buf, MAX_FILE_SIZE);
  if (lvr.len == -1)
  {
/* File size is too big for the buffer we have -
 * exit with an error.
 */
    fprintf(stderr,
       "\n\nError while reading file '%s':\n", file);
    fprintf(stderr,
      "The file you selected to read is
        too large for the buffer.\n");
    fprintf(stderr,
       "Increase the MAX_FILE_SIZE macro in the source code,\n");
    fprintf(stderr,
       "reprecompile, compile, and link, and try again.\n");
    fprintf(stderr,
       "The current value of MAX_FILE_SIZE is %d bytes.\n",
            MAX_FILE_SIZE);

    EXEC SQL rollback work release;

    exit(1);
  }

  EXEC SQL whenever sqlerror do sql_error("insert");
  EXEC SQL insert into executables (name, binary)
    values (:key, :lvr);

  EXEC SQL commit;
  printf("Inserted.\n");
}


/* Retrieves the executable identified by key into file */
```

```
int
retrieve(key, file)
char *key, *file;
{

/* Type equivalence key to the string external datatype.*/
  EXEC SQL VAR key is string(21);

  long_varraw lvr;
  short ind;
  int num_written;

  printf("Retrieving executable stored under key '%s' to file '%s'...\n",
          key, file);

  EXEC SQL whenever sqlerror do sql_error("retrieve");
  EXEC SQL select binary
    into :lvr :ind
    from executables
    where name = :key;

  num_written = write_file(file, lvr.buf, lvr.len);
  if (num_written != lvr.len) {
/* Error while writing - exit with an error. */
    fprintf(stderr,
       "\n\nError while writing file '%s':\n", file);
    fprintf(stderr,
       "Can't create the output file.  Check to be sure that you\n");
    fprintf(stderr,
       "have write permissions in the directory into which you\n");
    fprintf(stderr,
       "are writing the file, and that there is enough disk space.\n");

    EXEC SQL rollback work release;

    exit(1);
  }

  printf("Retrieved.\n");
}

void
list_executables()
{
  char key[21];
```

```
/* Type equivalence key to the string external
 * datatype, so we don't have to null-terminate it.
 */
  EXEC SQL VAR key is string(21);

  EXEC SQL whenever sqlerror do sql_error("list_executables");

  EXEC SQL declare key_cursor cursor for
    select name from executables;

  EXEC SQL open key_cursor;

  printf("\nExecutables currently stored:\n");
  printf("----------- --------- ------\n");

  while (1)
  {
    EXEC SQL whenever not found do break;
    EXEC SQL fetch key_cursor into :key;

    printf("%s\n", key);
  }

  EXEC SQL whenever not found continue;

  EXEC SQL close key_cursor;

  printf("\nTotal: %d\n", sqlca.sqlerrd[2]);
}

/* Prints the menu selections. */
void
print_menu()
{
  printf("\nSample 4 Menu.  Would you like to:\n");
  printf("(I)nsert a new executable into the database\n");
  printf("(R)etrieve an executable from the database\n");
  printf("(L)ist the executables currently stored in the database\n");
  printf("(Q)uit the program\n\n");
  printf("Enter i, r, l, or q: ");
}
```

4

Advanced Pro*C/C++ Applications

This chapter presents advanced techniques in Pro*C/C++. Topics are:

- National Language Support
- NCHAR Variables
- Handling LOB Types
- Cursor Variables
- Connecting to Oracle8
- Concurrent Connections
- Changing Passwords at Runtime
- Embedding (OCI Release 7) Calls
- Developing Multi-threaded Applications
- SQLLIB Extensions for OCI Release 8 Interoperability
- Interfacing to OCI Release 8
- Developing X/Open Applications

National Language Support

Although the widely-used 7- or 8-bit ASCII and EBCDIC character sets are adequate to represent the Roman alphabet, some Asian languages, such as Japanese, contain thousands of characters. These languages can require at least 16 bits (two bytes) to represent each character. How does Oracle8 deal with such dissimilar languages?

Oracle8 provides National Language Support (NLS), which lets you process single-byte and multi-byte character data and convert between character sets. It also lets your applications run in different language environments. With NLS, number and date formats adapt automatically to the language conventions specified for a user session. Thus, NLS allows users around the world to interact with Oracle8 in their native languages.

You control the operation of language-dependent features by specifying various NLS parameters. Default values for these parameters can be set in the Oracle8 initialization file. Table 4–1 shows what each NLS parameter specifies.

Table 4–1 NLS Parameters

NLS Parameter	Specifies ...
NLS_LANGUAGE	language-dependent conventions
NLS_TERRITORY	territory-dependent conventions
NLS_DATE_FORMAT	date format
NLS_DATE_LANGUAGE	language for day and month names
NLS_NUMERIC_CHARACTERS	decimal character and group separator
NLS_CURRENCY	local currency symbol
NLS_ISO_CURRENCY	ISO currency symbol
NLS_SORT	sort sequence

The main parameters are NLS_LANGUAGE and NLS_TERRITORY. NLS_LANGUAGE specifies the default values for language-dependent features, which include

- language for Server messages
- language for day and month names

- sort sequence

NLS_TERRITORY specifies the default values for territory-dependent features, which include

- date format
- decimal character
- group separator
- local currency symbol
- ISO currency symbol

You can control the operation of language-dependent NLS features for a user session by specifying the parameter NLS_LANG as follows:

```
NLS_LANG = <language>_<territory>.<character set>
```

where *language* specifies the value of NLS_LANGUAGE for the user session, *territory* specifies the value of NLS_TERRITORY, and *character set* specifies the encoding scheme used for the terminal. An *encoding scheme* (usually called a character set or code page) is a range of numeric codes that corresponds to the set of characters a terminal can display. It also includes codes that control communication with the terminal.

You define NLS_LANG as an environment variable (or the equivalent on your system). For example, on UNIX using the C shell, you might define NLS_LANG as follows:

```
setenv NLS_LANG French_France.WE8ISO8859P1
```

During an Oracle8 database session you can change the values of NLS parameters. Use the ALTER SESSION statement as follows:

```
ALTER SESSION SET <nls_parameter> = <value>
```

The Pro*C/C++ Precompiler fully supports all the NLS features that allow your applications to process foreign-language data stored in an Oracle8 database. For example, you can declare foreign-language character variables and pass them to string functions such as INSTRB, LENGTHB, and SUBSTRB. These functions have the same syntax as the INSTR, LENGTH, and SUBSTR functions, respectively, but operate on a per-byte basis rather than a per-character basis.

You can use the functions NLS_INITCAP, NLS_LOWER, and NLS_UPPER to handle special instances of case conversion. And, you can use the function NLSSORT to specify WHERE-clause comparisons based on linguistic rather than

binary ordering. You can even pass NLS parameters to the TO_CHAR, TO_DATE, and TO_NUMBER functions. For more information about NLS, see *Oracle8 Application Developer's Guide.*

NCHAR Variables

Two internal database datatypes are for multi-byte character data. They are *NCHAR* and NVARCHAR2 (also known as *NCHAR VARYING).* You use these datatypes only in relational columns. Pro*C/C++ supported multi-byte NCHAR host variables in earlier releases, with slightly different semantics.

When you set the command-line option *NLS_LOCAL* to YES, multi-byte support with earlier semantics will be provided by SQLLIB (the letter "N" is stripped from the quoted string), as in Oracle7. SQLLIB provides blank padding and stripping, sets indicator variables, etc.

If you set NLS_LOCAL to NO (the default), Oracle8 supports multi-byte strings with the new semantics (the letter "N" will be concatenated in front of the quoted string). The database, rather than SQLLIB provides blank padding and stripping, and setting of indicator variables. Use NLS_LOCAL=NO for all new applications.

CHARACTER SET [IS] NCHAR_CS

You specify which host variables hold National Character Set data. You insert the clause "*CHARACTER SET [IS] NCHAR_CS"* in character variable declarations. Then you are able to store National Character Set data in those variables. You can omit the token *IS*. NCHAR_CS is the name of the National Character Set.

For example:

```
char character set is nchar_cs *str = "<Japanese_string>";
```

*I*n this example, <*Japanese_string*> consists of double-byte characters which are in the National Character Set *JA16EUCFIXED*, as defined by the variable NLS_NCHAR.

You can accomplish the same thing by entering NLS_CHAR=str on the command line, and coding in your application:

```
char *str = "<Japanese_string>"
```

Pro*C/C++ treats variables declared this way as of the character set specified by the environment variable *NLS_NCHAR*. The variable size of an NCHAR variable is specified as a byte count, the same way that ordinary C variables are.

To select data into str, use the following simple query:

```
EXEC SQL
SELECT ENAME INTO :str FROM EMP WHERE DEPT = n'<Japanese_string1>';
```

Or, you can use *str* in the following SELECT:

```
EXEC SQL SELECT DEPT INTO :dept FROM DEPT_TAB WHERE ENAME = :str;
```

Environment Variable NLS_NCHAR

You set the environment variable NLS_NCHAR to specify a client-side (database) National character Set. When NLS_LOCAL=NO, the database supports NCHAR, if you have set a valid National Character Set with the precompiler option NLS_NCHAR.

NLS_NCHAR must have a valid character set specification (not a language name, that is set by NLS_LANG) at both precompile-time and runtime. SQLLIB performs a runtime check when the first SQL statement is executed. If the precompile-time and runtime character sets are different, SQLLIB will return an error code.

CONVBUFSZ Clause in VAR

You can override the default assignments by equivalencing host variables to Oracle8 external datatypes, using the EXEC SQL VAR statement. This is called *host variable equivalencing*.

The EXEC SQL VAR statement can have an optional clause: *CONVBUFSZ* (<size>). You specify the size, <size>, in bytes, of the buffer in the Oracle8 runtime library used to perform conversion of the specified host variable between character sets.

The new syntax is:

```
EXEC SQL VAR <id> is <datatype> [CONVBUFSZ [IS] (<size>)] ;
```

or

```
EXEC SQL VAR <id> [cONVBUFSZ [IS] (<size>)];
```

where <datatype> is:

```
<SQL datatype> [ ( {<length> | <precision>, <scale> } ) ]
```

where:

host_variable	is an input or output host variable (or host table) declared earlier. The VARCHAR and VARRAW external datatypes have a 2-byte length field followed by an *n*-byte data field, where *n* lies in the range 1 .. 65533. So, if *type_name* is VARCHAR or VARRAW, *host_variable* must be at least 3 bytes long. The LONG VARCHAR and LONG VARRAW external datatypes have a 4-byte length field followed by an *n*-byte data field, where *n* lies in the range 1 .. 2147483643. So, if *type_name* is LONG VARCHAR or LONG VARRAW, *host_variable* must be at least 5 bytes long.
ext_type_name	is the name of a valid external datatype such as RAW or STRING.
length	is a constant expression or a constant integer specifying a valid length in bytes. The value of length must be large enough to accommodate the external datatype. When *type_name* is VARNUM, ROWID, or DATE, you cannot specify *length* because it is predefined. For other external datatypes, *length* is optional. It defaults to the length of *host_variable*. When specifying *length*, if *type_name* is VARCHAR, VARRAW, LONG VARCHAR, or LONG VARRAW, use the maximum length of the data field. Pro*C/C++ accounts for the length field. If *type_name* is LONG VARCHAR or LONG VARRAW and the data field exceeds 65533 bytes, put "-1" in the *length* field.
precision and scale	are constant expressions or constants that represent, respectively, the number of significant digits and the point at which rounding will occur. For example, a scale of 2 means the value is rounded to the nearest hundredth (3.456 becomes 3.46); a scale of -3 means the number is rounded to the nearest thousand (3456 becomes 3000). You can specify a *precision* of 1 .. 99 and a *scale* of -84 .. 99. However, the maximum precision and scale of a database column are 38 and 127, respectively. So, if *precision* exceeds 38, you cannot insert the value of *host_variable* into a database column. On the other hand, if the scale of a column value exceeds 99, you cannot select or fetch the value into *host_variable*.

size	the size, in bytes, of a buffer used to perform conversion of the specified host_variable to another character set. A constant or constant expression.

There must be at least one of the two clauses, or both. The EXEC SQL VAR statement cannot be used with NCHAR variables.

Note that <size>, <length>, <precision> and <scale> can be any arbitrarily complex C constant expression whose value is known when the precompiler is run.

For example:

```
#define LENGTH 10
...
char ename[LENGTH+1];
exec sql var ename is string(LENGTH+1) convbufsz is (LENGTH*2);
```

Note also that macros are permitted in this statement.

When you have not used the CONVBUFSZ clause, the Oracle8 runtime automatically determines a buffer size based on the ratio of the host variable character size (determined by NLS_LANG) and the character size of the database character set. This can sometimes result in the creation of a buffer of LONG size. Database tables are allowed to have only one LONG column. An error is raised if there is more than one LONG value.

To avoid such errors, you use a length shorter than the size of a LONG. If a character set conversion results in a value longer than the length specified by CONVBUFSZ, then an error is returned at runtime. For a syntax diagram of this statement, see "VAR (Oracle Embedded SQL Directive)" on page -75.

Character Strings in Embedded SQL

A multi-byte character string in an embedded SQL statement consists of a character literal that identifies the string as multi-byte, immediately followed by the string. The string is enclosed in the usual single quotes.

For example, an embedded SQL statement such as

```
EXEC SQL SELECT empno INTO :emp_num FROM emp
    WHERE ename=N'<Japanese_string>';
```

contains a multi-byte character string (<Japanese_string> could actually be Kanji), since the N character literal preceding the string identifies it as a multi-byte string. Since Oracle8 is case-insensitive, you can use "n" or "N" in the example.

Strings Restrictions

You cannot use datatype equivalencing (the TYPE or VAR commands) with NLS multi-byte character strings.

Dynamic SQL method 4 is not available for NLS multi-byte character string host variables in Pro*C/C++.

Indicator Variables

You can use indicator variables with host character variables that are NLS multi-byte (as specified using the NLS_CHAR option).

Handling LOB Types

LOB types can appear as table columns and also as object type attributes. These are the LOB datatypes: binary LOB (BLOB), character LOB (CLOB), National Character LOB (NCLOB) and binary external file LOB (BFILE).

Declaring LOBs

A Pro*C/C++ host variable that corresponds to a LOB attribute in a table must be declared as *OCIBlobLocator**, *OCIClobLocator**, or *OCIBfileLocator** depending on its LOB type. These special LOB locator types are defined in the OCI header file *oci.h*. In case a LOB column appears as an object type attribute, OTT (Object Type Translator) will translate the attribute to a LOB descriptor pointer of the appropriate type.

An indicator variable for the LOB descriptors is a signed 2-byte scalar quantity, declared as *OCIInd*.

Using LOBs in Embedded SQL

Host variables for LOB locators are structures that are dynamically allocated and freed. The memory management scheme differs somewhat based on whether the LOB locator is for a relational column or for an embedded object type attribute, the important difference being that memory for an embedded LOB locator comes from the object cache during allocation of the object itself, whereas other LOB locators do not reside in the object cache.

Locators for LOB Columns in Tables

When it is used as a host variable for a column, you must explicitly allocate memory for a LOB locator using the EXEC SQL ALLOCATE command before

using it in any embedded SQL or PL/SQL statement. At the end of its use, you free a previously-allocated locator with the EXEC SQL FREE command. The allocated space is also freed automatically by SQLLIB when all the database connections in Pro*C/C++ are closed.

At runtime, the ALLOCATE statement will allocate a LOB descriptor of the appropriate type based on the type of the host variable. Upon a successful allocation, the value of the LOB host variable will be set to point to the allocated memory.

Once a LOB locator has been allocated, the host variable may be used in SQL statements and in embedded PL/SQL blocks. See *PL/SQL User's Guide and Reference*

LOB Operations in OCI and in Embedded PL/SQL

LOB data can be manipulated through the LOB locator host variables using OCI functions such as *OCILobRead()*, *OCILobWrite()*, *OCILobOpenFile()* etc., to read, write, and otherwise manipulate LOB data.

An alternative way to operate on LOB data is to use PL/SQL stored procedures defined in the package 'dbms_lob'. This will be illustrated by a sample program.

Sample Program for LOB Datatypes

The following program illustrates the use of LOB variables. The EXEC SQL TYPE command is used to equivalence a blob variable with a LONG RAW datatype 8192 bytes in length.

A stream of binary data, (from a blob variable) is stored in a database BLOB column using a PL/SQL procedure, *Store_Obj*, which has procedure DBMS_LOB.WRITE embedded in it. Then the data is retrieved using a PL/SQL procedure, *Get_Obj*, which has procedure DBMS_LOB.READ embedded in it. The buffers holding the output data and the input data are then compared for equality.

```
#include <stdio.h>
#include <string.h>
#include <sqlca.h>

#define LENGTH 8192

typedef char blob[LENGTH];
EXEC SQL TYPE blob IS LONG RAW(LENGTH);

void sqlerror()
```

```
{
  EXEC SQL WHENEVER SQLERROR CONTINUE;
  printf("%.*s\n", sqlca.sqlerrm.sqlerrml, sqlca.sqlerrm.sqlerrmc);
  EXEC SQL ROLLBACK WORK RELEASE;
  exit(1);
}

void main()
{
  EXEC SQL BEGIN DECLARE SECTION;
    char           *usr = "scott/tiger";
    int             size1;
    int             size2;
    blob            b1;
    blob            b2;
  EXEC SQL END DECLARE SECTION;

  EXEC SQL WHENEVER SQLERROR DO sqlerror();

  EXEC SQL CONNECT :usr;

  printf("Initialize BLOB buffers\n");
  memset(b1, 65, LENGTH);  b1[LENGTH-1]=0;
  memset(b2, 95, LENGTH);  b2[LENGTH-1]=0;

  size1 = LENGTH;
  size2 = LENGTH;

  printf("Writing BLOB from buffer #1\n");
  EXEC SQL EXECUTE
    BEGIN
      Store_Obj(:b1, :size1);
    END;
  END-EXEC;

  EXEC SQL COMMIT;

  printf("Reading BLOB into buffer #2\n");
  EXEC SQL EXECUTE
    BEGIN
      Get_Obj(:b2, :size2);
    END;
  END-EXEC;

  printf("Write and Read Succeeded\n");
```

```
  if (!strcmp((const char *)b1, (const char *)b2))
    printf("BLOB buffers are Equal\n");
  else
    {
      int i;
      for (i = 0; i < LENGTH; i++)
        if (b1[i] != b2[i]) break;
      printf("BLOB buffers differ at index %d\n", i);
    }

  EXEC SQL ROLLBACK WORK RELEASE;
  exit(0);
}
```

For more information on LOBs, see *Oracle8 Server Application Developer's Guide*. For more information on embedding PL/SQL, see "Using Embedded PL/SQL" in this guide. For more information on the EXEC SQL TYPE command, see "User-Defined Type Equivalencing"on page 3 - 60.

Cursor Variables

You can use *cursor variables* in your Pro*C/C++ program for queries. A cursor variable is a handle for a cursor that must be defined and opened on the Oracle (release 7.2 or later) server, using PL/SQL. See the *PL/SQL User's Guide and Reference* for complete information about cursor variables.

The advantages of cursor variables are:

- *Ease of maintenance*: queries are centralized, in the stored procedure that opens the cursor variable. If you need to change the cursor, you only need to make the change in one place: the stored procedure. There is no need to change each application.
- *Convenient security*: the user of the application is the username used when the Pro*C/C++ application connects to the server. The user must have *execute* permission on the stored procedure that opens the cursor but not *read* permission on the tables used in the query. This capability can be used to limit access to the columns in the table, and access to other stored procedures.

Declaring a Cursor Variable

You declare a cursor variable in your Pro*C/C++ program using the Pro*C/C++ pseudotype SQL_CURSOR. For example:

```
EXEC SQL BEGIN DECLARE SECTION;
    sql_cursor     emp_cursor;             /* a cursor variable */
    SQL_CURSOR     dept_cursor;      /* another cursor variable */
    sql_cursor     *ecp;      /* a pointer to a cursor variable */
    ...
EXEC SQL END DECLARE SECTION;
ecp = &emp_cursor;             /* assign a value to the pointer */
```

You can declare a cursor variable using the type specification SQL_CURSOR, in all upper case, or sql_cursor, in all lower case; you cannot use mixed case.

A cursor variable is just like any other host variable in the Pro*C/C++ program. It has scope, following the scope rules of C. You can pass it as a parameter to other functions, even functions external to the source file in which you declared it. You can also define functions that return cursor variables, or pointers to cursor variables.

> **Caution:** A SQL_CURSOR is implemented as a C **struct** in the code that Pro*C/C++ generates. So you can always pass it by pointer to another function, or return a pointer to a cursor variable from a function. But you can only pass it or return it by value if your C compiler supports these operations.

Allocating a Cursor Variable

Before you can use a cursor variable, either to open it or to FETCH it, you must allocate the cursor. You do this using the new precompiler command ALLOCATE. For example, to allocate the SQL_CURSOR *emp_cursor* that was declared in the example above, you write the statement:

```
EXEC SQL ALLOCATE :emp_cursor;
```

Allocating a cursor does *not* require a call to the server, either at precompile time or at runtime. If the ALLOCATE statement contains an error (for example, an undeclared host variable), Pro*C/C++ issues a precompile time (PCC) error. Allocating a cursor variable *does* cause heap memory to be used. For this reason, you should normally avoid allocating a cursor variable in a program loop. Memory allocated for cursor variables is *not* freed when the cursor is closed, but only when the connection is closed.

Opening a Cursor Variable

You must open a cursor variable on the Oracle8 Server. You cannot use the embedded SQL OPEN command to open a cursor variable. You can open a cursor variable either by calling a PL/SQL stored procedure that opens the cursor (and

defines it in the same statement). Or, you can open and define a cursor variable using an anonymous PL/SQL block in your Pro*C/C++ program.

For example, consider the following PL/SQL package, stored in

the database:

```
CREATE PACKAGE demo_cur_pkg AS
    TYPE EmpName IS RECORD (name VARCHAR2(10));
    TYPE cur_type IS REF CURSOR RETURN EmpName;
    PROCEDURE open_emp_cur (
                curs     IN OUT cur_type,
                dept_num IN     NUMBER);
END;

CREATE PACKAGE BODY demo_cur_pkg AS
    CREATE PROCEDURE open_emp_cur (
                curs     IN OUT cur_type,
                dept_num IN     NUMBER) IS
    BEGIN
        OPEN curs FOR
            SELECT ename FROM emp
                WHERE deptno = dept_num
                ORDER BY ename ASC;
    END;
END;
```

After this package has been stored, you can open the cursor *curs* by calling the *open_emp_cur* stored procedure from your Pro*C/C++ program, and FETCH from the cursor in the program. For example:

```
...
sql_cursor    emp_cursor;
char          emp_name[11];
...
EXEC SQL ALLOCATE :emp_cursor;  /* allocate the cursor variable */
...
/* Open the cursor on the server side. */
EXEC SQL EXECUTE
    begin
        demo_cur_pkg.open_emp_cur(:emp_cursor, :dept_num);
    end;
;
EXEC SQL WHENEVER NOT FOUND DO break;
for (;;)
{
```

```
    EXEC SQL FETCH :emp_cursor INTO :emp_name;
    printf("%s\n", emp_name);
}
...
```

To open a cursor using a PL/SQL anonymous block in your Pro*C/C++ program, you define the cursor in the anonymous block. For example:

```
int dept_num = 10;
...
EXEC SQL EXECUTE
    BEGIN
        OPEN :emp_cursor FOR SELECT ename FROM emp
             WHERE deptno = :dept_num;
    END;
END-EXEC;
...
```

The above examples show how to use PL/SQL to open a cursor variable. You can also open a cursor variable using embedded SQL with the CURSOR clause:

```
...
sql_cursor emp_cursor;
...
EXEC ORACLE OPTION(select_error=no);
EXEC SQL
    SELECT CURSOR(SELECT ename FROM emp WHERE deptno = :dept_num)
    INTO :emp_cursor FROM DUAL;
EXEC ORACLE OPTION(select_error=yes);
```

In the above statement, the emp_cursor cursor variable is bound to the first column of the outermost select. The first column is itself a query, but it is represented in the form compatible with a sql_cursor host variable since the CURSOR(...) conversion clause is used.

Before using queries which involve the CURSOR clause, you must set the select_error option to NO. This will prevent the cancellation of the parent cursor and allow the program to run without errors.

Opening in a Stand-Alone Stored Procedure

In the example above, a reference cursor was defined inside a package, and the cursor was opened in a procedure in that package. But it is not always necessary to define a reference cursor inside the package that contains the procedures that open the cursor.

If you need to open a cursor inside a stand-alone stored procedure, you can define the cursor in a separate package, and then reference that package in the stand-alone stored procedure that opens the cursor. Here is an example:

```
PACKAGE dummy IS
    TYPE EmpName IS RECORD (name VARCHAR2(10));
    TYPE emp_cursor_type IS REF CURSOR RETURN EmpName;
END;
-- and then define a stand-alone procedure:
PROCEDURE open_emp_curs (
      emp_cursor IN OUT dummy.emp_cursor_type;
      dept_num   IN     NUMBER) IS
    BEGIN
        OPEN emp_cursor FOR
            SELECT ename FROM emp WHERE deptno = dept_num;
    END;
END;
```

Return Types

When you define a reference cursor in a PL/SQL stored procedure, you must declare the type that the cursor returns. See the *PL/SQL User's Guide and Reference* for complete information on the reference cursor type and its return types.

Closing a Cursor Variable

Use the CLOSE command to close a cursor variable. For example, to close the *emp_cursor* cursor variable that was OPENed in the examples above, use the embedded SQL statement:

```
EXEC SQL CLOSE :emp_cursor;
```

Note that the cursor variable is a host variable, and so you must precede it with a colon.

You can re-use ALLOCATEd cursor variables. You can open, FETCH, and CLOSE as many times as needed for your application. However, if you disconnect from the server, then reconnect, you must re-ALLOCATE cursor variables.

> **Note:** Cursors are automatically de-allocated by the SQLLIB runtime library upon exiting the current connection.

Using Cursor Variables with the OCI (Release 7 Only)

You can share a Pro*C/C++ cursor variable with an OCI function. To do so, you must use the SQLLIB conversion functions, *sqlcdat()* and *sqlcur()*. These functions convert between OCI cursor data areas and Pro*C/C++ cursor variables.

The *sqlcdat()* function translates an allocated cursor variable to an OCI cursor data area. The syntax is:

```
void sqlcdat(Cda_Def *cda, void *cur, int *retval);
```

where the parameters are:

cda	A pointer to the destination OCI cursor data area.
cur	A pointer to the source Pro*C/C++ cursor variable.
retval	0 if no error, otherwise a SQLLIB (SQL) error number.

> **Note:** In the case of an error, the *V2* and *rc* return code fields in the CDA also receive the error codes. The *rows processed count* field in the CDA is not set.

The *sqlcur()* function translates an OCI cursor data area to a Pro*C/C++ cursor variable. The syntax is:

```
void sqlcur(void *cur, Cda_Def *cda, int *retval);
```

where the parameters are:

cur	A pointer to the destination Pro*C/C++ cursor variable.
cda	A pointer to the source OCI cursor data area.
retval	0 if no error, otherwise an error code.

> **Note:** The SQLCA structure is not updated by this routine. The SQLCA components are only set after a database operation is performed using the translated cursor.

ANSI and K&R prototypes for these functions are provided in the *sql2oci.h* header file. Memory for both *cda* and *cur* must be allocated prior to calling these functions.

Restrictions

The following restrictions apply to the use of cursor variables:

- You cannot translate a cursor variable to an OCI release 8 equivalent.

- You cannot use cursor variables with dynamic SQL.
- You can only use cursor variables with the ALLOCATE, FETCH, FREE, and CLOSE commands
- The DECLARE CURSOR command does not apply to cursor variables.
- You cannot FETCH from a CLOSEd cursor variable.
- You cannot FETCH from a non-ALLOCATEd cursor variable.
- If you precompile with MODE=ANSI, it is an error to close a cursor variable that is already closed.
- You cannot use the AT clause with the ALLOCATE command, nor with the FETCH and CLOSE commands if they reference a cursor variable.
- Cursor variables cannot be stored in columns in the database.
- A cursor variable itself cannot be declared in a package specification. Only the *type* of the cursor variable can be declared in the package specification.
- A cursor variable cannot be a component of a PL/SQL record.

A Sample Program

The following sample programs—a PL/SQL script and a Pro*C/C++ program—demonstrate how you can use cursor variables. These sources are available on-line in your *demo* directory.

cv_demo.sql

```
-- PL/SQL source for a package that declares and
-- opens a ref cursor
CONNECT SCOTT/TIGER
CREATE OR REPLACE PACKAGE emp_demo_pkg as
   TYPE emp_cur_type IS REF CURSOR RETURN emp%ROWTYPE;
     PROCEDURE open_cur(curs IN OUT emp_cur_type, dno IN NUMBER);
END emp_demo_pkg;


CREATE OR REPLACE PACKAGE BODY emp_demo_pkg AS
    PROCEDURE open_cur(curs IN OUT emp_cur_type, dno IN NUMBER) IS
    BEGIN
        OPEN curs FOR SELECT *
            FROM emp WHERE deptno = dno
```

```
            ORDER BY ename ASC;
    END;
END emp_demo_pkg;
```

sample11.pc

```
/*
 *  Fetch from the EMP table, using a cursor variable.
 *  The cursor is opened in the stored PL/SQL procedure
 *  open_cur, in the EMP_DEMO_PKG package.
 *
 *  This package is available on-line in the file
 *  sample11.sql, in the demo directory.
 *
 */

#include <stdio.h>
#include <sqlca.h>

/* Error handling function. */
void sql_error();

main()
{
    char temp[32];

    EXEC SQL BEGIN DECLARE SECTION;
        char *uid = "scott/tiger";
        SQL_CURSOR emp_cursor;
        int dept_num;
        struct
        {
            int   emp_num;
            char  emp_name[11];
            char  job[10];
            int   manager;
            char  hire_date[10];
            float salary;
            float commission;
            int   dept_num;
        } emp_info;
        struct
        {
            short emp_num_ind;
```

```
            short emp_name_ind;
            short job_ind;
            short manager_ind;
            short hire_date_ind;
            short salary_ind;
            short commission_ind;
            short dept_num_ind;
        } emp_info_ind;
    EXEC SQL END DECLARE SECTION;

    EXEC SQL WHENEVER SQLERROR do sql_error("Oracle error");

/* Connect to Oracle. */
    EXEC SQL CONNECT :uid;

/* Allocate the cursor variable. */
    EXEC SQL ALLOCATE :emp_cursor;

/* Exit the inner for (;;) loop when NO DATA FOUND. */
    EXEC SQL WHENEVER NOT FOUND DO break;

    for (;;)
    {
        printf("\nEnter department number  (0 to exit): ");
        gets(temp);
        dept_num = atoi(temp);
        if (dept_num <= 0)
            break;

        EXEC SQL EXECUTE
            begin
                emp_demo_pkg.open_cur(:emp_cursor, :dept_num);
            end;
        END-EXEC;

        printf("\nFor department %d--\n", dept_num);
        printf("ENAME\t             SAL\t            COMM\n");
        printf("-----\t             ---\t            ----\n");


/* Fetch each row in the EMP table into the data struct.
   Note the use of a parallel indicator struct. */
        for (;;)
        {
             EXEC SQL FETCH :emp_cursor
```

```
                INTO :emp_info INDICATOR :emp_info_ind;

            printf("%s\t", emp_info.emp_name);
            printf("%8.2f\t\t", emp_info.salary);
            if (emp_info_ind.commission_ind != 0)
                printf("    NULL\n");
            else
                printf("%8.2f\n", emp_info.commission);
        }

    }


/* Close the cursor. */
    EXEC SQL CLOSE :emp_cursor;
    exit(0);
}


void
sql_error(msg)
char *msg;
{
    long clen, fc;
    char cbuf[128];

    clen = (long) sizeof (cbuf);
    sqlgls(cbuf, &clen, &fc);

    printf("\n%s\n", msg);
    printf("Statement is--\n%s\n", cbuf);
    printf("Function code is %ld\n\n", fc);

    sqlglm(cbuf, (int *) &clen, (int *) &clen);
    printf ("\n%.*s\n", clen, cbuf);

    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL ROLLBACK WORK;
    exit(-1);
}
```

Connecting to Oracle8

Your Pro*C/C++ program must connect to Oracle8 before querying or manipulating data. To log on, simply use the CONNECT statement

```
EXEC SQL CONNECT :username IDENTIFIED BY :password;
```

where *username* and *password* are **char** or VARCHAR host variables.

Or, you can use the statement

```
EXEC SQL CONNECT :usr_pwd;
```

where the host variable *usr_pwd* contains your username and password separated by a slash character (/).

The CONNECT statement must be the first SQL statement executed by the program. That is, other SQL statements can physically but not logically precede the CONNECT statement in the precompilation unit.

To supply the Oracle8 username and password separately, you define two host variables as character strings or VARCHARs. (If you supply a username containing both username and password, only one host variable is needed.)

Make sure to set the username and password variables before the CONNECT is executed, or it will fail. Your program can prompt for the values, or you can hard code them as follows:

```
char *username = "SCOTT";
char *password = "TIGER";
...
EXEC SQL WHENEVER SQLERROR ...
EXEC SQL CONNECT :username IDENTIFIED BY :password;
```

However, you cannot hard code a username and password into the CONNECT statement. Nor can you use quoted literals. For example, both of the following statements are *invalid*:

```
EXEC SQL CONNECT SCOTT IDENTIFIED BY TIGER;
EXEC SQL CONNECT 'SCOTT' IDENTIFIED BY 'TIGER';
```

Connecting Using Net8

To connect using a Net8 driver, substitute a service name, as defined in your *tnsnames.ora* configuration file or in Oracle Names.

If you are using Oracle Names, the name server obtains the service name from the network definition database.

Note: SQL*Net V1 does not work with Oracle8.

See *Oracle Net8 Administrator's Guide* for more information about Net8.

Automatic Connects

You can automatically connect to Oracle8 with the username

```
OPS$username
```

where *username* is the current operating system username, and OPS$*username* is a valid Oracle8 database username. (The actual value for OPS$ is defined in the INIT.ORA parameter file.) You simply pass to the Pro*C/C++ Precompiler a slash character, as follows:

```
...
char  *oracleid = "/";
...
EXEC SQL CONNECT :oracleid;
```

This automatically connects you as user OPS$*username*. For example, if your operating system username is RHILL, and OPS$RHILL is a valid Oracle8 username, connecting with '/' automatically logs you on to Oracle8 as user OPS$RHILL.

You can also pass a '/' in a string to the precompiler. However, the string cannot contain trailing blanks. For example, the following CONNECT statement will fail:

```
...
char oracleid[10] = "/    ";
...
EXEC SQL CONNECT :oracleid;
```

The AUTO_CONNECT Precompiler Option

If AUTO_CONNECT=YES, and the application is not already connected to a database when it processes the first executable SQL statement, it attempts to connect using the userid

```
OPS$<username>
```

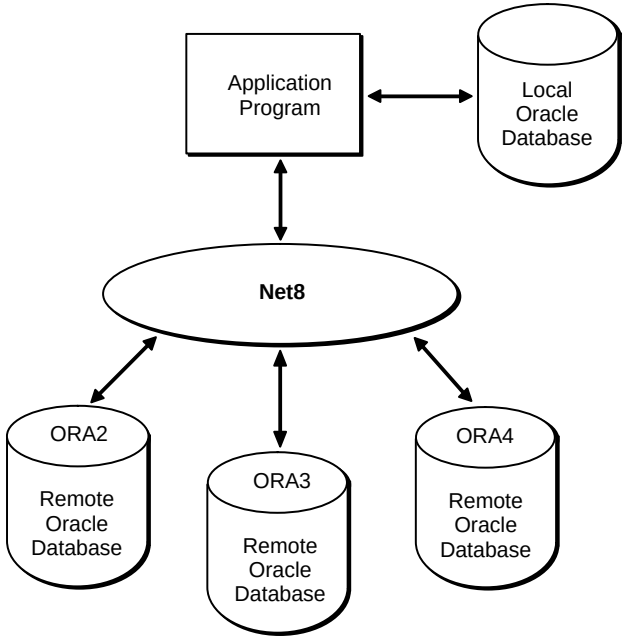
where *username* is your current operating system user or task name and OPS$username is a valid Oracle8 userid. The default value of AUTO_CONNECT is NO.

When AUTO_CONNECT=NO, you must use the CONNECT statement in your program to connect to Oracle.

Concurrent Connections

The Pro*C / C++ Precompiler supports distributed processing via Net8 Your application can concurrently access any combination of local and remote databases or make multiple connections to the same database. In Figure 4–1, an application program communicates with one local and three remote Oracle8 databases. ORA2, ORA3, and ORA4 are simply logical names used in CONNECT statements.

Figure 4–1 Connecting via Net8



By eliminating the boundaries in a network between different machines and operating systems, Net8 provides a distributed processing environment for Oracle8

tools. This section shows you how Pro*C/C++ supports distributed processing via Net8. You learn how your application can

- directly or indirectly access other databases
- concurrently access any combination of local and remote databases
- make multiple connections to the same database

For details on installing Net8 and identifying available databases, refer to the *Oracle Net8 Administrator's Guide* and your system-specific Oracle8 documentation.

Some Preliminaries

The communicating points in a network are called *nodes*. Net8 lets you transmit information (SQL statements, data, and status codes) over the network from one node to another.

A *protocol* is a set of rules for accessing a network. The rules establish such things as procedures for recovering after a failure and formats for transmitting data and checking errors.

The Net8 syntax for connecting to the default database in the local domain is simply to use the service name for the database.

If the service name is not in the default (local) domain, you must use a global specification (all domains specified). For example:

```
HR.US.ORACLE.COM
```

Default Databases and Connections

Each node has a *default* database. If you specify a database name, but no domain, in your CONNECT statement, you connect to the default database on the named local or remote node.

A *default* connection is made by a CONNECT statement that has no AT clause. The connection can be to any default or non-default database at any local or remote node. SQL statements without an AT clause are executed against the default connection. Conversely, a *non-default* connection is made by a CONNECT statement that has an AT clause. SQL statements with an AT clause are executed against the non-default connection.

All database names must be unique, but two or more database names can specify the same connection. That is, you can have multiple connections to any database on any node.

Explicit Connections

Usually, you establish a connection to Oracle8 as follows:

```
EXEC SQL CONNECT :username IDENTIFIED BY :password;
```

You can also use

```
EXEC SQL CONNECT :usr_pwd;
```

where *usr_pwd* contains *username*/*password*.

You can automatically connect to Oracle8 with the userid

```
OPS$username
```

where *username* is your current operating system user or task name and OPS$*username* is a valid Oracle8 userid. You simply pass to the precompiler a slash (/) character, as follows:

```
char oracleid = '/';
...
EXEC SQL CONNECT :oracleid;
```

This automatically connects you as user OPS$*username*.

If you do not specify a database and node, you are connected to the default database at the current node. If you want to connect to a different database, you must explicitly identify that database.

With *explicit connections*, you connect to another database directly, giving the connection a name that will be referenced in SQL statements. You can connect to several databases at the same time and to the same database multiple times.

Single Explicit Connections

In the following example, you connect to a single non-default database at a remote node:

```
/* declare needed host variables */
char  username[10]  = "scott";
char  password[10]  = "tiger";
char  db_string[20] = "NYNON";

/* give the database connection a unique name */
EXEC SQL DECLARE DB_NAME DATABASE;

/* connect to the non-default database  */
```

```
EXEC SQL CONNECT :username IDENTIFIED BY :password
   AT DB_NAME USING :db_string;
```

The identifiers in this example serve the following purposes:

- The host variables *username* and *password* identify a valid user.
- The host variable *db_string* contains the Net8 syntax for connecting to a non-default database at a remote node.
- The undeclared identifier DB_NAME names a non-default connection; it is an identifier used by Oracle, *not* a host or program variable.

The USING clause specifies the network, machine, and database to be associated with DB_NAME. Later, SQL statements using the AT clause (with DB_NAME) are executed at the database specified by *db_string*.

Alternatively, you can use a character host variable in the AT clause, as the following example shows:

```
/* declare needed host variables */
char  username[10]  = "scott";
char  password[10]  = "tiger";
char  db_name[10]   = "oracle1";
char  db_string[20] = "NYNON";

/* connect to the non-default database using db_name */
EXEC SQL CONNECT :username IDENTIFIED BY :password
   AT :db_name USING :db_string;
...
```

If *db_name* is a host variable, the DECLARE DATABASE statement is not needed. Only if DB_NAME is an undeclared identifier must you execute a DECLARE DB_NAME DATABASE statement before executing a CONNECT ... AT DB_NAME statement.

SQL Operations If granted the privilege, you can execute any SQL data manipulation statement at the non-default connection. For example, you might execute the following sequence of statements:

```
EXEC SQL AT DB_NAME SELECT ...
EXEC SQL AT DB_NAME INSERT ...
EXEC SQL AT DB_NAME UPDATE ...
```

In the next example, *db_name* is a host variable:

```
EXEC SQL AT :db_name DELETE ...
```

If *db_name* is a host variable, all database tables referenced by the SQL statement must be defined in DECLARE TABLE statements. Otherwise, the precompiler issues a warning.

For more information, see "Using DECLARE TABLE" on page D-5, and "DECLARE TABLE (Oracle Embedded SQL Directive)" on page F-27.

PL/SQL Blocks You can execute a PL/SQL block using the AT clause. The following example shows the syntax:

```
EXEC SQL AT :db_name EXECUTE
    begin
        /* PL/SQL block here */
    end;
END-EXEC;
```

Cursor Control

Cursor control statements such as OPEN, FETCH, and CLOSE are exceptions—they never use an AT clause. If you want to associate a cursor with an explicitly identified database, use the AT clause in the DECLARE CURSOR statement, as follows:

```
EXEC SQL AT :db_name DECLARE emp_cursor CURSOR FOR ...
EXEC SQL OPEN emp_cursor ...
EXEC SQL FETCH emp_cursor ...
EXEC SQL CLOSE emp_cursor;
```

If *db_name* is a host variable, its declaration must be within the scope of all SQL statements that refer to the DECLAREd cursor. For example, if you OPEN the cursor in one subprogram, then FETCH from it in another subprogram, you must declare *db_name* globally.

When OPENing, CLOSing, or FETCHing from the cursor, you do not use the AT clause. The SQL statements are executed at the database named in the AT clause of the DECLARE CURSOR statement or at the default database if no AT clause is used in the cursor declaration.

The AT :*host_variable* clause allows you to change the connection associated with a cursor. However, you cannot change the association while the cursor is open. Consider the following example:

```
EXEC SQL AT :db_name DECLARE emp_cursor CURSOR FOR ...
strcpy(db_name, "oracle1");
```

```
EXEC SQL OPEN emp_cursor;
EXEC SQL FETCH emp_cursor INTO ...
strcpy(db_name, "oracle2");
EXEC SQL OPEN emp_cursor;   /*  illegal, cursor still open */
EXEC SQL FETCH emp_cursor INTO ...
```

This is illegal because *emp_cursor* is still open when you try to execute the second OPEN statement. Separate cursors are not maintained for different connections; there is only one *emp_cursor*, which must be closed before it can be reopened for another connection. To debug the last example, simply close the cursor before reopening it, as follows:

```
...
EXEC SQL CLOSE emp_cursor;  -- close cursor first
strcpy(db_name, "oracle2");
EXEC SQL OPEN emp_cursor;
EXEC SQL FETCH emp_cursor INTO ...
```

Dynamic SQL

Dynamic SQL statements are similar to cursor control statements in that some never use the AT clause.

For dynamic SQL Method 1, you must use the AT clause if you want to execute the statement at a non-default connection. An example follows:

```
EXEC SQL AT :db_name EXECUTE IMMEDIATE :sql_stmt;
```

For Methods 2, 3, and 4, you use the AT clause only in the DECLARE STATEMENT statement if you want to execute the statement at a non-default connection. All other dynamic SQL statements such as PREPARE, DESCRIBE, OPEN, FETCH, and CLOSE never use the AT clause. The next example shows Method 2:

```
EXEC SQL AT :db_name DECLARE sql_stmt STATEMENT;
EXEC SQL PREPARE slq_stmt FROM :sql_string;
EXEC SQL EXECUTE sql_stmt;
```

The following example shows Method 3:

```
EXEC SQL AT :db_name DECLARE sql_stmt STATEMENT;
EXEC SQL PREPARE slq_stmt FROM :sql_string;
EXEC SQL DECLARE emp_cursor CURSOR FOR sql_stmt;
EXEC SQL OPEN emp_cursor ...
EXEC SQL FETCH emp_cursor INTO ...
EXEC SQL CLOSE emp_cursor;
```

Multiple Explicit Connections

You can use the AT *db_name* clause for multiple explicit connections, just as you can for a single explicit connection. In the following example, you connect to two non-default databases concurrently:

```
/* declare needed host variables */
char  username[10]   = "scott";
char  password[10]   = "tiger";
char  db_string1[20] = "NYNON1";
char  db_string2[20] = "CHINON";
...
/* give each database connection a unique name */
EXEC SQL DECLARE DB_NAME1 DATABASE;
EXEC SQL DECLARE DB_NAME2 DATABASE;
/* connect to the two non-default databases */
EXEC SQL CONNECT :username IDENTIFIED BY :password
   AT DB_NAME1 USING :db_string1;
EXEC SQL CONNECT :username IDENTIFIED BY :password
   AT DB_NAME2 USING :db_string2;
```

The identifiers DB_NAME1 and DB_NAME2 are declared and then used to name the default databases at the two non-default nodes so that later SQL statements can refer to the databases by name.

Alternatively, you can use a host variable in the AT clause, as the following example shows:

```
/* declare needed host variables */
char  username[10]   = "scott";
char  password[10]   = "tiger";
char  db_name[20];
char  db_string[20];
int   n_defs = 3;    /* number of connections to make */
...
for (i = 0; i < n_defs; i++)
{
    /* get next database name and Net8 string */
    printf("Database name: ");
    gets(db_name);
    printf("Net8) string: ");
    gets(db_string);
    /* do the connect */
    EXEC SQL CONNECT :username IDENTIFIED BY :password
```

```
        AT :db_name USING :db_string;
}
```

You can also use this method to make multiple connections to the same database, as the following example shows:

```
strcpy(db_string, "NYNON");
for (i = 0; i < ndefs; i++)
{
    /* connect to the non-default database */
    printf("Database name: ");
    gets(db_name);
    EXEC SQL CONNECT :username IDENTIFIED BY :password
       AT :db_name USING :db_string;
}
...
```

You must use different database names for the connections, even though they use the same Net8 string. However, you can connect twice to the same database using just one database name because that name identifies the default and non-default databases.

Ensuring Data Integrity

Your application program must ensure the integrity of transactions that manipulate data at two or more remote databases. That is, the program must commit or roll back *all* SQL statements in the transactions. This might be impossible if the network fails or one of the systems crashes.

For example, suppose you are working with two accounting databases. You debit an account on one database and credit an account on the other database, then issue a COMMIT at each database. It is up to your program to ensure that both transactions are committed or rolled back.

Implicit Connections

Implicit connections are supported through the Oracle8 distributed query facility, which does not require explicit connections, but only supports the SELECT statement. A distributed query allows a single SELECT statement to access data on one or more non-default databases.

The distributed query facility depends on database links, which assign a name to a CONNECT *statement* rather than to the connection itself. At run time, the embedded SELECT statement is executed by the specified Oracle8 Server, which *implicitly* connects to the non-default database(s) to get the required data.

Single Implicit Connections

In the next example, you connect to a single non-default database. First, your program executes the following statement to define a database link (database links are usually established interactively by the DBA or user):

```
EXEC SQL CREATE DATABASE LINK db_link
     CONNECT TO username IDENTIFIED BY password
         USING 'NYNON';
```

Then, the program can query the non-default EMP table using the database link, as follows:

```
EXEC SQL SELECT ENAME, JOB INTO :emp_name, :job_title
     FROM emp@db_link
     WHERE DEPTNO = :dept_number;
```

The database link is not related to the database name used in the AT clause of an embedded SQL statement. It simply tells Oracle8 where the non-default database is located, the path to it, and what Oracle8 username and password to use. The database link is stored in the data dictionary until it is explicitly dropped.

In our example, the default Oracle8 Server logs on to the non-default database via Net8 using the database link *db_link*. The query is submitted to the default Server, but is "forwarded" to the non-default database for execution.

To make referencing the database link easier, you can create a synonym as follows (again, this is usually done interactively):

```
EXEC SQL CREATE SYNONYM emp FOR emp@db_link;
```

Then, your program can query the non-default EMP table, as follows:

```
EXEC SQL SELECT ENAME, JOB INTO :emp_name, :job_title
     FROM emp
     WHERE DEPTNO = :dept_number;
```

This provides location transparency for *emp*.

Multiple Implicit Connections

In the following example, you connect to two non-default databases concurrently. First, you execute the following sequence of statements to define two database links and create two synonyms:

```
EXEC SQL CREATE DATABASE LINK db_link1
     CONNECT TO username1 IDENTIFIED BY password1
         USING 'NYNON';
```

```
EXEC SQL CREATE DATABASE LINK db_link2
     CONNECT TO username2 IDENTIFIED BY password2
         USING 'CHINON';
EXEC SQL CREATE SYNONYM emp FOR emp@db_link1;
EXEC SQL CREATE SYNONYM dept FOR dept@db_link2;
```

Then, your program can query the non-default EMP and DEPT tables, as follows:

```
EXEC SQL SELECT ENAME, JOB, SAL, LOC
     FROM emp, dept
     WHERE emp.DEPTNO = dept.DEPTNO AND DEPTNO = :dept_number;
```

Oracle8 executes the query by performing a join between the non-default EMP table at *db_link1* and the non-default DEPT table at *db_link2*.

Changing Passwords at Runtime

Pro*C/C++ now provides client applications with a convenient way to change a user password at runtime through a simple extension to the EXEC SQL CONNECT statement.

The syntax for the CONNECT statement now has an optional ALTER AUTHORIZATION clause. The new syntax for CONNECT is shown here:

```
EXEC SQL CONNECT { :user IDENTIFIED BY :oldpswd | :usr_psw }
[ [ AT { dbname | :host_variable }] USING :connect_string ]
[ ALTER AUTHORIZATION :newpswd ]
```

Using the ALTER AUTHORIZATION Clause

This section describes the possible outcomes of different variations of the ALTER AUTHORIZATION clause..

Standard CONNECT

If an application issues the following statement

```
EXEC SQL CONNECT ..;   /* No ALTER AUTHORIZATION clause */
```

it performs a normal connection attempt. The possible results include the following:

1. The application will connect without issue.
2. The application will connect, but will receive a password warning. The warning indicates that the password has expired but is in a grace period which will

allow logins. At this point, the user is encouraged to change the password before the account becomes locked.

3. The application will fail to connect. Possible causes include the following:
    - The password is incorrect.
    - The account has expired, and is possibly in a locked state.

Change Password on CONNECT

The following CONNECT statement

```
EXEC SQL CONNECT .. ALTER AUTHORIZATION :newpswd;
```

indicates that the application wants to change the account password to the value indicated by `newpswd`. After the change is made, an attempt is made to connect as `user/newpswd`. This can have the following results:

1. The application will connect without issue
2. The application will fail to connect. This could be due to either of the following:
    - Password verification failed for some reason. In this case the password remains unchanged.
    - The account is locked. Changes to the password are not permitted.

Example

This simple example is intended to demonstrate all the variations on the syntax of the new clause used with the connect statement. When run, this program switches the password between 'tiger' and 'lion' repeatedly, returning it to 'tiger' before completing. (*inst1_alias* is a loopback to the same database.)

```
#include <sqlca.h>
main()
{
  char *userpass = "scott/tiger";
  char *user = "scott";
  char *pass = "tiger";
  char *atdb = "remote";
  char *using = "inst1_alias";
  char *newpw = "lion";
  char *newuserpass = "scott/lion";

  exec sql whenever sqlerror do printf("%.70s\n",sqlca.sqlerrm.sqlerrmc);
```

```
  exec sql connect :userpass alter authorization :newpw;
  exec sql connect :user identified by :newpw alter authorization :pass;
  exec sql connect :userpass at :atdb using :using alter authorization
           :newpw;
  exec sql connect :user identified by :newpw
           at :atdb using :using alter authorization :pass;
  exec sql connect :userpass using :using alter authorization :newpw;
  exec sql connect :newuserpass;
  exec sql connect :user identified by :newpw;
  exec sql connect :newuserpass at :atdb using :using;
  exec sql connect :newuserpass using :using;
  exec sql connect :user identified by :newpw at :atdb using :using;
  exec sql connect :newuserpass alter authorization :pass;

  exit(0);
}
```

Embedding (OCI Release 7) Calls

To embed OCI calls in your Pro*C/C++ program, take the following steps:

- Declare an OCI Logon Data Area (LDA) in your Pro*C/C++ program (outside the Declare Section if you precompile with MODE=ANSI). The LDA is a structure defined in the OCI header file *oci.h*. For details, see the *Programmer's Guide to the Oracle Call Interface.*
- Connect to Oracle8 using the embedded SQL statement CONNECT, not the OCI *orlon()* or *onblon()* calls.
- Call the SQLLIB runtime library function *sqllda()* to set up the LDA.

That way, the Pro*C/C++ Precompiler and the OCI "know" that they are working together. However, there is no sharing of Oracle8 cursors.

You need not worry about declaring the OCI Host Data Area (HDA) because the Oracle8 runtime library manages connections and maintains the HDA for you.

Setting Up the LDA

You set up the LDA by issuing the OCI call

```
sqllda(&lda);
```

where *lda* identifies the LDA data structure.

If the setup fails, the *lda_rc* field in the *lda* is set to 1012 to indicate the error.

Remote and Multiple Connections

A call to *sqllda()* sets up an LDA for the connection used by the most recently executed SQL statement. To set up the different LDAs needed for additional connections, just call *sqllda()* with a different *lda* after each CONNECT. In the following example, you connect to two non-default databases concurrently:

```
#include <ocidfn.h>
Lda_Def lda1;
Lda_Def lda2;

char username[10], password[10], db_string1[20], dbstring2[20];
...
strcpy(username, "scott");
strcpy(password, "tiger");
strcpy(db_string1, "NYNON");
strcpy(db_string2, "CHINON");
/* give each database connection a unique name */
EXEC SQL DECLARE DB_NAME1 DATABASE;
EXEC SQL DECLARE DB_NAME2 DATABASE;
/* connect to first non-default database */
EXEC SQL CONNECT :username IDENTIFIED BY :password;
    AT DB_NAME1 USING :db_string1;
/* set up first LDA */
sqllda(&lda1);
/* connect to second non-default database */
EXEC SQL CONNECT :username IDENTIFIED BY :password;
    AT DB_NAME2 USING :db_string2;
/* set up second LDA */
sqllda(&lda2);
```

DB_NAME1 and DB_NAME2 are *not* C variables; they are SQL identifiers. You use them only to name the default databases at the two non-default nodes, so that later SQL statements can refer to the databases by name.

New Names for SQLLIB Public Functions

The new names of SQLLIB functions are listed in Table 4–2. You can use these SQLLIB functions for both threaded and non-threaded applications. Previously, for example, *sqlglm()* was documented as the non-threaded version of this function, while *sqlglmt()* was the threaded version. The names *sqlglm()* and *sqlglmt()* are still available, but are deprecated in release 8.0. The new function, *SQLErrorGetText*(), requires the same arguments as *sqlglmt()* . For non-threaded applications, pass the defined constant SQL_SINGLE_RCTX as the context.

Each standard SQLLIB public function is thread-safe and accepts the runtime context as the first argument. For example, the syntax for *SQLErrorGetText()* is:

```
void SQLErrorGetText(dvoid *context,  char   *message_buffer,
           size_t *buffer_size,
           size_t *message_length);
```

In summary, the old function names will continue to work in your existing applications. You can use the new function names in the new applications that you will write.

Table 4–2 is a list of all the SQLLIB public functions and their corresponding syntax. Cross-references to the non-threaded usages are provided to help you find more complete descriptions.

> **Attention:** For the specific datatypes used in the argument lists for these functions, refer to your platform-specific *sqlcpr.h* file.

Table 4–2 SQLLIB Public Functions -- New Names

Old Name	New Function Prototype	Cross-reference
sqlaldt()	struct SQLDA *SQLSQLDAAlloc(dvoid *context, unsigned int maximum_variables, unsigned int maximum_name_length, unsigned int maximum_ind_name_length);	see also sqlaldt() on page 14-5
sqlcdat()	void SQLCDAFromResultSetCursor(dvoid *context, Cda_Def *cda, void *cursor, sword *return_value);	see also sqlcdat() on page 4-16
sqlclut()	void SQLSQLDAFree(dvoid *context, struct SQLDA *descriptor_name);	see also sqlcu() on page 14-37
sqlcurt()	void SQLCDAToResultSetCursor(dvoid *context, void *cursor, Cda_Def *cda, sword *return_value)	see also sqlclur() on page 4-16
sqlglmt()	void SQLErrorGetText(dvoid *context, char *message_buffer, size_t *buffer_size, size_t *message_length);	see also sqlglm() on "Getting the Full Text of Error Messages" on page 11-23

Table 4–2 SQLLIB Public Functions -- New Names

Old Name	New Function Prototype	Cross-reference
sqlglst()	void SQLStmtGetText(dvoid *context, char *statement_buffer, size_t *statement_length, size_t *sqlfc);	see also sqlgls() on "Obtaining the Text of SQL Statements" on page 11-32
sqlld2t()	void SQLLDAGetNamed(dvoid *context, Lda_Def *lda, text *cname, sb4 *cname_length);	see also sqlld2() on page 4-62
sqlldat()	void SQLCDAGetCurrent(dvoid *context, Lda_Def *lda);	see also sqllda() on page 4-35
sqlnult()	void SQLColumnNullCheck(dvoid *context, unsigned short *value_type, unsigned short *type_code, int *null_status);	see also sqlnul() on page 14-17
sqlprct()	void SQLNumberPrecV6(dvoid *context, long *length, int *precision, int *scale);	see also sqlprc() on page 14-16
sqlpr2t()	void SQLNumberPrecV7(dvoid *context, unsigned long *length, int *precision, int *scale);	see also sqlpr2() on page 14-16
sqlvcpt()	void SQLVarcharGetLength(dvoid *context, unsigned long *data_length, unsigned long *total_length);	see also sqlvcp() on "Finding the Length of the VARCHAR Array Component" on page 3-46.
Added in Pro*C/C++ rel 8.	sword SQLEnvGet(dvoid *rctx, OCIEnv **oeh);	see "SQLEnvGet()" on page 4-57.
Added in Pro*C/C++ rel 8.	sword SQLSvcCtxGet(dvoid *rctx, text *dbmae, sb4 dbnamelen, OCISvcCtx **svc);	see "SQLSvcCtxGet()" on page 4-57.

Developing Multi-threaded Applications

If your development platform does not support threads, ignore this section.

Multi-threaded applications have multiple *threads* executing in a shared address space. Threads are "lightweight" subprocesses that execute within a process. They share code and data segments, but have their own program counters, machine registers and stack. Global and static variables are common to all threads, and a mutual exclusivity mechanism is often required to manage access to these variables from multiple threads within an application. *Mutexes* are the synchronization mechanism to insure that data integrity is preserved.

For further discussion of mutexes, see texts on multi-threading. For more detailed information about multi-threaded applications, refer to your thread-package specific reference material.

The Pro*C/C++ Precompiler supports development of multi-threaded Oracle8 Server applications (on platforms that support multi-threaded applications) using the following:

- a command-line option to generate thread-safe code
- embedded SQL statements and directives to support multi-threading
- thread-safe SQLLIB and other client-side Oracle8 libraries

  Attention: If your development platform does not support multi-threading, the information in this section does not apply.

  Note: While your platform may support a particular thread package, see your platform-specific Oracle8 documentation to determine whether Oracle8 supports it.

The following topics discuss how to use the preceding features to develop multi-threaded Pro*C/C++ applications:

- runtime contexts for multi-threaded applications
- two models for using runtime contexts
- user-interface features for multi-threaded applications
- programming considerations for writing multi-threaded applications with Pro*C/C++
- a sample multi-threaded Pro*C/C++ application

Runtime Contexts in Pro*C/C++

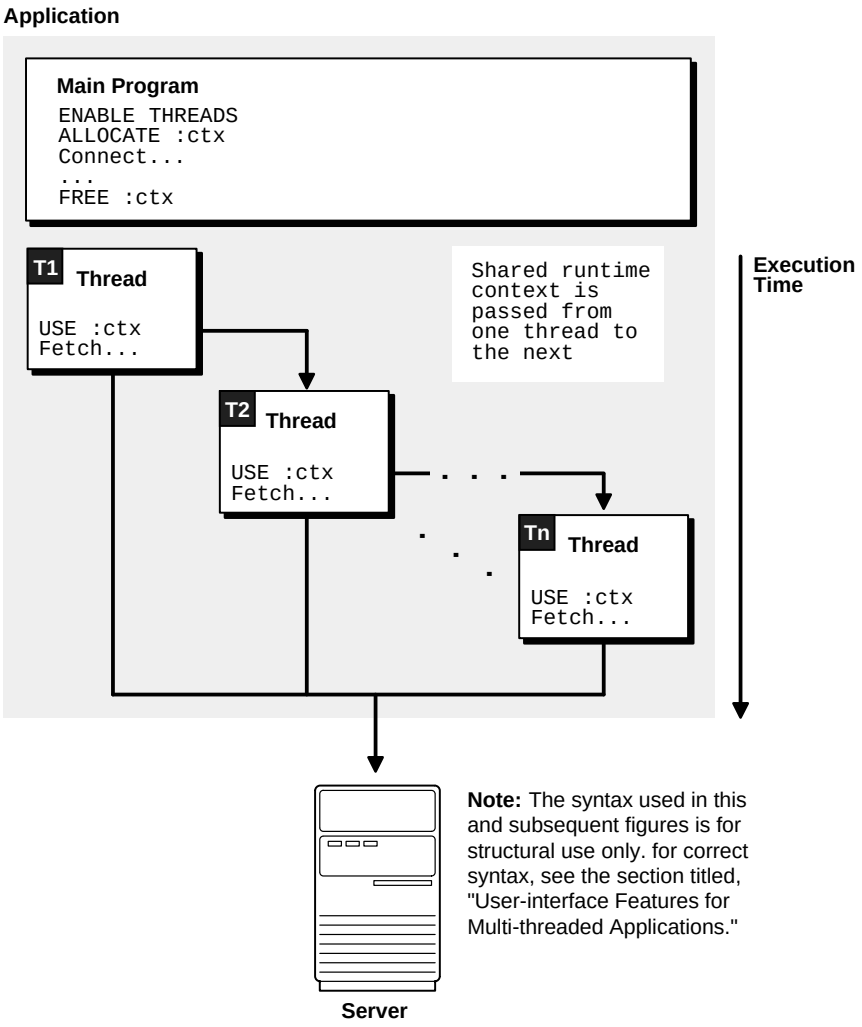
To loosely couple a thread and a connection, Pro*C/C++ introduces the notion of a *runtime context*. The runtime context includes the following resources and their current states:

- zero or more connections to one or more Oracle8 Servers
- zero or more cursors used for the server connections
- inline options, such as MODE, HOLD_CURSOR, RELEASE_CURSOR, and SELECT_ERROR

Rather than simply supporting a loose coupling between threads and connections, the Pro*C/C++ Precompiler allows developers to loosely couple threads with runtime contexts. Pro*C/C++ allows an application to define a handle to a runtime context, and pass that handle from one thread to another.

For example, an interactive application spawns a thread, T1, to execute a query and return the first 10 rows to the application. T1 then terminates. After obtaining the necessary user input, another thread, T2, is spawned (or an existing thread is used) and the runtime context for T1 is passed to T2 so it can fetch the next 10 rows by processing the same cursor.

Figure 4–2 Loosely Coupling Connections and Threads



Runtime Context Usage Models

Two possible models for using runtime contexts in multi-threaded Pro*C / C++ applications are shown here:

- multiple threads sharing a single runtime context
- multiple threads using separate runtime contexts

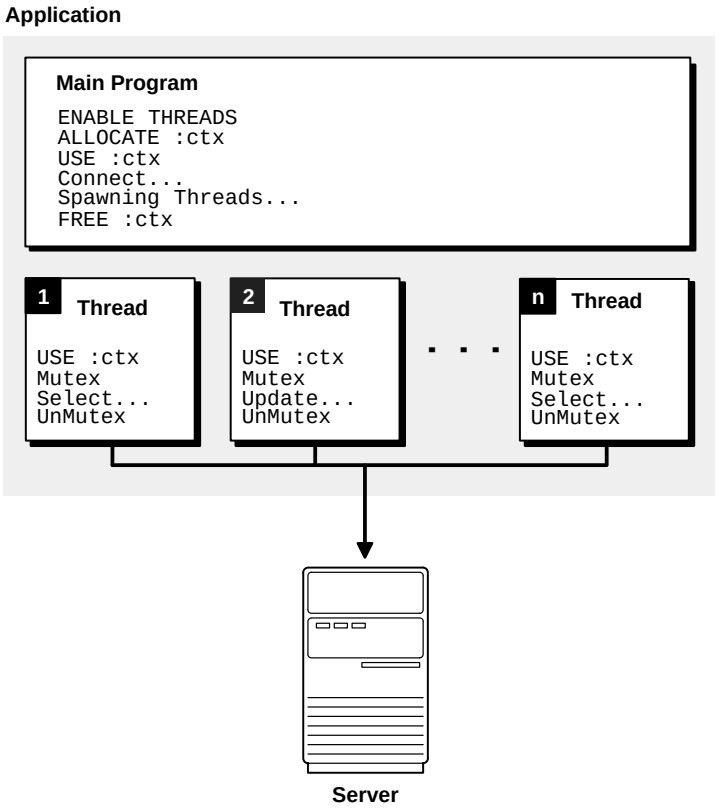
Regardless of the model you use for runtime contexts, you *cannot* share a runtime context between multiple threads *at the same time*. If two or more threads attempt to use the same runtime context simultaneously, the following runtime error occurs:

```
SQL-02131:  Runtime context in use
```

Multiple Threads Sharing a Single Runtime Context

Figure 4–3 shows an application running in a multi-threaded environment. The various threads share a single runtime context to process one or more SQL statements. Again, runtime contexts cannot be shared by multiple threads at the same time. The mutexes in Figure 4–3 show how to prevent concurrent usage.

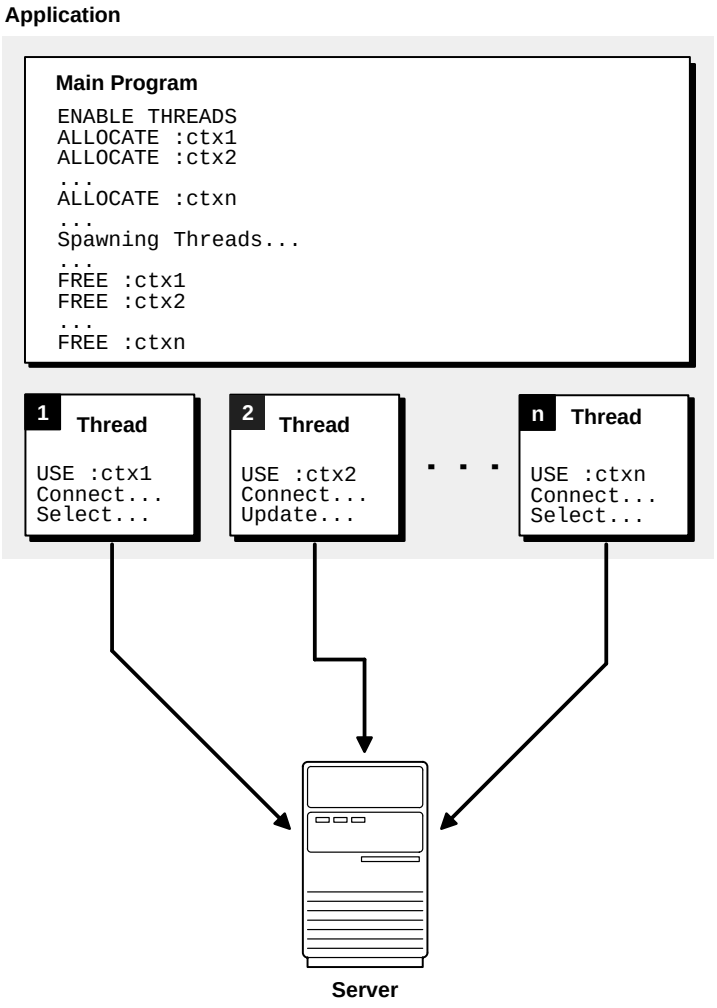
Figure 4–3 Context Sharing Among Threads



Multiple Threads Sharing Multiple Runtime Contexts

Figure 4–4 shows an application that executes multiple threads using multiple runtime contexts. In this situation, the application does not require mutexes, because each thread has a dedicated runtime context.

Figure 4–4 No Context Sharing Among Threads



User-interface Features for Multi-threaded Applications

The Pro*C/C++ Precompiler provides the following user-interface features to support multi-threaded applications:

- command-line option, THREADS=YES | NO
- embedded SQL statements and directives

- thread-safe SQLLIB public functions

THREADS Option THREADS

With THREADS=YES specified on the command line, the Pro*C/C++ Precompiler ensures that the generated code is thread-safe, given that you follow the guidelines described in "Programming Considerations" on page 4-47. With THREADS=YES specified, Pro*C/C++ verifies that all SQL statements execute within the scope of a user-defined runtime context. If your program does not meet this requirement, the following precompiler error is returned:

```
PCC-02390:  No EXEC SQL CONTEXT USE statement encountered
```

Embedded SQL Statements and Directives

The following embedded SQL statements and directives support the definition and usage of runtime contexts and threads:

- EXEC SQL ENABLE THREADS;
- EXEC SQL CONTEXT ALLOCATE :*context_var*;
- EXEC SQL CONTEXT USE :*context_var*;
- EXEC SQL CONTEXT FREE :*context_var*;

For these EXEC SQL statements, *context_var* is the handle to the runtime context and must be declared of type **sql_context** as follows:

```
sql_context <context_variable>;
```

EXEC SQL ENABLE THREADS

This executable SQL statement initializes a process that supports multiple threads. This must be the first executable SQL statement in your multi-threaded application. For more detailed information, see “ENABLE THREADS (Executable Embedded SQL Extension)” on page F-36.

EXEC SQL CONTEXT ALLOCATE

This executable SQL statement allocates and initializes memory for the specified runtime context; the runtime-context variable must be declared of type sql_context. For more detailed information, see “CONTEXT ALLOCATE” on “CONTEXT ALLOCATE (Executable Embedded SQL Extension)” on page F-16.

EXEC SQL CONTEXT USE This directive instructs the precompiler to use the specified runtime context for subsequent executable SQL statements. The runtime context

specified must be previously allocated using an EXEC SQL CONTEXT ALLOCATE statement.

The EXEC SQL CONTEXT USE directive works similarly to the EXEC SQL WHENEVER directive in that it affects all executable SQL statements which positionally follow it in a given source file without regard to standard C scope rules. In the following example, the UPDATE statement in *function2()* uses the global runtime context, *ctx1*:

```
sql_context ctx1;            /* declare global context ctx1     */

function1()
{
   sql_context :ctx1;         /* declare local context ctx1      */
   EXEC SQL CONTEXT ALLOCATE :ctx1;
   EXEC SQL CONTEXT USE :ctx1;
   EXEC SQL INSERT INTO ...  /* local ctx1 used for this stmt   */
   ...
}

function2()
{
   EXEC SQL UPDATE ...       /* global ctx1 used for this stmt */
}
```

In the next example, there is no global runtime context. The precompiler refers to the *ctx1* runtime context in the generated code for the UPDATE statement. However, there is no context variable in scope for *function2()*, so errors are generated at compile time.

```
function1()
{
   sql_context ctx1;         /* local context variable declared */
   EXEC SQL CONTEXT ALLOCATE :ctx1;
   EXEC SQL CONTEXT USE :ctx1;
   EXEC SQL INSERT INTO ...     /* ctx1 used for this statement */
   ...
}
function2()
{
   EXEC SQL UPDATE ...   /* Error! No context variable in scope */
}
```

For more detailed information, see “CONTEXT OBJECT OPTION GET (Executable Embedded SQL Extension)” on page F-18.

EXEC SQL CONTEXT FREE

This executable SQL statement frees the memory associated with the specified runtime context and places a null pointer in the host program variable. For more detailed information, see "CONTEXT FREE (Executable Embedded SQL Extension)" on page F-17.

Examples

The following code fragments show how to use embedded SQL statements and precompiler directives for two typical programming models; they use *thread_create()* to create threads.

The first example showing multiple threads using multiple runtime contexts:

```
main()
{
   sql_context ctx1,ctx2;           /* declare runtime contexts */
   EXEC SQL ENABLE THREADS;
   EXEC SQL CONTEXT ALLOCATE :ctx1;
   EXEC SQL CONTEXT ALLOCATE :ctx2;
   ...
/* spawn thread, execute function1 (in the thread) passing ctx1 */
   thread_create(..., function1, ctx1);
/* spawn thread, execute function2 (in the thread) passing ctx2 */
   thread_create(..., function2, ctx2);
   ...
   EXEC SQL CONTEXT FREE :ctx1;
   EXEC SQL CONTEXT FREE :ctx2;
   ...
}

void function1(sql_context ctx)
{
   EXEC SQL CONTEXT USE :ctx;
/* execute executable SQL statements on runtime context ctx1!!! */
   ...
}

void function2(sql_context ctx)
{
   EXEC SQL CONTEXT USE :ctx;
/* execute executable SQL statements on runtime context ctx2!!! */
   ...
}
```

The next example shows how to use multiple threads that share a common runtime context. Because the SQL statements executed in *function1()* and *function2()* potentially execute at the same time, you must place mutexes around every *executable* EXEC SQL statement to ensure serial, therefore safe, manipulation of the data.

```
main()
{
   sql_context ctx;                  /* declare runtime context */
   EXEC SQL CONTEXT ALLOCATE :ctx;
   ...
/* spawn thread, execute function1 (in the thread) passing ctx  */
   thread_create(..., function1, ctx);
/* spawn thread, execute function2 (in the thread) passing ctx  */
   thread_create(..., function2, ctx);
   ...
}

void function1(sql_context ctx)
{
   EXEC SQL CONTEXT USE :ctx;
/* Execute SQL statements on runtime context ctx.               */
   ...
}

void function2(sql_context ctx)
{
   EXEC SQL CONTEXT USE :ctx;
/* Execute SQL statements on runtime context ctx.               */
   ...
}
```

Programming Considerations

While Oracle8 ensures that the SQLLIB code is thread-safe, you are responsible for ensuring that your Pro*C/C++ source code is designed to work properly with threads; for example, carefully consider your use of static and global variables.

In addition, multi-threaded requires design decisions regarding the following:

- declaring the SQLCA as a thread-safe struct, typically an auto variable and one for each runtime context
- declaring the SQLDA as a thread-safe struct, like the SQLCA, typically an auto variable and one for each runtime context

- declaring host variables in a thread-safe fashion, in other words, carefully consider your use of static and global host variables.
- avoiding simultaneous use of a runtime context in multiple threads
- whether or not to use default database connections or to explicitly define them using the AT clause

Also, no more than one executable embedded SQL statement, for example, EXEC SQL UPDATE, may be outstanding on a runtime context at a given time.

Existing requirements for precompiled applications also apply. For example, all references to a given cursor must appear in the same source file.

Example

The following program is one approach to writing a multi-threaded embedded SQL application. The program creates as many sessions as there are threads. Each thread executes zero or more transactions, that are specified in a transient structure called “records.”

Note: This program was developed specifically for a Sun workstation running Solaris. Either the DCE or Solaris threads package is usable with this program. See your platform-specific documentation for the availability of threads packages.

```
/*
 * Name:         Thread_example1.pc
 *
 * Description: This program illustrates how to use threading in
 *      conjunction with precompilers. The program creates as many
 *      sessions as there are threads. Each thread executes zero or
 *      more transactions, that are specified in a transient
 *      structure called 'records'.
 * Requirements:
 *      The program requires a table 'ACCOUNTS' to be in the schema
 *      scott/tiger. The description of ACCOUNTS is:
 *  SQL> desc accounts
 *   Name                           Null?    Type
 *  ------------------------------- -------  ------
 *  ACCOUNT                                  NUMBER(36)
 *  BALANCE                                  NUMBER(36,2)
 *
 *  For proper execution, the table should be filled with the accounts
 *      10001 to 10008.
 *
 *
```

```
 */

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sqlca.h>

#define      _EXC_OS_        _EXC__UNIX
#define      _CMA_OS_        _CMA__UNIX

#ifdef DCE_THREADS
  #include <pthread.h>
#else
  #include <thread.h>
#endif

/* Function prototypes */
void   err_report();
#ifdef DCE_THREADS
void   do_transaction();
#else
void   *do_transaction();
#endif
void   get_transaction();
void   logon();
void   logoff();

#define CONNINFO "scott/tiger"
#define THREADS  3

struct parameters
{ sql_context * ctx;
  int thread_id;
};
typedef struct parameters parameters;

struct record_log
{  char action;
   unsigned int from_account;
   unsigned int to_account;
   float  amount;
};
typedef struct record_log record_log;

record_log records[]= { { 'M', 10001, 10002, 12.50 },
```

```
                        { 'M', 10001, 10003, 25.00 },
                        { 'M', 10001, 10003, 123.00 },
                        { 'M', 10001, 10003, 125.00 },
                        { 'M', 10002, 10006, 12.23 },
                        { 'M', 10007, 10008, 225.23 },
                        { 'M', 10002, 10008, 0.70 },
                        { 'M', 10001, 10003, 11.30 },
                        { 'M', 10003, 10002, 47.50 },
                        { 'M', 10002, 10006, 125.00 },
                        { 'M', 10007, 10008, 225.00 },
                        { 'M', 10002, 10008, 0.70 },
                        { 'M', 10001, 10003, 11.00 },
                        { 'M', 10003, 10002, 47.50 },
                        { 'M', 10002, 10006, 125.00 },
                        { 'M', 10007, 10008, 225.00 },
                        { 'M', 10002, 10008, 0.70 },
                        { 'M', 10001, 10003, 11.00 },
                        { 'M', 10003, 10002, 47.50 },
                        { 'M', 10008, 10001, 1034.54}};

static unsigned int trx_nr=0;
#ifdef DCE_THREADS
pthread_mutex_t mutex;
#else
mutex_t mutex;
#endif



/*********************************************************************
 *  Main
 *********************************************************************/
main()
{
  sql_context ctx[THREADS];
#ifdef DCE_THREADS
  pthread_t thread_id[THREADS];
  pthread_addr_t status;
#else
  thread_t thread_id[THREADS];
  int status;
#endif
  parameters params[THREADS];
  int i;
```

```
  EXEC SQL ENABLE THREADS;

  EXEC SQL WHENEVER SQLERROR DO err_report(sqlca);

  /* Create THREADS sessions by connecting THREADS times */
  for(i=0;i<THREADS;i++)
  {
    printf("Start Session %d....",i);
    EXEC SQL CONTEXT ALLOCATE :ctx[i];
    logon(ctx[i],CONNINFO);
  }

  /*Create mutex for transaction retrieval */
#ifdef DCE_THREADS
  if (pthread_mutex_init(&mutex,pthread_mutexattr_default))
#else
  if (mutex_init(&mutex, USYNC_THREAD, NULL))
#endif
  {
     printf("Can't initialize mutex\n");
     exit(1);
  }

  /*Spawn threads*/
  for(i=0;i<THREADS;i++)
  {
    params[i].ctx=ctx[i];
    params[i].thread_id=i;

    printf("Thread %d... ",i);
#ifdef DCE_THREADS
    if (pthread_create(&thread_id[i],pthread_attr_default,
        (pthread_startroutine_t)do_transaction,
        (pthread_addr_t) &params[i]))
#else
    if (status = thr_create
    (NULL, 0, do_transaction, &params[i], 0, &thread_id[i]))
#endif
      printf("Cant create thread %d\n",i);
    else
      printf("Created\n");
  }


  /* Logoff sessions....*/
```

```
  for(i=0;i<THREADS;i++)
  {
     /*wait for thread to end */
     printf("Thread %d ....",i);
#ifdef DCE_THREADS
     if (pthread_join(thread_id[i],&status))
       printf("Error when waiting for thread % to terminate\n", i);
     else
      printf("stopped\n");

     printf("Detach thread...");
     if (pthread_detach(&thread_id[i]))
       printf("Error detaching thread! \n");
     else
       printf("Detached!\n");
#else
     if (thr_join(thread_id[i], NULL, NULL))
       printf("Error waiting for thread to terminate\n");
#endif
     printf("Stop Session %d....",i);
     logoff(ctx[i]);
     EXEC SQL CONTEXT FREE :ctx[i];
  }


  /*Destroys mutex*/
#ifdef DCE_THREADS
  if (pthread_mutex_destroy(&mutex))
#else
  if (mutex_destroy(&mutex))
#endif
  {
    printf("Can't destroy mutex\n");
    exit(1);
  }
}

/*****************************************************************
 * Function: do_transaction
 *
 * Description:  This functions executes one transaction out of the
 *               records array. The records array is 'managed' by
 *               the get_transaction function.
 *
 *
```

```
 ********************************************************************/
#ifdef DCE_THREADS
void do_transaction(params)
#else
void *do_transaction(params)
#endif
parameters *params;
{
  struct sqlca sqlca;
  record_log *trx;
  sql_context ctx=params->ctx;

  /* Done all transactions ? */
  while (trx_nr < (sizeof(records)/sizeof(record_log)))
  {
    get_transaction(&trx);

    EXEC SQL WHENEVER SQLERROR DO err_report(sqlca);
    EXEC SQL CONTEXT USE :ctx;

    printf("Thread %d executing transaction\n",params->thread_id);
    switch(trx->action)
    {
      case 'M':  EXEC SQL UPDATE ACCOUNTS
                          SET    BALANCE=BALANCE+:trx->amount
                          WHERE  ACCOUNT=:trx->to_account;
                 EXEC SQL UPDATE ACCOUNTS
                          SET    BALANCE=BALANCE-:trx->amount
                          WHERE  ACCOUNT=:trx->from_account;
                 break;
       default:  break;
    }
    EXEC SQL COMMIT;
  }
}


/*************************************************************
 * Function: err_report
 *
 * Description: This routine prints out the most recent error
 *
 *************************************************************/
void      err_report(sqlca)
struct sqlca sqlca;
```

```
{
  if (sqlca.sqlcode < 0)
   printf("\n%.*s\n\n",sqlca.sqlerrm.sqlerrml,sqlca.sqlerrm.sqlerrmc);
  exit(1);
}

/*************************************************************
 * Function: logon
 *
 * Description: Logs on onto the database as USERNAME/PASSWORD
 *
 *************************************************************/
void      logon(ctx,connect_info)
sql_context ctx;
char * connect_info;
{
    EXEC SQL WHENEVER SQLERROR DO err_report(sqlca);
    EXEC SQL CONTEXT USE :ctx;
    EXEC SQL CONNECT :connect_info;
    printf("Connected!\n");

}

/*************************************************************
 * Function: logoff
 *
 * Description: This routine logs off the database
 *
 *************************************************************/
void      logoff(ctx)
sql_context ctx;
{
    EXEC SQL WHENEVER SQLERROR DO err_report(sqlca);
    EXEC SQL CONTEXT USE :ctx;
    EXEC SQL COMMIT WORK RELEASE;
    printf("Logged off!\n");
}


/*************************************************************
 * Function: get_transaction
 *
 * Description: This routine returns the next transaction to process
 *
 *************************************************************/
```

```
void get_transaction(trx)
record_log ** trx;
{
#ifdef DCE_THREADS
  if (pthread_mutex_lock(&mutex))
#else
  if (mutex_lock(&mutex))
#endif
    printf("Can't lock mutex\n");

  *trx=&records[trx_nr];

  trx_nr++;

#ifdef DCE_THREADS
  if (pthread_mutex_unlock(&mutex))
#else
  if (mutex_unlock(&mutex))
#endif
    printf("Can't unlock mutex\n");
}
```

SQLLIB Extensions for OCI Release 8 Interoperability

An OCI environment handle will be tied to the Pro*C/C++ runtime context, which is of the *sql_context* type introduced in Oracle 7.3. That is, one Pro*C/C++ runtime context maintained by SQLLIB during application execution will be associated with at most one OCI environment handle. Multiple database connections are allowed for each Pro*C/C++ runtime context, which will be associated to the OCI environment handle for the runtime context.

Establishing and Terminating a Runtime Context and OCI Release 8 Environment

An EXEC SQL CONTEXT USE statement specifies a runtime context to be used in a Pro*C/C++ program. This context applies to all executable SQL statements that positionally follow it in a given Pro*C/C++ file until another EXEC SQL CONTEXT USE statement occurs. If no EXEC SQL CONTEXT USE appears in a source file, the default "global" context is assumed. Thus, the current runtime context, and therefore the current OCI environment handle, is known at any point in the program.

The runtime context and its associated OCI environment handle are initialized when a database logon is performed using EXEC SQL CONNECT in Pro*C/C++.

When a Pro*C/C++ runtime context is freed using the EXEC SQL CONTEXT FREE statement, the associated OCI environment handle is terminated and all of its resources, such as space allocated for the various OCI handles and LOB locators, are de-allocated. This command releases all other memory associated with the Pro*C/C++ runtime context. An OCI environment handle that is established for the default "global" runtime remains allocated until the Pro*C/C++ program terminates.

Parameters in the OCI Release 8 Environment Handle

An OCI environment established through Pro*C/C++ will use the following parameters:

- The callback functions used by the environment for allocating memory, freeing memory, writing to a text file, and flushing the output buffer will be trivial functions that call malloc(), free(), fprintf(stderr, ...), and fflush(stderr) respectively.
- The language will be obtained from the NLS environment variable NLS_LANG.
- The error message buffer will be allocated in thread-specific storage.

Interfacing to OCI Release 8

SQLLIB library provides routines to obtain the OCI environment and service context handles for database connections established through a Pro*C/C++ program. Once the OCI handles are obtained, the user can call various OCI routines, e.g. to perform client-side DATE arithmetic, execute navigational operations on objects etc. See Chapter 8, "Object Support in Pro*C/C++" for more details. These SQLLIB functions are described below, and their prototypes are available in the public header file *sql2oci.h*.

A Pro*C/C++ user who mixes embedded SQL and calls in the other Oracle programmatic interfaces must exercise reasonable care. For example, if a user terminates a connection directly using the OCI interface, SQLLIB state is out-of-sync; the behavior for subsequent SQL statements in the Pro*C/C++ program is undefined in such cases.

Starting with release 8.0, the new SQLLIB functions that provide interoperability with the Oracle8 OCI are declared in header file *sql2oci.h*:

- *SQLEnvGet()*, to return a pointer to an OCI environment handle associated with a given SQLLIB runtime context. Used for both single- and multi-threaded environments.

- *SQLSvcCtxGet()*, to return an OCI service context handle for a Pro*C/C++ database connection. Used for both single- and multi-threaded environments.
- Pass the constant `SQL_SINGLE_RCTX`, defined as zero when you include sql2oci.h, as the first parameter in either function, when using single-threaded runtime contexts.

SQLEnvGet()

The SQLLIB library function *SQLEnvGet()* (SQLIB OCI Environment Get) returns the pointer to the OCI environment handle associated with a given SQLLIB runtime context. The prototype for this function is:

```
sword SQLEnvGet(dvoid *rctx, OCIEnv **oeh);
```

where:

Description	Sets *oeh* to the OCIEnv corresponding to the runtime context
Parameters	*rctx* (IN) pointer to a SQLLIB runtime context
	oeh (OUT) pointer to OCIEnv
Returns	SQL_SUCCESS on success
	SQL_ERROR on failure
Notes	The usual error status variables in Pro*C/C++ such as SQLCA and SQLSTATE will not be affected by a call to this function

SQLSvcCtxGet()

The SQLLIB library function *SQLSvcCtxGet()* (SQLIB OCI Service Context Get) returns the OCI service context for the Pro*C/C++ database connection. The OCI service context can then be used in direct calls to OCI functions. The prototype for this function is:

```
sword SQLSvcCtxGet(dvoid *rctx, text *dbname,
       sb4 dbnamelen, OCISvcCtx **svc);
```

where:

Description	Sets *svc* to the OCI Service Context corresponding to the runtime context

Parameters	*rctx* (IN) = pointer to a SQLLIB runtime context
	dbname (IN) = buffer containing the "logical" name for this connection
	dbnamelen (IN) = length of the dbname buffer
	svc (OUT) = address of an OCISvcCtx pointer
Returns	SQL_SUCCESS on success
	SQL_ERROR on failure

Notes

1. The usual error status variables in Pro*C/C++ such as SQLCA and SQLSTATE will not be affected by a call to this function
2. *dbname* is the same identifier used in an AT clause in an embedded SQL statement.
3. If *dbname* is a NULL pointer or *dbnamelen* is 0, then the default database connection is assumed, as in a SQL statement with no AT clause.
4. A value of -1 for *dbnamelen* is used to indicate that *dbname* is a zero-terminated string.

Embedding OCI Calls

To embed OCI release 8 calls in your Pro*C/C++ program:

1. Include the public header sql2oci.h

2. Declare an environment handle (type OCIEnv *) in your Pro*C/C++ program:

```
OCIEnv *oeh;
```

3. Optionally, declare a service context handle (type OCISvcCtx *) in your Pro*C/C++ program if the OCI function you wish to call requires the ServiceContext handle.

```
OCISvcCtx *svc;
```

4. Declare an error handle (type OCIError *) in your Pro*C/C++ program:

```
OCIError *err;
```

5. Connect to Oracle using the embedded SQL statement CONNECT. Do not connect using OCI.

```
EXEC SQL CONNECT ...
```

6. Obtain the OCI Environment handle that is associated with the desired runtime context using the SQLEnvGet function.

For single-threaded applications:

```
retcode = SQLEnvGet(SQL_SINGLE_RCTX, &oeh);
```

or for multi-threaded applications:

```
sql_context ctx1;
...
EXEC SQL CONTEXT ALLOCATE :ctx1;
EXEC SQL CONTEXT USE :ctx1;
...
EXEC SQL CONNECT :uid IDENTIFIED BY :pwd;
...
retcode = SQLEnvGet(ctx1, &oeh);
```

7. Allocate an OCI error handle using the retrieved environment handle

```
retcode = OCIHandleAlloc((dvoid *)oeh, (dvoid **)err,
                  (ub4)OCI_HTYPE_ERROR, (ub4)0, (dvoid **)0);
```

8. Optionally, if needed by the OCI call you use, obtain the OCIServiceContext handle using the SQLSvcCtxGet call:

For single-threaded applications:

```
retcode = SQLSvcCtxGet(SQL_SINGLE_RCTX,
                  (text *)dbname, (ub4)dbnlen, &svc);
```

or, for multi-threaded applications:

```
sql_context ctx1;
...
EXEC SQL ALLOCATE :ctx1;
EXEC SQL CONTEXT USE :ctx1;
...
EXEC SQL CONNECT :uid IDENTIFIED BY :pwd AT :dbname
     USING :hst;
```

```
...
retcode = SQLSvcCtxGet(ctx1, (text *)dbname,
          (ub4)strlen(dbname), &svc);
```

Note: A null pointer may be passed as the *dbname* if the Pro*C/C++ connection is not named with an AT clause.

Developing X/Open Applications

X/Open applications run in a distributed transaction processing (DTP) environment. In an abstract model, an X/Open application calls on *resource managers* (RMs) to provide a variety of services. For example, a database resource manager provides access to data in a database. Resource managers interact with a *transaction manager* (TM), which controls all transactions for the application.

Figure 4–5 Hypothetical DTP Model

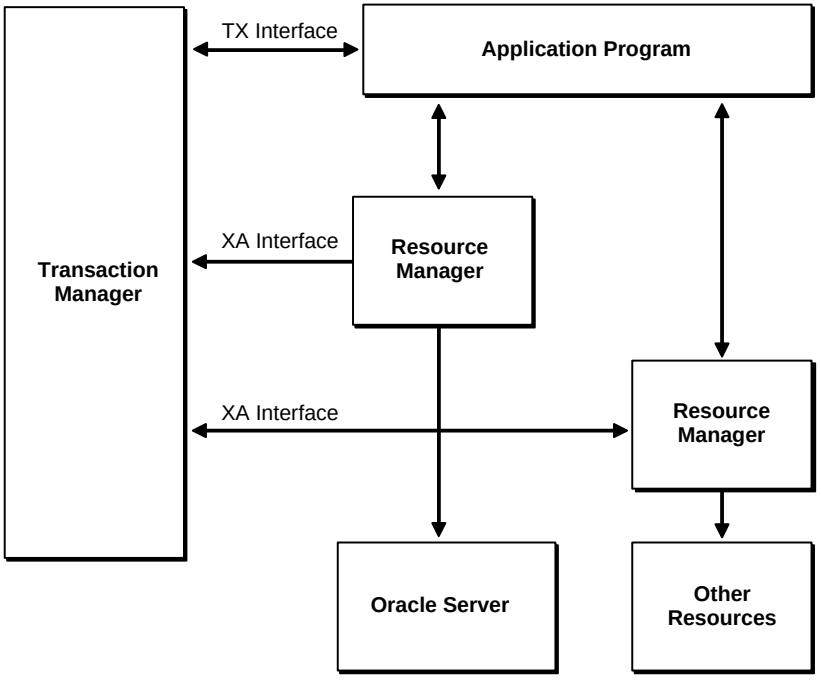


Figure 4–5 shows one way that components of the DTP model can interact to provide efficient access to data in an Oracle8 database. The DTP model specifies the *XA interface* between resource managers and the transaction manager. Oracle supplies an XA-compliant library, which you must link to your X/Open application. Also, you must specify the *native interface* between your application program and the resource managers.

The DTP model that specifies how a transaction manager and resource managers interact with an application program is described in the X/Open guide *Distributed Transaction Processing Reference Model* and related publications, which you can obtain by writing to

X/Open Company Ltd.

1010 El Camino Real, Suite 380

Menlo Park, CA 94025

For instructions on using the XA interface, see your Transaction Processing (TP) Monitor user's guide.

Oracle-Specific Issues

You can use the precompiler to develop applications that comply with the X/Open standards. However, you must meet the following requirements.

Connecting to Oracle8

The X/Open application does not establish and maintain connections to a database. Instead, the transaction manager and the XA interface, which is supplied by Oracle, handle database connections and disconnections transparently. So, normally an X/Open-compliant application does not execute CONNECT statements.

Transaction Control

The X/Open application must not execute statements such as COMMIT, ROLLBACK, SAVEPOINT, and SET TRANSACTION that affect the state of global transactions. For example, the application must not execute the COMMIT statement because the transaction manager handles commits. Also, the application must not execute SQL data definition statements such as CREATE, ALTER, and RENAME because they issue an implicit COMMIT.

The application can execute an internal ROLLBACK statement if it detects an error that prevents further SQL operations. However, this might change in later releases of the XA interface.

OCI Calls (Release 7 Only)

If you want your X/Open application to issue OCI calls, you must use the runtime library routine *sqlld2()*, which sets up an LDA for a specified connection established through the XA interface. For a description of the *sqlld2()* call, see the *Programmer's Guide to the Oracle Call Interface*. Note that the following OCI calls cannot be issued by an X/Open application: OCOM, OCON, OCOF, ONBLON, ORLON, OLON, OLOGOF.

For a discussion of how to use OCI Release 8 calls in Pro*C/C++, see "Interfacing to OCI Release 8" on page 4-56.

Linking

To get XA functionality, you must link the XA library to your X/Open application object modules. For instructions, see your system-specific Oracle8 documentation.

5

Using Embedded SQL

This chapter helps you to understand and apply the basic techniques of embedded SQL programming. Topics are:

- Using Host Variables
- Using Indicator Variables
- The Basic SQL Statements
- Using the SELECT Statement
- Using the INSERT Statement
- Using Subqueries
- Using the UPDATE Statement
- Using the DELETE Statement
- Using the WHERE Clause
- Using Cursors
- Using the DECLARE CURSOR Statement
- Using the OPEN Statement
- Using the FETCH Statement
- Using the CLOSE Statement
- Optimizer Hints
- Using the CURRENT OF Clause
- Using All the Cursor Statements
- A Complete Example

Using Host Variables

Oracle uses host variables to pass data and status information to your program; your program uses host variables to pass data to Oracle.

Output versus Input Host Variables

Depending on how they are used, host variables are called output or input host variables.

Host variables in the INTO clause of a SELECT or FETCH statement are called *output* host variables because they hold column values output by Oracle. Oracle assigns the column values to corresponding output host variables in the INTO clause.

All other host variables in a SQL statement are called *input* host variables because your program inputs their values to Oracle. For example, you use input host variables in the VALUES clause of an INSERT statement and in the SET clause of an UPDATE statement. They are also used in the WHERE, HAVING, and FOR clauses. Input host variables can appear in a SQL statement wherever a value or expression is allowed.

> **Attention:** In an ORDER BY clause, you *can* use a host variable, but it is treated as a constant or literal, and hence the contents of the host variable have no effect. For example, the SQL statement
>
> ```
> EXEC SQL SELECT ename, empno INTO :name,:number FROM emp ORDER BY :ord;
> ```
>
> appears to contain an input host variable, *:ord*. However, the host variable in this case is treated as a constant, and regardless of the value of *:ord*, no ordering is done.

You cannot use input host variables to supply SQL keywords or the names of database objects. Thus, you cannot use input host variables in data definition statements such as ALTER, CREATE, and DROP. In the following example, the DROP TABLE statement is *invalid*:

```
char table_name[30];

printf("Table name? ");
gets(table_name);

EXEC SQL DROP TABLE :table_name;  -- host variable not allowed
```

If you need to change database object names at runtime, use dynamic SQL. See "Using Dynamic SQL" on page 13-1 for more information about dynamic SQL.

Before Oracle executes a SQL statement containing input host variables, your program must assign values to them. An example follows:

```
int     emp_number;
char    temp[20];
VARCHAR emp_name[20];
/* get values for input host variables */
printf("Employee number? ");
gets(temp);
emp_number = atoi(temp);
printf("Employee name? ");
gets(emp_name.arr);
emp_name.len = strlen(emp_name.arr);

EXEC SQL INSERT INTO EMP (EMPNO, ENAME)
    VALUES (:emp_number, :emp_name);
```

Notice that the input host variables in the VALUES clause of the INSERT statement are prefixed with colons.

Using Indicator Variables

You can associate any host variable with an optional indicator variable. Each time the host variable is used in a SQL statement, a result code is stored in its associated indicator variable. Thus, indicator variables let you monitor host variables.

You use indicator variables in the VALUES or SET clause to assign nulls to input host variables and in the INTO clause to detect nulls or truncated values in output host variables.

On Input The values your program can assign to an indicator variable have the following meanings:

-1	Oracle will assign a null to the column, ignoring the value of the host variable.
>=0	Oracle will assign the value of the host variable to the column.

On Output The values Oracle can assign to an indicator variable have the following meanings:

-1	The column value is null, so the value of the host variable is indeterminate.

0	Oracle assigned an intact column value to the host variable.
>0	Oracle assigned a truncated column value to the host variable. The integer returned by the indicator variable is the original length of the column value, and SQLCODE in SQLCA is set to zero.
-2	Oracle assigned a truncated column variable to the host variable, but the original column value could not be determined (a LONG column, for example).

Remember, an indicator variable must be defined in the Declare Section as a 2-byte integer and, in SQL statements, must be prefixed with a colon and must immediately follow its host variable.

Inserting Nulls

You can use indicator variables to INSERT nulls. Before the INSERT, for each column you want to be null, set the appropriate indicator variable to -1, as shown in the following example:

```
set ind_comm = -1;

EXEC SQL INSERT INTO emp (empno, comm)
     VALUES (:emp_number, :commission:ind_comm);
```

The indicator variable *ind_comm* specifies that a null is to be stored in the COMM column.

You can hard code the null instead, as follows:

```
EXEC SQL INSERT INTO emp (empno, comm)
     VALUES (:emp_number, NULL);
```

While this is less flexible, it might be more readable. Typically, you insert nulls conditionally, as the next example shows:

```
printf("Enter employee number or 0 if not available: ");
scanf("%d", &emp_number);

if (emp_number == 0)
    ind_empnum = -1;
else
    ind_empnum = 0;

EXEC SQL INSERT INTO emp (empno, sal)
```

```
    VALUES (:emp_number:ind_empnum, :salary);
```

Handling Returned Nulls

You can also use indicator variables to manipulate returned nulls, as the following example shows:

```
EXEC SQL SELECT ename, sal, comm
    INTO :emp_name, :salary, :commission:ind_comm
    FROM emp
    WHERE empno = :emp_number;
 if (ind_comm == -1)
    pay = salary;   /* commission is null; ignore it */
else
    pay = salary + commission;
```

Fetching Nulls

When DBMS=V6, you can SELECT or FETCH nulls into a host variable not associated with an indicator variable, as the following example shows:

```
/* assume that commission is NULL */
EXEC SQL SELECT ename, sal, comm
    INTO :emp_name, :salary, :commission
    FROM emp
    WHERE empno = :emp_number;
```

SQLCODE in the SQLCA is set to zero indicating that Oracle executed the statement without detecting an error or exception.

However, when DBMS=V7 or DBMS=V8, if you SELECT or FETCH nulls into a host variable not associated with an indicator variable, Oracle issues the following error message:

```
ORA-01405: fetched column value is NULL
```

For more information about the DBMS option, see "DBMS" on page 9-14.

Testing for Nulls

You can use indicator variables in the WHERE clause to test for nulls, as the following example shows:

```
EXEC SQL SELECT ename, sal
INTO :emp_name, :salary
FROM emp
```

```
WHERE :commission INDICATOR :ind_comm IS NULL ...
```

However, you cannot use a relational operator to compare nulls with each other or with other values. For example, the following SELECT statement fails if the COMM column contains one or more nulls:

```
EXEC SQL SELECT ename, sal
INTO :emp_name, :salary
FROM emp
WHERE comm = :commission;
```

The next example shows how to compare values for equality when some of them might be nulls:

```
EXEC SQL SELECT ename, sal
     INTO :emp_name, :salary
     FROM emp
     WHERE (comm = :commission) OR ((comm IS NULL) AND
          (:commission INDICATOR :ind_comm IS NULL));
```

Fetching Truncated Values

When DBMS=V6, if you SELECT or FETCH a truncated column value into a host variable not associated with an indicator variable, Oracle issues the following error message:

```
ORA-01406: fetched column value was truncated
```

However, when DBMS=V7 or V8, a warning is generated instead of an error.

The Basic SQL Statements

Executable SQL statements let you query, manipulate, and control Oracle data and create, define, and maintain Oracle objects such as tables, views, and indexes. This chapter focuses on the statements that query and manipulate data.

When executing a data manipulation statement such as INSERT, UPDATE, or DELETE, your only concern, besides setting the values of any input host variables, is whether the statement succeeds or fails. To find out, you simply check the SQLCA. (Executing any SQL statement sets the SQLCA variables.) You can check in the following two ways:

- implicit checking with the WHENEVER statement
- explicit checking of SQLCA variables

For more information about the SQLCA and the WHENEVER statement, see Chapter 11, “Handling Runtime Errors”.

When executing a SELECT statement (query), however, you must

also deal with the rows of data it returns. Queries can be classified

as follows:

- queries that return no rows (that is, merely check for existence)
- queries that return only one row
- queries that return more than one row

Queries that return more than one row require explicitly declared cursors or the use of *host arrays* (host variables declared as arrays).

Note: Host arrays let you process “batches” of rows. For more information, see Chapter 12, “Using Host Arrays”. This chapter assumes the use of scalar host variables.

The following embedded SQL statements let you query and manipulate Oracle data:

SELECT	Returns rows from one or more tables.
INSERT	Adds new rows to a table.
UPDATE	Modifies rows in a table.
DELETE	Removes unwanted rows from a table.

The following embedded SQL statements let you define and manipulate an explicit cursor:

DECLARE	Names the cursor and associates it with a query.
OPEN	Executes the query and identifies the active set.
FETCH	Advances the cursor and retrieves each row in the active set, one by one.
CLOSE	Disables the cursor (the active set becomes undefined).

In the coming sections, first you learn how to code INSERT, UPDATE, DELETE, and single-row SELECT statements. Then, you progress to multirow SELECT

statements. For a detailed discussion of each statement and its clauses, see *Oracle8 SQL Reference*.

Using the SELECT Statement

Querying the database is a common SQL operation. To issue a query you use the SELECT statement. In the following example, you query the EMP table:

```
EXEC SQL SELECT ename, job, sal + 2000
INTO :emp_name, :job_title, :salary
FROM emp
WHERE empno = :emp_number;
```

The column names and expressions following the keyword SELECT make up the *select list*. The select list in our example contains three items. Under the conditions specified in the WHERE clause (and following clauses, if present), Oracle returns column values to the host variables in the INTO clause.

The number of items in the select list should equal the number of host variables in the INTO clause, so there is a place to store every returned value.

In the simplest case, when a query returns one row, its form is that shown in the last example. However, if a query can return more than one row, you must FETCH the rows using a cursor or SELECT them into a host-variable array. Cursors and the FETCH statement are discussed later in this chapter; array processing is discussed in Chapter 12, “Using Host Arrays”.

If a query is written to return only one row but might actually return several rows, the result of the SELECT is indeterminate. Whether this causes an error depends on how you specify the SELECT_ERROR option. The default value, YES, generates an error if more than one row is returned.

Available Clauses

You can use all of the following standard SQL clauses in your

SELECT statements:

- INTO
- FROM
- WHERE
- CONNECT BY
- START WITH

- GROUP BY
- HAVING
- ORDER BY
- FOR UPDATE OF

Except for the INTO clause, the text of embedded SELECT statements can be executed and tested interactively using SQL*Plus. In SQL*Plus, you use substitution variables or constants instead of input host variables.

Using the INSERT Statement

You use the INSERT statement to add rows to a table or view. In the following example, you add a row to the EMP table:

```
EXEC SQL INSERT INTO emp (empno, ename, sal, deptno)
VALUES (:emp_number, :emp_name, :salary, :dept_number);
```

Each column you specify in the *column list* must belong to the table named in the INTO clause. The VALUES clause specifies the row of values to be inserted. The values can be those of constants, host variables, SQL expressions, SQL functions such as USER and SYSDATE, or user-defined PL/SQL functions.

The number of values in the VALUES clause must equal the number of names in the column list. However, you can omit the column list if the VALUES clause contains a value for each column in the table, in the order that they are defined in the table.

Using Subqueries

A *subquery* is a nested SELECT statement. Subqueries let you conduct multipart searches. They can be used to

- supply values for comparison in the WHERE, HAVING,
- and START WITH clauses of SELECT, UPDATE, and
- DELETE statements
- define the set of rows to be inserted by a CREATE TABLE or INSERT statement
- define values for the SET clause of an UPDATE statement

The following example uses a subquery in an INSERT statement to copy rows from one table to another:

```
EXEC SQL INSERT INTO emp2 (empno, ename, sal, deptno)
SELECT empno, ename, sal, deptno FROM emp
WHERE job = :job_title;
```

Notice how the INSERT statement uses the subquery to obtain intermediate results.

Using the UPDATE Statement

You use the UPDATE statement to change the values of specified columns in a table or view. In the following example, you UPDATE the SAL and COMM columns in the EMP table:

```
EXEC SQL UPDATE emp
SET sal = :salary, comm = :commission
WHERE empno = :emp_number;
```

You can use the optional WHERE clause to specify the conditions under which rows are UPDATEd. See "Using the WHERE Clause" on page 5-10.

The SET clause lists the names of one or more columns for which you must provide values. You can use a subquery to provide the values, as the following example shows:

```
EXEC SQL UPDATE emp
SET sal = (SELECT AVG(sal)*1.1 FROM emp WHERE deptno = 20)
WHERE empno = :emp_number;
```

Using the DELETE Statement

You use the DELETE statement to remove rows from a table or view. In the following example, you delete all employees in a given department from the EMP table:

```
EXEC SQL DELETE FROM emp
WHERE deptno = :dept_number;
```

You can use the optional WHERE clause to specify the condition under which rows are DELETEd.

Using the WHERE Clause

You use the WHERE clause to SELECT, UPDATE, or DELETE only those rows in a table or view that meet your search condition. The WHERE-clause *search condition* is a Boolean expression, which can include scalar host variables, host arrays (not in SELECT statements), subqueries, and user-defined stored functions.

If you omit the WHERE clause, all rows in the table or view are processed. If you omit the WHERE clause in an UPDATE or DELETE statement, Oracle sets *sqlwarn[4]* in the SQLCA to 'W' to warn that all rows were processed.

Using Cursors

When a query returns multiple rows, you can explicitly define a cursor to

- process beyond the first row returned by the query
- keep track of which row is currently being processed

Or, you can use host arrays; see Chapter 12, "Using Host Arrays".

A cursor identifies the current row in the set of rows returned by the query. This allows your program to process the rows one at a time. The following statements let you define and manipulate a cursor:

- DECLARE CURSOR
- OPEN
- FETCH
- CLOSE

First you use the DECLARE CURSOR statement to name the cursor and associate it with a query.

The OPEN statement executes the query and identifies all the rows that meet the query search condition. These rows form a set called the active set of the cursor. After OPENing the cursor, you can use it to retrieve the rows returned by its associated query.

Rows of the active set are retrieved one by one (unless you use host arrays). You use a FETCH statement to retrieve the current row in the active set. You can execute FETCH repeatedly until all rows have been retrieved.

When done FETCHing rows from the active set, you disable the cursor with a CLOSE statement, and the active set becomes undefined.

The following sections show you how to use these cursor control statements in your application program.

Using the DECLARE CURSOR Statement

You use the DECLARE CURSOR statement to define a cursor by giving it a name and associating it with a query, as the following example shows:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
     SELECT ename, empno, sal
     FROM emp
     WHERE deptno = :dept_number;
```

The cursor name is an identifier used by the precompiler, *not* a host or program variable, and should not be defined in the Declare Section. Cursor names cannot be hyphenated. They can be any length, but only the first 31 characters are significant. For ANSI compatibility, use cursor names no longer than 18 characters.

The SELECT statement associated with the cursor cannot include an INTO clause. Rather, the INTO clause and list of output host variables are part of the FETCH statement.

Because it is declarative, the DECLARE CURSOR statement must physically (not just logically) precede all other SQL statements referencing the cursor. That is, forward references to the cursor are not allowed. In the following example, the OPEN statement is misplaced:

```
...
EXEC SQL OPEN emp_cursor;

EXEC SQL DECLARE emp_cursor CURSOR FOR
SELECT ename, empno, sal
    FROM emp
    WHERE ename = :emp_name;
```

The cursor control statements (DECLARE, OPEN, FETCH, CLOSE) must all occur within the same precompiled unit. For example, you cannot DECLARE a cursor in file A, then OPEN it in file B.

Your host program can DECLARE as many cursors as it needs. However, in a given file, every DECLARE statement must be unique. That is, you cannot DECLARE two cursors with the same name in one precompilation unit, even across blocks or procedures, because the scope of a cursor is global within a file.

If you will be using many cursors, you might want to specify the MAXOPENCURSORS option. For more information, see Chapter 9, “Running the Pro*C/C++ Precompiler”, and Appendix C, “Performance Tuning”.

Using the OPEN Statement

You use the OPEN statement to execute the query and identify the active set. In the following example, you OPEN a cursor named *emp_cursor*:

```
EXEC SQL OPEN emp_cursor;
```

OPEN positions the cursor just before the first row of the active set. It also zeroes the rows-processed count kept by the third element of SQLERRD in the SQLCA. However, none of the rows is actually retrieved at this point. That will be done by the FETCH statement.

Once you OPEN a cursor, the query's input host variables are not re-examined until you reOPEN the cursor. Thus, the active set does not change. To change the active set, you must reOPEN the cursor.

Generally, you should CLOSE a cursor before reOPENing it. However, if you specify MODE=ORACLE (the default), you need not CLOSE a cursor before reOPENing it. This can increase performance; for details, see Appendix C, "Performance Tuning".

The amount of work done by OPEN depends on the values of three precompiler options: HOLD_CURSOR, RELEASE_CURSOR, and MAXOPENCURSORS. For more information, see the section "Using the Precompiler Options" on page 9-10.

Using the FETCH Statement

You use the FETCH statement to retrieve rows from the active set and specify the output host variables that will contain the results. Recall that the SELECT statement associated with the cursor cannot include an INTO clause. Rather, the INTO clause and list of output host variables are part of the FETCH statement. In the following example, you FETCH INTO three host variables:

```
EXEC SQL FETCH emp_cursor
INTO :emp_name, :emp_number, :salary;
```

The cursor must have been previously DECLAREd and OPENed. The first time you execute FETCH, the cursor moves from before the first row in the active set to the first row. This row becomes the current row. Each subsequent execution of FETCH advances the cursor to the next row in the active set, changing the current row. The cursor can only move forward in the active set. To return to a row that has already been FETCHed, you must reOPEN the cursor, then begin again at the first row of the active set.

If you want to change the active set, you must assign new values to the input host variables in the query associated with the cursor, then reOPEN the cursor. When MODE=ANSI, you must CLOSE the cursor before reOPENing it.

As the next example shows, you can FETCH from the same cursor using different sets of output host variables. However, corresponding host variables in the INTO clause of each FETCH statement must have the same datatype.

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
SELECT ename, sal FROM emp WHERE deptno = 20;
...
EXEC SQL OPEN emp_cursor;

EXEC SQL WHENEVER NOT FOUND GOTO ...
for (;;)
{
    EXEC SQL FETCH emp_cursor INTO :emp_name1, :salary1;
    EXEC SQL FETCH emp_cursor INTO :emp_name2, :salary2;
    EXEC SQL FETCH emp_cursor INTO :emp_name3, :salary3;
    ...
}
```

If the active set is empty or contains no more rows, FETCH returns the "no data found" error code to *sqlcode* in the SQLCA, or to the SQLCODE or SQLSTATE status variables. The status of the output host variables is indeterminate. (In a typical program, the WHENEVER NOT FOUND statement detects this error.) To re-use the cursor, you must reOPEN it.

It is an error to FETCH on a cursor under the following conditions:

- before OPENing the cursor
- after a "no data found" condition
- after CLOSEing it

Using the CLOSE Statement

When done FETCHing rows from the active set, you CLOSE the cursor to free the resources, such as storage, acquired by OPENing the cursor. When a cursor is closed, parse locks are released. What resources are freed depends on how you specify the HOLD_CURSOR and RELEASE_CURSOR options. In the following example, you CLOSE the cursor named *emp_cursor*:

```
EXEC SQL CLOSE emp_cursor;
```

You cannot FETCH from a closed cursor because its active set becomes undefined. If necessary, you can reOPEN a cursor (with new values for the input host variables, for example).

When MODE=ORACLE, issuing a COMMIT or ROLLBACK closes cursors referenced in a CURRENT OF clause. Other cursors are unaffected by COMMIT or ROLLBACK and if open, remain open. However, when MODE=ANSI, issuing a COMMIT or ROLLBACK closes *all* explicit cursors. For more information about COMMIT and ROLLBACK, see Chapter 10, "Defining and Controlling Transactions". For more information about the CURRENT OF clause, see the next section.

Optimizer Hints

The Pro*C/C++ Precompiler supports optimizer hints in SQL statements. An *optimizer hint* is a suggestion to the Oracle SQL optimizer that can override the optimization approach that would normally be taken. You can use hints to specify the

- optimization approach for a SQL statement
- access path for each referenced table
- join order for a join
- method used to join tables

Hints allow you to choose between rule-based and cost-based optimization. With cost-based optimization, you can use further hints to maximize throughput or response time.

Issuing Hints

You can issue an optimizer hint inside a C or C++ style comment, immediately after a SELECT, DELETE, or UPDATE command. You indicate that the comment contains one or more hints by following the comment opener with a plus sign, leaving no space between the opener and the '+'. For example, the following statement uses the ALL_ROWS hint to let the cost-based approach optimize the statement for the goal of best throughput:

```
EXEC SQL SELECT /*+ ALL_ROWS (cost-based) */ empno, ename, sal, job
    INTO :emp_rec FROM emp
    WHERE deptno = :dept_number;
```

As shown in this statement, the comment can contain optimizer hints as well as other comments.

For more information about the cost-based optimizer, and optimizer hints, see *Oracle8 Application Developer's Guide.*

Using the CURRENT OF Clause

You use the CURRENT OF *cursor_name* clause in a DELETE or UPDATE statement to refer to the latest row FETCHed from the named cursor. The cursor must be open and positioned on a row. If no FETCH has been done or if the cursor is not open, the CURRENT OF clause results in an error and processes no rows.

The FOR UPDATE OF clause is optional when you DECLARE a cursor that is referenced in the CURRENT OF clause of an UPDATE or DELETE statement. The CURRENT OF clause signals the precompiler to add a FOR UPDATE clause if necessary. For more information, see "Using FOR UPDATE OF" on page 10-10.

In the following example, you use the CURRENT OF clause to refer to the latest row FETCHed from a cursor named *emp_cursor*:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
     SELECT ename, sal FROM emp WHERE job = 'CLERK'
     FOR UPDATE OF sal;
...
EXEC SQL OPEN emp_cursor;
EXEC SQL WHENEVER NOT FOUND GOTO ...
for (;;) {
    EXEC SQL FETCH emp_cursor INTO :emp_name, :salary;
    ...
    EXEC SQL UPDATE emp SET sal = :new_salary
         WHERE CURRENT OF emp_cursor;
}
```

Restrictions

You cannot use CURRENT OF clause on an index-organized table.

An explicit FOR UPDATE OF or an implicit FOR UPDATE acquires exclusive row locks. All rows are locked at the OPEN, not as they are FETCHed, and are released when you COMMIT or ROLLBACK. Therefore, you cannot FETCH from a FOR UPDATE cursor after a COMMIT. If you try to do this, Oracle returns a 1002 error code.

Also, you cannot use host arrays with the CURRENT OF clause. For an alternative, see "Mimicking CURRENT OF" on page 12-27.

Furthermore, you cannot reference multiple tables in an associated FOR UPDATE OF clause, which means that you cannot do joins with the CURRENT OF clause.

Finally, you cannot use dynamic SQL with the CURRENT OF clause.

Using All the Cursor Statements

The following example shows the typical sequence of cursor control statements in an application program:

```
   ...
/* define a cursor */
   EXEC SQL DECLARE emp_cursor CURSOR FOR
        SELECT ename, job
        FROM emp
        WHERE empno = :emp_number
        FOR UPDATE OF job;

/* open the cursor and identify the active set */
   EXEC SQL OPEN emp_cursor;

/* break if the last row was already fetched */
   EXEC SQL WHENEVER NOT FOUND DO break;

/* fetch and process data in a loop */
   for (;;)
   {
      EXEC SQL FETCH emp_cursor INTO :emp_name, :job_title;

/* optional host-language statements that operate on
   the FETCHed data */

      EXEC SQL UPDATE emp
           SET job = :new_job_title
           WHERE CURRENT OF emp_cursor;
   }
...
/* disable the cursor */
   EXEC SQL CLOSE emp_cursor;
   EXEC SQL COMMIT WORK RELEASE;
   ...
```

A Complete Example

The following complete program illustrates the use of a cursor and the FETCH statement. The program prompts for a department number, then displays the names of all employees in that department.

All FETCHes except the final one return a row and, if no errors were detected during the FETCH, a success status code. The final FETCH fails and returns the "no data found" Oracle error code to *sqlca.sqlcode*. The cumulative number of rows actually FETCHed is found in *sqlerrd[2]* in the SQLCA.

```
#include <stdio.h>

/* declare host variables */
char userid[12] = "SCOTT/TIGER";
char emp_name[10];
int  emp_number;
int  dept_number;
char temp[32];
void sql_error();

/* include the SQL Communications Area */
#include <sqlca.h>

main()
{  emp_number = 7499;
/* handle errors */
   EXEC SQL WHENEVER SQLERROR do sql_error("Oracle error");

/* connect to Oracle */
   EXEC SQL CONNECT :userid;
   printf("Connected.\n");

/* declare a cursor */
   EXEC SQL DECLARE emp_cursor CURSOR FOR
   SELECT ename
      FROM emp
      WHERE deptno = :dept_number;

   printf("Department number? ");
   gets(temp);
   dept_number = atoi(temp);

/* open the cursor and identify the active set */
   EXEC SQL OPEN emp_cursor;

   printf("Employee Name\n");
   printf("-------------\n");
/* fetch and process data in a loop
   exit when no more data */
   EXEC SQL WHENEVER NOT FOUND DO break;
```

```
   while (1)
   {
      EXEC SQL FETCH emp_cursor INTO :emp_name;
      printf("%s\n", emp_name);
   }
   EXEC SQL CLOSE emp_cursor;
   EXEC SQL COMMIT WORK RELEASE;
   exit(0);
}

void
sql_error(msg)
char *msg;
{
   char buf[500];
   int buflen, msglen;

   EXEC SQL WHENEVER SQLERROR CONTINUE;
   EXEC SQL ROLLBACK WORK RELEASE;
   buflen = sizeof (buf);
   sqlglm(buf, &buflen, &msglen);
   printf("%s\n", msg);
   printf("%*.s\n", msglen, buf);
   exit(1);
}
```

6

Using Embedded PL/SQL

This chapter shows you how to improve performance by embedding PL/SQL transaction processing blocks in your program. After pointing out the advantages of PL/SQL, this chapter discusses the following subjects:

- Embedding PL/SQL Blocks
- Using Host Variables
- Using Indicator Variables
- Using Host Arrays
- Using Cursors
- Stored Subprograms
- Using Dynamic SQL

Advantages of PL/SQL

This section looks at some of the features and benefits offered by PL/SQL, such as

- Better Performance
- Integration with Oracle
- Cursor FOR Loops
- Procedures and Functions
- Packages
- PL/SQL Tables
- User-Defined Records

For more information about PL/SQL, see *PL/SQL User's Guide and Reference*.

Better Performance

PL/SQL can help you reduce overhead, improve performance, and increase productivity. For example, without PL/SQL, Oracle must process SQL statements one at a time. Each SQL statement results in another call to the Server and higher overhead. However, with PL/SQL, you can send an entire block of SQL statements to the Server. This minimizes communication between your application and Oracle.

Integration with Oracle

PL/SQL is tightly integrated with the Oracle Server. For example, most PL/SQL datatypes are native to the Oracle data dictionary. Furthermore, you can use the %TYPE attribute to base variable declarations on column definitions stored in the data dictionary, as the following example shows:

```
job_title  emp.job%TYPE;
```

That way, you need not know the exact datatype of the column. Furthermore, if a column definition changes, the variable declaration changes accordingly and automatically. This provides data independence, reduces maintenance costs, and allows programs to adapt as the database changes.

Cursor FOR Loops

With PL/SQL, you need not use the DECLARE, OPEN, FETCH, and CLOSE statements to define and manipulate a cursor. Instead, you can use a cursor FOR loop, which implicitly declares its loop index as a record, opens the cursor

associated with a given query, repeatedly fetches data from the cursor into the record, then closes the cursor. An example follows:

```
DECLARE
...
BEGIN
   FOR emprec IN (SELECT empno, sal, comm FROM emp) LOOP
   IF emprec.comm / emprec.sal > 0.25 THEN ...
   ...
END LOOP;
END;
```

Notice that you use dot notation to reference components in the record.

Procedures and Functions

PL/SQL has two types of subprograms called *procedures* and *functions*, which aid application development by letting you isolate operations. Generally, you use a procedure to perform an action and a function to compute a value.

Procedures and functions provide *extensibility*. That is, they let you tailor the PL/SQL language to suit your needs. For example, if you need a procedure that creates a new department, just write your own as follows:

```
PROCEDURE create_dept
  (new_dname  IN CHAR(14),
   new_loc    IN CHAR(13),
   new_deptno OUT NUMBER(2)) IS
BEGIN
   SELECT deptno_seq.NEXTVAL INTO new_deptno FROM dual;
   INSERT INTO dept VALUES (new_deptno, new_dname, new_loc);
END create_dept;
```

When called, this procedure accepts a new department name and location, selects the next value in a department-number database sequence, inserts the new number, name, and location into the *dept* table, then returns the new number to the caller.

You use *parameter modes* to define the behavior of formal parameters. There are three parameter modes: IN (the default), OUT, and IN OUT. An IN parameter lets you pass values to the subprogram being called. An OUT parameter lets you return values to the caller of a subprogram. An IN OUT parameter lets you pass initial values to the subprogram being called and return updated values to the caller.

The datatype of each actual parameter must be convertible to the datatype of its corresponding formal parameter. Table 6–1 shows the legal conversions between datatypes.

Packages

PL/SQL lets you bundle logically related types, program objects, and subprograms into a *package*. With the Procedural Database Extension, packages can be compiled and stored in an Oracle database, where their contents can be shared by many applications.

Packages usually have two parts: a specification and a body. The *specification* is the interface to your applications; it declares the types, constants, variables, exceptions, cursors, and subprograms available for use. The *body* defines cursors and subprograms; it implements the specification. In the following example, you "package" two employment procedures:

```
PACKAGE emp_actions IS  -- package specification
  PROCEDURE hire_employee (empno NUMBER, ename CHAR, ...);

  PROCEDURE fire_employee (emp_id NUMBER);
END emp_actions;

PACKAGE BODY emp_actions IS  -- package body
  PROCEDURE hire_employee (empno NUMBER, ename CHAR, ...) IS
  BEGIN
    INSERT INTO emp VALUES (empno, ename, ...);
  END hire_employee;

  PROCEDURE fire_employee (emp_id NUMBER) IS
  BEGIN
    DELETE FROM emp WHERE empno = emp_id;
  END fire_employee;
END emp_actions;
```

Only the declarations in the package specification are visible and accessible to applications. Implementation details in the package body are hidden and inaccessible.

PL/SQL Tables

PL/SQL provides a composite datatype named TABLE. Objects of type TABLE are called *PL/SQL tables*, which are modeled as (but not the same as) database tables. PL/SQL tables have only one column and use a primary key to give you array-like

access to rows. The column can belong to any scalar type (such as CHAR, DATE, or NUMBER), but the primary key must belong to type BINARY_INTEGER.

You can declare PL/SQL table types in the declarative part of any block, procedure, function, or package. In the following example, you declare a TABLE type called *NumTabTyp*:

```
...
DECLARE
   TYPE NumTabTyp IS TABLE OF NUMBER
      INDEX BY BINARY_INTEGER;
...
BEGIN
   ...
END;
...
```

Once you define type *NumTabTyp*, you can declare PL/SQL tables of that type, as the next example shows:

```
num_tab  NumTabTyp;
```

The identifier *num_tab* represents an entire PL/SQL table.

You reference rows in a PL/SQL table using array-like syntax to specify the primary key value. For example, you reference the ninth row in the PL/SQL table named *num_tab* as follows:

```
num_tab(9) ...
```

User-Defined Records

You can use the %ROWTYPE attribute to declare a record that represents a row in a table or a row fetched by a cursor. However, you cannot specify the datatypes of components in the record or define components of your own. The composite datatype RECORD lifts those restrictions.

Objects of type RECORD are called *records*. Unlike PL/SQL tables, records have uniquely named components, which can belong to different datatypes. For example, suppose you have different kinds of data about an employee such as name, salary, hire date, and so on. This data is dissimilar in type but logically related. A record that contains such components as the name, salary, and hire date of an employee would let you treat the data as a logical unit.

You can declare record types and objects in the declarative part of any block, procedure, function, or package. In the following example, you declare a RECORD type called *DeptRecTyp*:

```
DECLARE
TYPE DeptRecTyp IS RECORD
    (deptno  NUMBER(4) NOT NULL, -- default is NULL allowed
    dname   CHAR(9),
    loc     CHAR(14));
```

Notice that the component declarations are like variable declarations. Each component has a unique name and specific datatype. You can add the NOT NULL option to any component declaration and so prevent the assigning of nulls to that component.

Once you define type *DeptRecTyp*, you can declare records of that type, as the next example shows:

```
dept_rec  DeptRecTyp;
```

The identifier *dept_rec* represents an entire record.

You use dot notation to reference individual components in a record. For example, you reference the *dname* component in the *dept_rec* record as follows:

```
dept_rec.dname ...
```

Embedding PL/SQL Blocks

The Pro*C/C++ Precompiler treats a PL/SQL block like a single embedded SQL statement. So, you can place a PL/SQL block anywhere in a program that you can place a SQL statement.

To embed a PL/SQL block in your Pro*C/C++ program, simply bracket the PL/SQL block with the keywords EXEC SQL EXECUTE and END-EXEC as follows:

```
EXEC SQL EXECUTE
DECLARE
...
BEGIN
   ...
END;
END-EXEC;
```

The keyword END-EXEC must be followed by a semicolon.

After writing your program, you precompile the source file in the

usual way.

When the program contains embedded PL/SQL, you must use the SQLCHECK=SEMANTICS command-line option, since the PL/SQL must be parsed by the Oracle Server. SQLCHECK=SEMANTICS requires the USERID option also, to connect to a server. For more information, see "Using the Precompiler Options" on page 9-10.

Using Host Variables

Host variables are the key to communication between a host language and a PL/SQL block. Host variables can be shared with PL/SQL, meaning that PL/SQL can set and reference host variables.

For example, you can prompt a user for information and use host variables to pass that information to a PL/SQL block. Then, PL/SQL can access the database and use host variables to pass the results back to your host program.

Inside a PL/SQL block, host variables are treated as global to the entire block and can be used anywhere a PL/SQL variable is allowed. Like host variables in a SQL statement, host variables in a PL/SQL block must be prefixed with a colon. The colon sets host variables apart from PL/SQL variables and database objects.

Restrictions on Host Variables

You can not use complex C expressions such as structure-member dereferencing in PL/SQL blocks. For more details and examples, see "Restriction" on page 6-12.

An Example

The following example illustrates the use of host variables with PL/SQL. The program prompts the user for an employee number, then displays the job title, hire date, and salary of that employee.

```
char username[100], password[20];
char job_title[20], hire_date[9], temp[32];
int emp_number;
float salary;

#include <sqlca.h>

printf("Username? \n");
gets(username);
printf("Password? \n");
gets(password);
```

```
EXEC SQL WHENEVER SQLERROR GOTO sql_error;

EXEC SQL CONNECT :username IDENTIFIED BY :password;
printf("Connected to Oracle\n");
for (;;)
{
   printf("Employee Number (0 to end)? ");
   gets(temp);
   emp_number = atoi(temp);

   if (emp_number == 0)
   {
      EXEC SQL COMMIT WORK RELEASE;
      printf("Exiting program\n");
      break;
   }
/*-------------- begin PL/SQL block -----------------*/
   EXEC SQL EXECUTE
   BEGIN
      SELECT job, hiredate, sal
         INTO :job_title, :hire_date, :salary
         FROM emp
         WHERE empno = :emp_number;
   END;
   END-EXEC;
/*-------------- end PL/SQL block -----------------*/

   printf("Number  Job Title  Hire Date  Salary\n");
   printf("-----------------------------------\n");
   printf("%6d  %8.8s  %9.9s  %6.2f\n",
   emp_number, job_title, hire_date, salary);
}
...
exit(0);

sql_error:
EXEC SQL WHENEVER SQLERROR CONTINUE;
EXEC SQL ROLLBACK WORK RELEASE;
printf("Processing error\n");
exit(1);
```

Notice that the host variable *emp_number* is set before the PL/SQL block is entered, and the host variables *job_title*, *hire_date*, and *salary* are set inside the block.

A More Complex Example

In the example below, you prompt the user for a bank account number, transaction type, and transaction amount, then debit or credit the account. If the account does not exist, you raise an exception. When the transaction is complete, you display its status.

```
#include <stdio.h>
#include <sqlca.h>

char username[20];
char password[20];
char status[80];
char temp[32];
int  acct_num;
double trans_amt;
void sql_error();



main()
{
   char trans_type;

/* printf("Username? ");
   gets(username);
   printf("Password? ");
   gets(password);
*/
   strcpy(password, "TIGER");
   strcpy(username, "SCOTT");

   EXEC SQL WHENEVER SQLERROR DO sql_error();
   EXEC SQL CONNECT :username IDENTIFIED BY :password;
   printf("Connected to Oracle\n");

   for (;;)
   {
      printf("Account Number (0 to end)? ");
      gets(temp);
      acct_num = atoi(temp);

      if(acct_num == 0)
      {
         EXEC SQL COMMIT WORK RELEASE;
```

```
            printf("Exiting program\n");
            break;
         }

         printf("Transaction Type - D)ebit or C)redit? ");
         gets(temp);
         trans_type = temp[0];

         printf("Transaction Amount? ");
         gets(temp);
         trans_amt = atof(temp);

      /*----------------- begin PL/SQL block -------------------*/
         EXEC SQL EXECUTE
         DECLARE
            old_bal      NUMBER(9,2);
            err_msg      CHAR(70);
            nonexistent  EXCEPTION;

         BEGIN
            :trans_type := UPPER(:trans_type);
            IF :trans_type = 'C' THEN       -- credit the account
               UPDATE accts SET bal = bal + :trans_amt
               WHERE acctid = :acct_num;
               IF SQL%ROWCOUNT = 0 THEN    -- no rows affected
                  RAISE nonexistent;
               ELSE
                  :status := 'Credit applied';
               END IF;
            ELSIF :trans_type = 'D' THEN    -- debit the account
               SELECT bal INTO old_bal FROM accts
                  WHERE acctid = :acct_num;
               IF old_bal >= :trans_amt THEN   -- enough funds
                  UPDATE accts SET bal = bal - :trans_amt
                     WHERE acctid = :acct_num;
                  :status := 'Debit applied';
               ELSE
                  :status := 'Insufficient funds';
               END IF;
            ELSE
               :status := 'Invalid type: ' || :trans_type;
            END IF;
            COMMIT;
         EXCEPTION
            WHEN NO_DATA_FOUND OR nonexistent THEN
```

```
            :status := 'Nonexistent account';
         WHEN OTHERS THEN
            err_msg := SUBSTR(SQLERRM, 1, 70);
            :status := 'Error: ' || err_msg;
      END;
      END-EXEC;
/*----------------- end PL/SQL block ---------------------- */

      printf("\nStatus: %s\n", status);
   }
   exit(0);
}


void
sql_error()
{
    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL ROLLBACK WORK RELEASE;
    printf("Processing error\n");
    exit(1);
}
```

VARCHAR Pseudotype

Recall from Chapter 3 that you can use the VARCHAR datatype to declare variable-length character strings. If the VARCHAR is an input host variable, you must tell Oracle what length to expect. So, set the length component to the actual length of the value stored in the string component.

If the VARCHAR is an output host variable, Oracle automatically sets the length component. However, to use a VARCHAR output host variable in your PL/SQL block, you must initialize the length component *before* entering the block. So, set the length component to the declared (maximum) length of the VARCHAR, as shown here:

```
int     emp_number;
varchar emp_name[10];
float   salary;
...
emp_name.len = 10;   /* initialize length component */

EXEC SQL EXECUTE
  BEGIN
    SELECT ename, sal INTO :emp_name, :salary
```

```
        FROM emp
        WHERE empno = :emp_number;
    ...
  END;
END-EXEC;
...
```

Restriction

Do not use C pointer or array syntax in PL/SQL blocks. The PL/SQL compiler does not understand C host-variable expressions and is, therefore, unable to parse them. For example, the following is *invalid*:

```
EXEC SQL EXECUTE
    BEGIN
        :x[5].name := 'SCOTT';
        ...
    END;
END-EXEC;
```

To avoid syntax errors, use a placeholder (a temporary variable), to hold the address of the structure field to populate structures as shown in the following *valid* example:

```
name = &employee.name
EXEC SQL EXECUTE
    BEGIN
        :name := ...;
        ...
    END;
END-EXEC;
```

Using Indicator Variables

PL/SQL does not need indicator variables because it can manipulate nulls. For example, within PL/SQL, you can use the IS NULL operator to test for nulls, as follows:

```
IF variable IS NULL THEN ...
```

And, you can use the assignment operator (:=) to assign nulls, as follows:

```
variable := NULL;
```

However, a host language such as C needs indicator variables because it cannot manipulate nulls. Embedded PL/SQL meets this need by letting you use indicator variables to

- accept nulls input from a host program
- output nulls or truncated values to a host program

When used in a PL/SQL block, indicator variables are subject to the following rules:

- You cannot refer to an indicator variable by itself; it must be appended to its associated host variable.
- If you refer to a host variable with its indicator variable, you must always refer to it that way in the same block.

In the following example, the indicator variable *ind_comm* appears with its host variable *commission* in the SELECT statement, so it must appear that way in the IF statement:

```
...
EXEC SQL EXECUTE
BEGIN
    SELECT ename, comm
        INTO :emp_name, :commission :ind_comm
        FROM emp
        WHERE empno = :emp_number;
    IF :commission :ind_comm IS NULL THEN ...
    ...
END;
END-EXEC;
```

Notice that PL/SQL treats *:commission :ind_comm* like any other simple variable. Though you cannot refer directly to an indicator variable inside a PL/SQL block, PL/SQL checks the value of the indicator variable when entering the block and sets the value correctly when exiting the block.

Handling Nulls

When entering a block, if an indicator variable has a value of -1, PL/SQL automatically assigns a null to the host variable. When exiting the block, if a host variable is null, PL/SQL automatically assigns a value of -1 to the indicator variable. In the next example, if *ind_sal* had a value of -1 before the PL/SQL block was entered, the *salary_missing* exception is raised. An *exception* is a named error condition.

```
...
EXEC SQL EXECUTE
BEGIN
    IF :salary :ind_sal IS NULL THEN
    RAISE salary_missing;
END IF;
...
END;
END-EXEC;
...
```

Handling Truncated Values

PL/SQL does not raise an exception when a truncated string value is assigned to a host variable. However, if you use an indicator variable, PL/SQL sets it to the original length of the string. In the following example, the host program will be able to tell, by checking the value of *ind_name*, if a truncated value was assigned to *emp_name*:

```
...
EXEC SQL EXECUTE
DECLARE
...
new_name  CHAR(10);
BEGIN
    ...
    :emp_name:ind_name := new_name;
    ...
END;
END-EXEC;
```

Using Host Arrays

You can pass input host arrays and indicator arrays to a PL/SQL block. They can be indexed by a PL/SQL variable of type BINARY_INTEGER or by a host variable compatible with that type. Normally, the entire host array is passed to PL/SQL, but you can use the ARRAYLEN statement (discussed later) to specify a smaller array dimension.

Furthermore, you can use a procedure call to assign all the values in a host array to rows in a PL/SQL table. Given that the array subscript range is *m* .. *n*, the corresponding PL/SQL table index range is always

1 .. *n* - *m* + 1. For example, if the array subscript range is 5 .. 10, the corresponding PL/SQL table index range is 1 .. (10 - 5 + 1) or 1 .. 6.

In the example below, you pass an array named *salary* to a PL/SQL block, which uses the array in a function call. The function is named *median* because it finds the middle value in a series of numbers. Its formal parameters include a PL/SQL table named *num_tab*. The function call assigns all the values in the actual parameter *salary* to rows in the formal parameter *num_tab*.

```
...
float salary[100];

/* populate the host array */

EXEC SQL EXECUTE
  DECLARE
    TYPE NumTabTyp IS TABLE OF REAL
        INDEX BY BINARY_INTEGER;
    median_salary  REAL;
    n  BINARY_INTEGER;
...
  FUNCTION median (num_tab NumTabTyp, n INTEGER)
    RETURN REAL IS
  BEGIN
    -- compute median
  END;
  BEGIN
    n := 100;
    median_salary := median(:salary, n);
    ...
  END;
END-EXEC;
...
```

> **Warning:** In dynamic SQL Method 4, you cannot bind a host array to a PL/SQL procedure with a parameter of type "table." For more information, see "Using Method 4" on page 13-25.

You can also use a procedure call to assign all row values in a PL/SQL table to corresponding elements in a host array. For an example, see the section "Stored Subprograms" on page 6-21.

Table 6–1 shows the legal conversions between row values in a PL/SQL table and elements in a host array. For example, a host array of type LONG is compatible

with a PL/SQL table of type VARCHAR2, LONG, RAW, or LONG RAW. Notably, it is not compatible with a PL/SQL table of type CHAR.

Table 6–1 Legal Datatype Conversions

Host Array	CHAR	DATE	LONG	LONG RAW	NUMBER	RAW	ROWID	VARCHAR2
CHARF	X							
CHARZ	X							
DATE		X						
DECIMAL					X			
DISPLAY					X			
FLOAT					X			
INTEGER					X			
LONG	X		X					
LONG VARCHAR			X	X		X		X
LONG VARRAW				X		X		
NUMBER					X			
RAW				X		X		
ROWID							X	
STRING			X	X		X		X
UNSIGNED					X			
VARCHAR			X	X		X		X
VARCHAR2			X	X		X		X
VARNUM					X			
VARRAW				X		X		

The Pro*C/C++ Precompiler does not check your usage of host arrays. For instance, no index range-checking is done.

ARRAYLEN Statement

Suppose you must pass an input host array to a PL/SQL block for processing. By default, when binding such a host array, the Pro*C/C++ Precompiler uses its declared dimension. However, you might not want to process the entire array. In that case, you can use the ARRAYLEN statement to specify a smaller array dimension. ARRAYLEN associates the host array with a host variable, which stores the smaller dimension. The statement syntax is

```
EXEC SQL ARRAYLEN host_array (dimension) [EXECUTE];
```

where *dimension* is a 4-byte integer host variable, *not* a literal or expression.

EXECUTE is an optional keyword.

The ARRAYLEN statement must appear along with, but somewhere after, the declarations of *host_array* and *dimension*. You cannot specify an offset into the host array. However, you might be able to use C features for that purpose. The following example uses ARRAYLEN to override the default dimension of a C host array named *bonus*:

```
float bonus[100];
int dimension;
EXEC SQL ARRAYLEN bonus (dimension);
/* populate the host array */
...
dimension = 25;  /* set smaller array dimension */
EXEC SQL EXECUTE
DECLARE
    TYPE NumTabTyp IS TABLE OF REAL
    INDEX BY BINARY_INTEGER;
    median_bonus  REAL;
    FUNCTION median (num_tab NumTabTyp, n INTEGER)
        RETURN REAL IS
  BEGIN
    -- compute median
  END;
  BEGIN
    median_bonus := median(:bonus, :my_dimension);
    ...
  END;
END-EXEC;
```

Only 25 array elements are passed to the PL/SQL block because ARRAYLEN downsizes the array from 100 to 25 elements. As a result, when the PL/SQL block

is sent to Oracle for execution, a much smaller host array is sent along. This saves time and, in a networked environment, reduces network traffic.

Optional Keyword EXECUTE

Host arrays used in a dynamic SQL method 2 EXEC SQL EXECUTE statement may have two different interpretations based on the presence or absence of the optional keyword EXECUTE. See "Using Method 2"on page 13 - 13.

By default (if the EXECUTE keyword is absent on an ARRAYLEN statement):

- The host array is a considered when determining the number of times a PL/SQL block will be executed. (The minimum array dimension is used.)
- The host array must not be bound to a PL/SQL index table.

If the keyword EXECUTE is present:

- The host array must be bound to an index table.
- The PL/SQL block will be executed one time.
- All host variables specified in the EXEC SQL EXECUTE statement must either
  - be specified in an ARRAYLEN ... EXECUTE statement, or
  - be a scalar.

For example, given the following PL/SQL procedure:

```
CREATE OR REPLACE PACKAGE pkg AS
       TYPE tab IS TABLE OF NUMBER(5) INDEX BY BINARY_INTEGER;
       PROCEDURE proc1 (parm1 tab, parm2 NUMBER, parm3 tab);
END;
```

The following Pro*C/C++ function demonstrates how host arrays can be used to determine how many times a given PL/SQL block is executed. In this case, the PL/SQL block will be execute 3 times resulting in 3 new rows in the emp table.

```
func1()
{
  int empno_arr[5] = {1111, 2222, 3333, 4444, 5555};
  char *ename_arr[3] = {"MICKEY", "MINNIE", "GOOFY"};
  char *stmt1 = "BEGIN INSERT INTO emp(empno, ename) VALUES :b1, :b2; END;";

  EXEC SQL PREPARE s1 FROM :stmt1;
  EXEC SQL EXECUTE s1 USING :empno_arr, ename_arr;
}
```

The following Pro*C/C++ function demonstrates how to bind a host array to a PL/SQL index table through dynamic method 2. Note the presence of the ARRAYLEN...EXECUTE statement for all host arrays specified in the EXEC SQL EXECUTE statement.

```
func2()
{
  int ii = 2;
  int int_tab[3] = {1,2,3};
  int dim = 3;
  EXEC SQL ARRAYLEN int_tab (dim) EXECUTE;

  char *stmt2 = "begin pkg.proc1(:v1, :v2, :v3); end; ";

  EXEC SQL PREPARE s2 FROM :stmt2;
  EXEC SQL EXECUTE s2 USING :int_tab, :ii, :int_tab;
}
```

However the following Pro*C/C++ function will result in a precompile-time error because there is no ARRAYLEN...EXECUTE statement for int_arr.

```
func3()
{
  int int_arr[3];
  int int_tab[3] = {1,2,3};
  int dim = 3;
  EXEC SQL ARRAYLEN int_tab (dim) EXECUTE;

  char *stmt3 = "begin pkg.proc1(:v1, :v2, :v3); end; ";

  EXEC SQL PREPARE s3 FROM :stmt3;
  EXEC SQL EXECUTE s3 USING :int_tab, :int_arr, :int_tab;
}
```

Using Cursors

Every embedded SQL statement is assigned a cursor, either explicitly by you in a DECLARE CURSOR statement or implicitly by the precompiler. Internally, the precompiler maintains a cache, called the *cursor cache*, to control the execution of embedded SQL statements. When executed, every SQL statement is assigned an entry in the cursor cache. This entry is linked to a private SQL area in your Program Global Area (PGA) within Oracle.

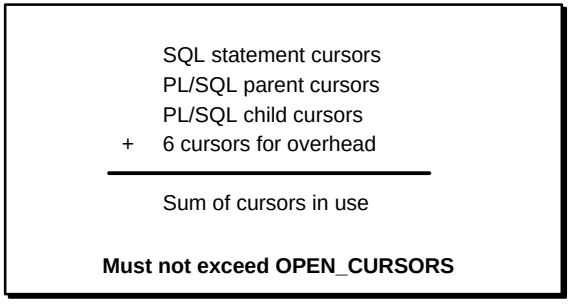
Various precompiler options, including MAXOPENCURSORS, HOLD_CURSOR, and RELEASE_CURSOR, let you manage the cursor cache to improve performance. For example, RELEASE_CURSOR controls what happens to the link between the cursor cache and private SQL area. If you specify RELEASE_CURSOR=YES, the link is removed after Oracle executes the SQL statement. This frees memory allocated to the private SQL area and releases parse locks. See "Cursor Control" on page C-7 for more information.

For purposes of cursor cache management, an embedded PL/SQL block is treated just like a SQL statement. At run time, a cursor, called a *parent cursor*, is associated with the entire PL/SQL block. A corresponding entry is made to the cursor cache, and this entry is linked to a private SQL area in the PGA.

Each SQL statement inside the PL/SQL block also requires a private SQL area in the PGA. So, PL/SQL manages a separate cache, called the *child cursor cache*, for these SQL statements. Their cursors are called *child cursors*. Because PL/SQL manages the child cursor cache, you do not have direct control over child cursors.

The maximum number of cursors your program can use simultaneously is set by the Oracle initialization parameter OPEN_CURSORS. Figure 6–1 shows you how to calculate the maximum number of cursors in use:

Figure 6–1 Maximum Cursors in Use



If your program exceeds the limit imposed by OPEN_CURSORS, you get the following Oracle error:

```
ORA-01000: maximum open cursors exceeded
```

You can avoid this error by specifying the RELEASE_CURSOR=YES and HOLD_CURSOR=NO options. If you do not want to precompile the entire program with RELEASE_CURSOR set to YES, simply reset it to NO after each PL/SQL block, as follows:

```
EXEC ORACLE OPTION (RELEASE_CURSOR=YES);
-- first embedded PL/SQL block
EXEC ORACLE OPTION (RELEASE_CURSOR=NO);
-- embedded SQL statements
EXEC ORACLE OPTION (RELEASE_CURSOR=YES);
-- second embedded PL/SQL block
EXEC ORACLE OPTION (RELEASE_CURSOR=NO);
-- embedded SQL statements
```

An Alternative

The MAXOPENCURSORS option specifies the initial size of the cursor cache. For example, when MAXOPENCURSORS=10, the cursor cache can hold up to 10 entries. If a new cursor is needed and HOLD_CURSOR=NO, and there are no free cache entries, the precompiler tries to reuse an entry. If you specify a very low value for MAXOPENCURSORS, the precompiler is forced to reuse the parent cursor more often. All the child cursors are released as soon as the parent cursor is reused.

Stored Subprograms

Unlike anonymous blocks, PL/SQL subprograms (procedures and functions) can be compiled separately, stored in an Oracle database, and invoked. A subprogram explicitly CREATEd using an Oracle tool such as SQL*Plus or SQL*DBA is called a *stored* subprogram. Once compiled and stored in the data dictionary, it is a database object, which can be re-executed without being recompiled.

When a subprogram within a PL/SQL block or stored procedure is sent to Oracle by your application, it is called an *inline* subprogram. Oracle compiles the inline subprogram and caches it in the System Global Area (SGA) but does not store the source or object code in the data dictionary.

Subprograms defined within a package are considered part of the package, and so are called *packaged* subprograms. Stored subprograms not defined within a package are called *stand-alone* subprograms.

Creating Stored Subprograms

You can embed the SQL statements CREATE FUNCTION, CREATE PROCEDURE, and CREATE PACKAGE in a host program, as the following example shows:

```
EXEC SQL CREATE
FUNCTION sal_ok (salary REAL, title CHAR)
RETURN BOOLEAN AS
```

```
min_sal  REAL;
max_sal  REAL;
  BEGIN
    SELECT losal, hisal INTO min_sal, max_sal
        FROM sals
        WHERE job = title;
    RETURN (salary >= min_sal) AND
           (salary <= max_sal);
  END sal_ok;
END-EXEC;
```

Notice that the embedded CREATE {FUNCTION | PROCEDURE | PACKAGE} statement is a hybrid. Like all other embedded CREATE statements, it begins with the keywords EXEC SQL (not EXEC SQL EXECUTE). But, unlike other embedded CREATE statements, it ends with the PL/SQL terminator END-EXEC.

In the example below, you create a package that contains a procedure named *get_employees*, which fetches a batch of rows from the EMP table. The batch size is determined by the caller of the procedure, which might be another stored subprogram or a client application.

The procedure declares three PL/SQL tables as OUT formal parameters, then fetches a batch of employee data into the PL/SQL tables. The matching actual parameters are host arrays. When the procedure finishes, it automatically assigns all row values in the PL/SQL tables to corresponding elements in the host arrays.

```
EXEC SQL CREATE OR REPLACE PACKAGE emp_actions AS
    TYPE CharArrayTyp IS TABLE OF VARCHAR2(10)
        INDEX BY BINARY_INTEGER;
    TYPE NumArrayTyp IS TABLE OF FLOAT
        INDEX BY BINARY_INTEGER;
  PROCEDURE get_employees(
    dept_number IN     INTEGER,
    batch_size  IN     INTEGER,
    found       IN OUT INTEGER,
    done_fetch  OUT    INTEGER,
    emp_name    OUT    CharArrayTyp,
    job-title   OUT    CharArrayTyp,
    salary      OUT    NumArrayTyp);
  END emp_actions;
END-EXEC;
EXEC SQL CREATE OR REPLACE PACKAGE BODY emp_actions AS

    CURSOR get_emp (dept_number IN INTEGER) IS
        SELECT ename, job, sal FROM emp
```

```
            WHERE deptno = dept_number;

  PROCEDURE get_employees(
    dept_number IN     INTEGER,
    batch_size  IN     INTEGER,
    found       IN OUT INTEGER,
    done_fetch  OUT    INTEGER,
    emp_name    OUT    CharArrayTyp,
    job_title   OUT    CharArrayTyp,
    salary      OUT    NumArrayTyp) IS

  BEGIN
    IF NOT get_emp%ISOPEN THEN
        OPEN get_emp(dept_number);
    END IF;
    done_fetch := 0;
    found := 0;
    FOR i IN 1..batch_size LOOP
        FETCH get_emp INTO emp_name(i),
        job_title(i), salary(i);
        IF get_emp%NOTFOUND THEN
            CLOSE get_emp;
            done_fetch := 1;
            EXIT;
        ELSE
            found := found + 1;
        END IF;
    END LOOP;
  END get_employees;
END emp_actions;
END-EXEC;
```

You specify the REPLACE clause in the CREATE statement to redefine an existing package without having to drop the package, recreate it, and regrant privileges on it. For the full syntax of the CREATE statement see *Oracle8 SQL Reference*.

If an embedded CREATE {FUNCTION | PROCEDURE | PACKAGE} statement fails, Oracle generates a warning, not an error.

Calling a Stored Subprogram

To invoke (call) a stored subprogram from your host program, you must use an anonymous PL/SQL block. In the following example, you call a stand-alone procedure named *raise_salary*:

```
EXEC SQL EXECUTE
  BEGIN
    raise_salary(:emp_id, :increase);
  END;
END-EXEC;
```

Notice that stored subprograms can take parameters. In this example, the actual parameters *emp_id* and *increase* are C host variables.

In the next example, the procedure *raise_salary* is stored in a package named *emp_actions*, so you must use dot notation to fully qualify the procedure call:

```
EXEC SQL EXECUTE
BEGIN
    emp_actions.raise_salary(:emp_id, :increase);
END;
END-EXEC;
```

An actual IN parameter can be a literal, scalar host variable, host array, PL/SQL constant or variable, PL/SQL table, PL/SQL user-defined record, procedure call, or expression. However, an actual OUT parameter cannot be a literal, procedure call, or expression.

In the following example, three of the formal parameters are PL/SQL tables, and the corresponding actual parameters are host arrays. The program calls the stored procedure *get_employees* (see page 6-21) repeatedly, displaying each batch of employee data, until no more data is found. This program is available on-line in the *demo* directory, in the file *sample9.pc*. A SQL script to create the CALLDEMO stored package is available in the file *calldemo.sql*.

```
/*************************************************************
Sample Program 9:  Calling a stored procedure

This program connects to ORACLE using the SCOTT/TIGER
account.  The program declares several host arrays, then
calls a PL/SQL stored procedure (GET_EMPLOYEES in the
CALLDEMO package) that fills the table OUT parameters.  The
PL/SQL procedure returns up to ASIZE values.

Sample9 keeps calling GET_EMPLOYEES, getting ASIZE arrays
each time, and printing the values, until all rows have been
retrieved.  GET_EMPLOYEES sets the done_flag to indicate "no
more data."
*************************************************************/
#include <stdio.h>
#include <string.h>
```

```
EXEC SQL INCLUDE sqlca.h;


typedef char asciz[20];
typedef char vc2_arr[11];

EXEC SQL BEGIN DECLARE SECTION;
/* User-defined type for null-terminated strings */
EXEC SQL TYPE asciz  IS STRING(20) REFERENCE;

/* User-defined type for a VARCHAR array element. */
EXEC SQL TYPE vc2_arr IS VARCHAR2(11) REFERENCE;

asciz     username;
asciz     password;
int       dept_no;              /* which department to query? */
vc2_arr   emp_name[10];            /* array of returned names */
vc2_arr   job[10];
float     salary[10];
int       done_flag;
int       array_size;
int       num_ret;                 /* number of rows returned */
EXEC SQL END DECLARE SECTION;

long      SQLCODE;



void print_rows();            /* produces program output      */
void sql_error();             /* handles unrecoverable errors */



main()
{
   int   i;
   char  temp_buf[32];

/* Connect to ORACLE. */
   EXEC SQL WHENEVER SQLERROR DO sql_error();
   strcpy(username, "scott");
   strcpy(password, "tiger");
   EXEC SQL CONNECT :username IDENTIFIED BY :password;
   printf("\nConnected to ORACLE as user: %s\n\n", username);
```

```
   printf("Enter department number: ");
   gets(temp_buf);
   dept_no = atoi(temp_buf);/* Print column headers. */
   printf("\n\n");
   printf("%-10.10s%-10.10s%s\n", "Employee", "Job", "Salary");
   printf("%-10.10s%-10.10s%s\n", "--------", "---", "------");

/* Set the array size. */
   array_size = 10;

   done_flag = 0;
   num_ret = 0;

/*  Array fetch loop.
 *  The loop continues until the OUT parameter done_flag is set.
 *  Pass in the department number, and the array size--
 *  get names, jobs, and salaries back.
 */
   for (;;)
   {
      EXEC SQL EXECUTE
         BEGIN calldemo.get_employees
            (:dept_no, :array_size, :num_ret, :done_flag,
             :emp_name, :job, :salary);
         END;
      END-EXEC;

      print_rows(num_ret);

      if (done_flag)
         break;
   }

/* Disconnect from the database. */
   EXEC SQL COMMIT WORK RELEASE;
   exit(0);
}
void
print_rows(n)
int n;
{
   int i;

    if (n == 0)
    {
```

```
        printf("No rows retrieved.\n");
        return;
    }

    for (i = 0; i < n; i++)
        printf("%10.10s%10.10s%6.2f\n",
               emp_name[i], job[i], salary[i]);
}

/* Handle errors. Exit on any error. */
void
sql_error()
{
   char msg[512];
   int buf_len, msg_len;


   EXEC SQL WHENEVER SQLERROR CONTINUE;

   buf_len = sizeof(msg);
   sqlglm(msg, &buf_len, &msg_len);

   printf("\nORACLE error detected:");
   printf("\n%.*s \n", msg_len, msg);

   EXEC SQL ROLLBACK WORK RELEASE;
   exit(1);
}
```

Remember, the datatype of each actual parameter must be convertible to the datatype of its corresponding formal parameter. Also, before a stored procedure is exited, all OUT formal parameters must be assigned values. Otherwise, the values of corresponding actual parameters are indeterminate.

Remote Access

PL/SQL lets you access remote databases via *database links*. Typically, database links are established by your DBA and stored in the Oracle data dictionary. A database link tells Oracle where the remote database is located, the path to it, and what Oracle username and password to use. In the following example, you use the database link *dallas* to call the *raise_salary* procedure:

```
EXEC SQL EXECUTE
BEGIN
    raise_salary@dallas(:emp_id, :increase);
```

```
END;
END-EXEC;
```

You can create synonyms to provide location transparency for remote subprograms, as the following example shows:

```
CREATE PUBLIC SYNONYM raise_salary
FOR raise_salary@dallas;
```

Getting Information about Stored Subprograms

Chapter 3 described how to embed OCI calls in your host program. After calling the library routine SQLLDA to set up the LDA, use the OCI call *odessp* to get useful information about a stored subprogram. When you call *odessp*, you must pass it a valid LDA

and the name of the subprogram. For packaged subprograms, you must also pass the name of the package. *odessp* returns information about each subprogram parameter such as its datatype, size, position, and so on. For details, see *Programmer's Guide to the Oracle Call Interface*.

You can also use the DESCRIBE_PROCEDURE stored procedure, in the DBMS_DESCRIBE package. See *Oracle8 Application Developer's Guide* for more information about this procedure.

Using Dynamic SQL

Recall that the precompiler treats an entire PL/SQL block like a single SQL statement. Therefore, you can store a PL/SQL block in a string host variable. Then, if the block contains no host variables, you can use dynamic SQL Method 1 to EXECUTE the PL/SQL string. Or, if the block contains a known number of host variables, you can use dynamic SQL Method 2 to PREPARE and EXECUTE the PL/SQL string. If the block contains an unknown number of host variables, you must use dynamic SQL Method 4.

For more information, refer to Chapter 13, "Using Dynamic SQL", and Chapter 14, "Using Dynamic SQL: Advanced Concepts".

> **Warning:** In dynamic SQL Method 4, you cannot bind a host array to a PL/SQL procedure with a parameter of type "table." For more information, see "Using Method 4" on page 13-25.

7

Using C++

This chapter describes how you can use the Pro*C/C++ Precompiler to precompile your C++ embedded SQL application, and how Pro*C/C++ generates C++ compatible code.

Topics are:

- Understanding C++ Support
- Precompiling for C++
- Sample Programs

Understanding C++ Support

To understand how Pro*C/C++ supports C++, you must understand the basic functional capabilities of Pro*C/C++. In particular, you must be aware of how Pro*C/C++ differs from Pro*C Version 1.

The basic capabilities of Pro*C/C++ are:

- Full C preprocessor support. You can use **#define**, **#include**, **#ifdef**, and other preprocessor directives in your Pro*C/C++ program, to handle constructs that the precompiler itself must process. See "Support for the C Preprocessor" on page 3-2 for more information.
- No need for EXEC SQL ... DECLARE statements to surround host variables. This allows full ANSI C standard function prototyping when function parameters are host variables. See the section "Declaring Host Variables" on page 3-27.
- Use of native C structures as host variables, including the ability to pass structs (or pointers to structs) as host variables to functions, and write functions that return host structures or struct pointers. See "Structure Pointers" on page 3-42 for more information.

To support its C preprocessor capabilities and to enable host variables to be declared outside a special Declare Section, Pro*C/C++ incorporates a complete C parser. The Pro*C/C++ parser is a C parser; it cannot parse C++ code.

This means that for C++ support, you must be able to disable the C parser, or at least partially disable it. To disable the C parser, the Pro*C/C++ Precompiler includes command-line options to give you control over the extent of C parsing that Pro*C/C++ performs on your source code. The section "Precompiling for C++" on page 7-3 fully describes these options.

No Special Macro Processing

Using C++ with Pro*C/C++ does not require any special preprocessing or special macro processors that are external to Pro*C/C++. There is no need to run a macro processor on the output of the precompiler to achieve C++ compatibility.

If you are a user of a release of Pro*C/C++ Precompiler before this one, and you did use macro processors on the precompiler output, you should be able to precompile your C++ applications using Pro*C/C++ with no changes to your code.

Precompiling for C++

To control precompilation so that it accommodates C++, there are four considerations:

- Code emission by the precompiler
- Parsing capability
- The output filename extension
- The location of system header files

Code Emission

You must be able to specify what kind of code, C compatible code or C++ compatible code, the precompiler generates. Pro*C/C++ by default generates C code. C++ is not a perfect superset of C. Some changes are required in generated code so that it can be compiled by a C++ compiler.

For example, in addition to emitting your application code, the precompiler interposes calls to its runtime library, SQLLIB. The functions in SQLLIB are C functions. There is no special C++ version of SQLLIB. For this reason, if you want to compile the generated code using a C++ compiler, Pro*C/C++ must declare the functions called in SQLLIB as C functions.

For C output, the precompiler would generate a prototype such as

```
void sqlora(unsigned long *, void *);
```

But for C++ compatible code, the precompiler must generate

```
extern "C" {
void sqlora(unsigned long *, void *);
};
```

You control the kind of code Pro*C/C++ generates using the precompiler option CODE. There are three values for this option: CPP, KR_C, and ANSI_C. The differences between these options can be illustrated by considering how the declaration of the SQLLIB function *sqlora* differs among the three values for the CODE option:

```
void sqlora( /*_ unsigned long *, void * _*/);  /* K&R C */

void sqlora(unsigned long *, void *);           /* ANSI C */

extern "C" {                                    /* CPP */
```

```
void sqlora(unsigned long *, void *);
};
```

When you specify CODE=CPP, the precompiler

- Generates C++ compilable code.
- Gives the output file a platform-specific file extension (suffix), such as ".C" or ".cc", rather than the standard ".c" extension. (You can override this by using the CPP_SUFFIX option.)
- Causes the value of the PARSE option to default to PARTIAL. You can also specify PARSE=NONE. If you specify PARSE=FULL, an error is issued at precompile time.
- Allows the use of the C++ style / / Comments in your code. This style of Commenting is also permitted inside SQL statements and PL/SQL blocks when CODE=CPP.
- Pro*C/C++ recognizes SQL optimizer hints that begin with / /+.

See Chapter 9, "Running the Pro*C/C++ Precompiler" for information about the KR_C and ANSI_C values for the CODE option.

Parsing Code

You must be able to control the effect of the Pro*C/C++ C parser on your code. You do this by using the PARSE precompiler option, which controls how the precompiler's C parser treats your code.

The values and effects of the PARSE option are:

PARSE=NONE — The value NONE has the following effects:

- C preprocessor directives are understood only inside a declare section.
- You must declare all host variables inside a Declare Section.
- Precompiler release 1.x behavior

PARSE=PARTIAL — The value PARTIAL has the following effects:

- All preprocessor directives are understood
- You must declare all host variables inside a Declare Section

This option value is the default if CODE=CPP

PARSE=FULL — The value FULL has the following effects:

- The precompiler C parser runs on your code.
- All Preprocessor directives are understood.
- You can declare host variables at any place that they can be declared legally in C.

This option value is the default if the value of the CODE option is anything other than CPP. It is an error to specify PARSE=FULL when CODE=CPP.

To generate C++ compatible code, the PARSE option must be either NONE or PARTIAL. If PARSE=FULL, the C parser runs, and it does not understand C++ constructs in your code, such as classes.

Output Filename Extension

Most C compilers expect a default extension of ".c" for their input files. Different C++ compilers, however, can expect different filename extensions. The CPP_SUFFIX option allows you to specify the filename extension that the precompiler generates. The value of this option is a string, without the quotes or the period. For example, CPP_SUFFIX=cc, or CPP_SUFFIX=C.

System Header Files

Pro*C/C++ searches for standard system header files, such as *stdio.h*, in standard locations that are platform specific. For example, on almost all UNIX systems, the file *stdio.h* has the full pathname */usr/include/stdio.h*.

But a C++ compiler has its own version of *stdio.h* that is not in the standard system location. When you are precompiling for C++, you must use the SYS_INCLUDE precompiler option to specify the directory paths that Pro*C/C++ searches to look for system header files. For example:

```
SYS_INCLUDE=(/usr/lang/SC2.0.1/include,/usr/lang/SC2.1.1/include)
```

Use the INCLUDE precompiler option to specify the location of non-system header files. See "INCLUDE" on page 9-22. The directories specified by the SYS_INCLUDE option are searched before directories specified by the INCLUDE option.

If PARSE=NONE, the values specified in SYS_INCLUDE and INCLUDE for system files are not relevant, since there is no need for Pro*C/C++ to include system

header files. (You can, of course, still include Pro*C/C++-specific headers, such *sqlca.h*, using the EXEC SQL INCLUDE statement.)

Sample Programs

This section includes three sample Pro*C/C++ programs that include C++ constructs. Each of these programs is available on-line, in your *demo* directory.

cppdemo1.pc

```
/*  cppdemo1.pc
 *
 *  Prompts the user for an employee number, then queries the
 *  emp table for the employee's name, salary and commission.
 *  Uses indicator variables (in an indicator struct) to
 *  determine if the commission is NULL.
 */

#include <iostream.h>
#include <stdio.h>
#include <string.h>

// Parse=partial by default when code=cpp,
// so preprocessor directives are recognized and parsed fully.
#define     UNAME_LEN      20
#define     PWD_LEN        40

// Declare section is required when CODE=CPP and/or
// PARSE={PARTIAL|NONE}
EXEC SQL BEGIN DECLARE SECTION;
  VARCHAR username[UNAME_LEN];  // VARCHAR is an ORACLE pseudotype
  varchar password[PWD_LEN];    // can be in lower case also

  // Define a host structure for the output values
  // of a SELECT statement
  struct empdat {
      VARCHAR   emp_name[UNAME_LEN];
      float     salary;
      float     commission;
  } emprec;

  // Define an indicator struct to correspond to the
  // host output struct
  struct empind {
```

```
      short     emp_name_ind;
      short     sal_ind;
      short     comm_ind;
  } emprec_ind;


  // Input host variables
  int   emp_number;
  int   total_queried;
EXEC SQL END DECLARE SECTION;

// Define a C++ class object to match the desired
// struct from the above declare section.
class emp {
  char  ename[UNAME_LEN];
  float salary;
  float commission;
public:
  // Define a constructor for this C++ object that
  // takes ordinary C objects.
  emp(empdat&, empind&);
  friend ostream& operator<<(ostream&, emp&);
};

emp::emp(empdat& dat, empind& ind)
{
  strncpy(ename, (char *)dat.emp_name.arr, dat.emp_name.len);
  ename[dat.emp_name.len] = '\0';
  this->salary = dat.salary;
  this->commission = (ind.comm_ind < 0) ? 0 : dat.commission;
}

ostream& operator<<(ostream& s, emp& e)
{
  return s << e.ename << " earns " << e.salary <<
              " plus " << e.commission << " commission."
           << endl << endl;
}

// Include the SQL Communications Area
// You can use #include or EXEC SQL INCLUDE
#include <sqlca.h>

// Declare error handling function
void sql_error(char *msg);
```

```
main()
{
  char temp_char[32];

  // Register sql_error() as the error handler
  EXEC SQL WHENEVER SQLERROR DO sql_error("ORACLE error:");

  // Connect to ORACLE.  Program calls sql_error()
  // if an error occurs
  // when connecting to the default database.
  // Note the (char *) cast when
  // copying into the VARCHAR array buffer.
  username.len = strlen(strcpy((char *)username.arr, "SCOTT"));
  password.len = strlen(strcpy((char *)password.arr, "TIGER"));

  EXEC SQL CONNECT :username IDENTIFIED BY :password;

  // Here again, note the (char *) cast when using VARCHARs
  cout << "\nConnected to ORACLE as user: "
       << (char *)username.arr << endl << endl;

  // Loop, selecting individual employee's results
  total_queried = 0;
  while (1)
  {
      emp_number = 0;
      printf("Enter employee number (0 to quit): ");
      gets(temp_char);
      emp_number = atoi(temp_char);
      if (emp_number == 0)
        break;

      // Branch to the notfound label when the
      // 1403 ("No data found") condition occurs
      EXEC SQL WHENEVER NOT FOUND GOTO notfound;

      EXEC SQL SELECT ename, sal, comm
         INTO :emprec INDICATOR :emprec_ind // You can also use
                                            // C++ style
         FROM EMP                  // Comments in SQL statemtents.
         WHERE EMPNO = :emp_number;

      {
        // Basic idea is to pass C objects to
```

```
        // C++ constructors thus
        // creating equivalent C++ objects used in the
        // usual C++ way
        emp e(emprec, emprec_ind);
        cout << e;
      }

      total_queried++;
      continue;
notfound:
      cout << "Not a valid employee number - try again."
           << endl << endl;
  } // end while(1)

  cout << endl << "Total rows returned was "
       << total_queried << endl;
  cout << "Have a nice day!" << endl << endl;

  // Disconnect from ORACLE
  EXEC SQL COMMIT WORK RELEASE;
  exit(0);
}


void sql_error(char *msg)
{
    EXEC SQL WHENEVER SQLERROR CONTINUE;
    cout << endl << msg << endl;
    cout << sqlca.sqlerrm.sqlerrmc << endl;
    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

cppdemo2.pc

```
/*  cppdemo2.pc:  Dynamic SQL Method 3
 *
 *  This program uses dynamic SQL Method 3 to retrieve
 *  the names of all employees in a given department
 *  from the EMP table.
 */

#include <iostream.h>
```

```
#include <stdio.h>
#include <string.h>

#define USERNAME "SCOTT"
#define PASSWORD "TIGER"

/* Include the SQL Communications Area, a structure through
 * which ORACLE makes runtime status information such as error
 * codes, warning flags, and diagnostic text available to the
 * program. Also include the ORACA.
 */
#include <sqlca.h>
#include <oraca.h>

// The ORACA=YES option must be specified
// to enable use of the ORACA
EXEC ORACLE OPTION (ORACA=YES);

EXEC SQL BEGIN DECLARE SECTION;
  char    *username = USERNAME;
  char    *password = PASSWORD;
  VARCHAR  sqlstmt[80];
  VARCHAR  ename[10];
  int      deptno = 10;
EXEC SQL END DECLARE SECTION;

void sql_error(char *msg);
main()
{
  // Call sql_error() function on any error
  // in an embedded SQL statement
    EXEC SQL WHENEVER SQLERROR DO sql_error("Oracle error");

  // Save text of SQL current statement in
  // the ORACA if an error occurs.
    oraca.orastxtf = ORASTFERR;

  // Connect to Oracle.

    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    cout << endl << "Connected to Oracle." << endl << endl;

/* Assign a SQL query to the VARCHAR sqlstmt.  Both the
 * array and the length parts must be set properly.  Note
 * that the query contains one host-variable placeholder,
```

```
 * v1, for which an actual input host variable must be
 * supplied at OPEN time.
 */
    strcpy((char *)sqlstmt.arr,
           "SELECT ename FROM emp WHERE deptno = :v1");
    sqlstmt.len = strlen((char *)sqlstmt.arr);

/* Display the SQL statement and its current input host
 * variable.
 */
    cout << (char *)sqlstmt.arr << endl;
    cout << "   v1 = " << deptno << endl << endl <<"Employee"
         << endl << "--------" << endl;

/* The PREPARE statement associates a statement name with
 * a string containing a SELECT statement.  The statement
 * name is a SQL identifier, not a host variable, and
 * therefore does not appear in the Declare Section.
 *
 * A single statement name can be PREPAREd more than once,
 * optionally FROM a different string variable.
 */
    EXEC SQL PREPARE S FROM :sqlstmt;

/* The DECLARE statement associates a cursor with a
 * PREPAREd statement.  The cursor name, like the statement
 * name, does not appear in the Declare Section.

 * A single cursor name can not be DECLAREd more than once.
 */
    EXEC SQL DECLARE C CURSOR FOR S;
/* The OPEN statement evaluates the active set of the
 * PREPAREd query USING the specified input host variables,
 * which are substituted positionally for placeholders in
 * the PREPAREd query.  For each occurrence of a
 * placeholder in the statement there must be a variable
 * in the USING clause.  That is, if a placeholder occurs
 * multiple times in the statement, the corresponding
 * variable must appear multiple times in the USING clause.
 *
 * The USING clause can be omitted only if the statement
 * contains no placeholders.  OPEN places the cursor at the
 * first row of the active set in preparation for a FETCH.
 *
 * A single DECLAREd cursor can be OPENed more than once,
```

```
 * optionally USING different input host variables.
 */
    EXEC SQL OPEN C USING :deptno;

/* Break the loop when all data have been retrieved. */

    EXEC SQL WHENEVER NOT FOUND DO break;

/* Loop until the NOT FOUND condition is detected. */

    while (1)
    {
/* The FETCH statement places the select list of the
 * current row into the variables specified by the INTO
 * clause, then advances the cursor to the next row.  If
 * there are more select-list fields than output host
 * variables, the extra fields will not be returned.
 * Specifying more output host variables than select-list
 * fields results in an ORACLE error.
 */
        EXEC SQL FETCH C INTO :ename;

/* Null-terminate the array before output. */

        ename.arr[ename.len] = '\0';
        cout << (char *)ename.arr << endl;
        }

/* Print the cumulative number of rows processed by the
 * current SQL statement.
 */
    printf("\nQuery returned %d row%s.\n\n", sqlca.sqlerrd[2],
        (sqlca.sqlerrd[2] == 1) ? "" : "s");

/* The CLOSE statement releases resources associated with
 * the cursor.
 */
    EXEC SQL CLOSE C;

/* Commit any pending changes and disconnect from Oracle. */
    EXEC SQL COMMIT RELEASE;

    cout << "Have a good day!" << endl << endl;
    exit(0);
}
```

```
void sql_error(char *msg)
{
    cout << endl << msg << endl;
    sqlca.sqlerrm.sqlerrmc[sqlca.sqlerrm.sqlerrml] = '\0';
    oraca.orastxt.orastxtc[oraca.orastxt.orastxtl] = '\0';
    oraca.orasfnm.orasfnmc[oraca.orasfnm.orasfnml] = '\0';
    cout << sqlca.sqlerrm.sqlerrmc << endl;
    cout << "in " << oraca.orastxt.orastxtc << endl;
    cout << "on line " << oraca.oraslnr << " of "
         << oraca.orasfnm.orasfnmc << endl << endl;

/* Disable ORACLE error checking to avoid an infinite loop
 * should another error occur within this routine.
 */
    EXEC SQL WHENEVER SQLERROR CONTINUE;

  // Release resources associated with the cursor.
    EXEC SQL CLOSE C;

  // Roll back any pending changes and disconnect from Oracle.
    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

cppdemo3.pc

```
/*
 * cppdemo3.pc : An example of C++ Inheritance
 *
 * This program finds all salesman and prints their names
 * followed by how much they earn in total (ie; including
 * any commissions).
 */

#include <iostream.h>
#include <stdio.h>
#include <sqlca.h>
#include <string.h>

#define NAMELEN 10
```

```
class employee {    // Base class is a simple employee
public:
  char ename[NAMELEN];
  int sal;
  employee(char *, int);
};

employee::employee(char *ename, int sal)
{
  strcpy(this->ename, ename);
  this->sal = sal;
}

// A salesman is a kind of employee
class salesman : public employee
{
  int comm;
public:
  salesman(char *, int, int);
  friend ostream& operator<<(ostream&, salesman&);
};

// Inherits employee attributes
salesman::salesman(char *ename, int sal, int comm)
  : employee(ename, sal), comm(comm) {}

ostream& operator<<(ostream& s, salesman& m)
{
  return s << m.ename << m.sal + m.comm << endl;
}

void print(char *ename, int sal, int comm)
{
  salesman man(ename, sal, comm);
  cout << man;
}

main()
{
  EXEC SQL BEGIN DECLARE SECTION;
    char *uid = "scott/tiger";
    char  ename[NAMELEN];
    int   sal, comm;
    short comm_ind;
  EXEC SQL END DECLARE SECTION;
```

```
  EXEC SQL WHENEVER SQLERROR GOTO error;

  EXEC SQL CONNECT :uid;
  EXEC SQL DECLARE c CURSOR FOR
    SELECT ename, sal, comm FROM emp WHERE job = 'SALESMAN'
      ORDER BY ename;
  EXEC SQL OPEN c;

  cout << "Name    Salary" << endl << "------  ------" << endl;

  EXEC SQL WHENEVER NOT FOUND DO break;
  while(1)
   {
     EXEC SQL FETCH c INTO :ename, :sal, :comm:comm_ind;
     print(ename, sal, (comm_ind < 0) ? 0 : comm);
   }
  EXEC SQL CLOSE c;
  exit(0);

error:
  cout << endl << sqlca.sqlerrm.sqlerrmc << endl;
  exit(1);
}
```

8

Object Support in Pro*C/C++

This chapter describes the support in Pro*C/C++ for Objects.

Support for Objects and for the Object Type Translator are available only if you have purchased the Oracle8 Enterprise Edition with the Objects Option.

Topics include:

- Introduction to Objects
- Using Object Types in Pro*C/C++
- The Object Cache
- Associative Interface
- Navigational Interface
- Converting Object Attributes and C Types
- New Precompiler Options for Objects
- An Object Example in Pro*C/C++
- Sample Code for Navigational Access
- Using C Structures
- Using Collection Types
- Using REFs
- Using OCIDate, OCIString, OCINumber, and OCIRaw
- Summarizing the New Database Types in Pro*C/C++
- Restrictions on Using Oracle8 Datatypes in Dynamic SQL

Introduction to Objects

In addition to the Oracle relational datatypes supported previously, starting with release 8.0, Pro*C/C++ supports user-defined datatypes, which are:

- Object types
- Collection object types
- REFs to object types
- Large objects (LOBs) as datatypes of objects.

Here is a brief description of the user-defined datatypes:

Object Types

An object type is a user-defined datatype that has *attributes*, the variables that form the datatype defined by a CREATE TYPE SQL statement, and *methods*, functions and procedures that are the set of allowed behaviors of the object type. We consider object types with only attributes in this guide.

For example:

```
--Defining an object type...
CREATE TYPE employee_type AS OBJECT(
    name    VARCHAR2(20),
    id      NUMBER,
    MEMBER FUNCTION get_id(name VARCHAR2) RETURN NUMBER);
/
--
--Creating an object table...
CREATE TABLE employees OF employee_type;
--Instantiating an object, using a constructor...
INSERT INTO employees VALUES (
        employee_type('JONES', 10042));
```

LONG, LONG RAW, NCLOB, NCHAR and NCHAR Varying are *not* allowed as datatypes in attributes of objects.

Nested Tables

A collection object type is a collection of scalar or other object types. Nested tables and varying-length arrays are the new collection types supported by Oracle8.

You can use the CREATE TYPE statement to define a table type that can be nested within other object types in one or more columns of a relational table.

For example:, to store several projects in each department of an organization:

```
CREATE TYPE project_type AS OBJECT(
    pno            CHAR(5),
    pname          CHAR(20),
    budget         DEC(7,2));
/
--
--creating a table type...
CREATE TYPE project_table AS TABLE OF project_type;
/
--
--project_table in each row is nested in the relational table depts
--
CREATE TABLE depts (
    dno            CHAR(5),
    dname          CHAR(20),
    budjets_limit  DEC(15,2),
    projects       project_table)
    NESTED TABLE projects STORE AS depts_projects ;
```

Varying Length Arrays

An array is an ordered set of elements, each of which has the same datatype. Starting with Oracle8, named arrays of varying length, called *VARRAY*s are allowed. You must specify the maximum size of the array when you define it. You create a VARRAY with a CREATE TYPE statement of the form:

```
CREATE TYPE processes AS VARRAY(10) OF NUMBER(12,2);
```

REFs

REF (short for "reference") was also new in Oracle8. It is a reference to an object stored in a database table, instead of the object itself. REF types can occur in relational columns and also as datatypes of an object type. For example, a table *employee_tab* can have a column that is a REF to an object type *employee_t* itself:

```
CREATE TYPE employee_t AS OBJECT(
   empname         CHAR(20),
   empno           INTEGER,
   manager         REF employee_t);
/
CREATE TABLE employee_tab OF employee_t;
```

Using Object Types in Pro*C/C++

Declare pointers to C structures generated by the OTT(Object Type Translator) as host and indicator variables in your Pro*C/C++ application. For more details, see Chapter 16, “Using the Object Type Translator”. Use of an indicator variable is optional for an object type, but Oracle recommends it.

Represent object types in a Pro*C/C++ program as C structures generated from the database objects using OTT. You must

- include in the Pro*C/C++ program the OTT-generated header file with structure definitions and the associated NULL indicator structures, and the C type for a REF to the object type.
- enter the typefile generated by OTT as an INTYPE Pro*C/C++ command-line option. This typefile encodes the correspondence between the OTT-generated C structures and the associated object types in the database, as well as schema and type version information.

Null Indicators

C structures representing the NULL status of object types are generated by the Object Type Translator. You must use these generated structure types in declaring indicator variables for object types.

Other Oracle8 types do not require special treatment for NULL indicators. See "Indicator Variables" on page 3-32, for more information about null indicators

Because object types have internal structure, null indicators for object types also have internal structure. A null indicator structure for a non-collection object type provides atomic (single) null status for the object type as a whole, as well as the null status of every attribute. OTT generates a C structure to represent the null indicator structure for the object type. The name of the null indicator structure is <Object_typename>_ind where <Object_typename> is the name of the C structure for the user-defined type in the database.

The Object Cache

The object cache is an area of memory on the client that is allocated for your program’s use in interfacing with database objects. There are two interfaces to working with objects. The associative interface manipulates “transient” copies of the objects and the navigational interface manipulates “persistent” objects.

Persistent Versus Transient Copies of Objects

Objects that you allocated in the cache with EXEC SQL ALLOCATE statements in Pro*C/C++ are *transient copies* of persistent objects in the Oracle database. As such, you can update these copies in the cache after they are fetched in, but in order to make these changes persistent in the database, you must use explicit SQL commands. This "transient copy" or "value-based" object caching model is an extension of the relational model, in which scalar columns of relational tables can be fetched into host variables, updated in place, and the updates communicated to the server.

Associative Interface

The associative interface manipulates transient copies of objects. Memory is allocated in the object cache with the EXEC SQL ALLOCATE statement.

One object cache is created for each SQLLIB runtime context.

Objects are retrieved by the EXEC SQL SELECT or EXEC SQL FETCH statements. These statements set values for the attributes of the host variable. If a null indicator is provided, it is also set.

Objects are inserted, updated, or deleted using EXEC SQL INSERT, EXEC SQL UPDATE, and EXEC SQL DELETE statements. The attributes of the object host variable must be set before the statement is executed.

Transactional statements EXEC SQL COMMIT and EXEC SQL ROLLBACK are used to write the changes permanently on the server or to abort the changes.

You explicitly free memory in the cache for the objects by use of the EXEC SQL FREE statement. When a connection is terminated, Oracle implicitly frees its allocated memory.

When to Use the Associative Interface

Use in these cases:

- to access large collections of objects where explicit joins between tables are not expensive.
- to access objects which are not referencable; they do not have object identity. For example, an object type in a relational column.
- when an operation such as UPDATE or INSERT is applied to a set of objects. For example, add a bonus of $1000 to all employees in a department.

ALLOCATE

You allocate space in the object cache with this statement. The syntax is:

```
EXEC SQL [AT [:]database] ALLOCATE :host_ptr [[INDICATOR] :ind_ptr] ;
```

Variables entered are:

database (IN)

a zero-terminated string containing the name of the database connection, as established previously through the statement:

```
EXEC SQL CONNECT :user [AT [:]database];
```

If the AT clause AT is omitted, or if *database* is an empty string, the default database connection is assumed.

host_ptr (IN)

a pointer to a host structure generated by OTT for object types, collection object types, or REFs, or a pointer to one of the new C datatypes: OCIDate, OCINumber, OCIRaw, or OCIString.

ind_ptr (IN)

The indicator variable, *ind_ptr*, is optional, as is the keyword INDICATOR. Only pointers to struct-typed indicators can be used in the ALLOCATE and FREE statements.

host_ptr and *ind_ptr* can be host arrays.

The duration of allocation is the session. Any instances will be freed when the session (connection) is terminated, even if not explicitly freed by a FREE statement.

For more details, see “ALLOCATE (Executable Embedded SQL Extension)” on page F-8 and “FREE (Executable Embedded SQL Extension)” on page F-44.

FREE

```
EXEC SQL [AT[:]database] [OBJECT] FREE :host_ptr [[INDICATOR] :ind_ptr];
```

You de-allocate the space for an Oracle8 object that is placed in the object cache using the FREE statement. Variables used are the same as in the ALLOCATE statement.

Note: Pointers to host and indicator variables are *not* set to null.

CACHE FREE ALL

```
EXEC SQL [AT [:]database] [OBJECT] CACHE FREE ALL;
```

Use the above statement to free all object cache memory for the specified database connection.

For more details, see “CACHE FREE ALL (Executable Embedded SQL Extension)” on page F-10.

Accessing Objects Using the Associative Interface

When accessing objects using SQL, Pro*C/C++ applications manipulate transient copies of the persistent objects. This is a direct extension of the relational access interface, which uses SELECT, UPDATE and DELETE statements.

In Figure 8–1 on page 8, you allocate memory in the cache for a transient copy of the persistent object. with the ALLOCATE statement. The allocated object does not contain data, but it has the form of the struct generated by the OTT.

```
person *per_p;
...
EXEC SQL ALLOCATE :per_p;
```

You can execute a SELECT statement to populate the cache. Or, use a FETCH statement or a C assignment to populate the cache with data.

```
EXEC SQL SELECT ... INTO :per_p FROM person_tab WHERE ...
```

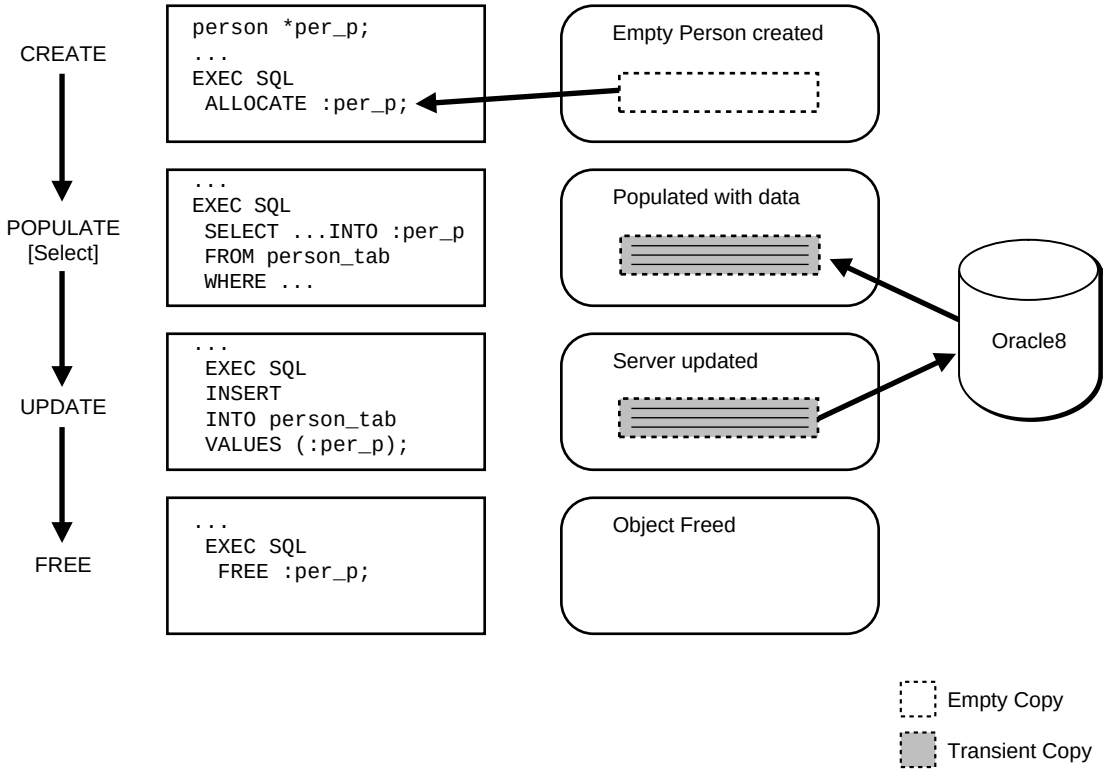
Make changes to the server objects with INSERT, UPDATE or DELETE statements, as shown in the illustration. You can insert the data is into the table by the INSERT statement:

```
EXEC SQL INSERT INTO person_tab VALUES(:per_p);
```

Finally, free memory associated with the copy of the object with the FREE statement:

```
EXEC SQL FREE :per_p;
```

Figure 8–1 Accessing Objects Using SQL



Navigational Interface

Use the navigational interface to access the same schema as the associative interface. The navigational interface accesses objects, both persistent and transient) by dereferencing REFs to objects and traversing ("navigating") from one object to another. Some definitions follow.

Pinning an object is the term used to mean dereferencing the object, allowing the program to access it.

Unpinning means indicating to the cache that the object is no longer needed.

Dereferencing can be defined as the server using the REF to create a version of the object in the client. While the cache maintains the association between objects in the

cache and the corresponding server objects, it does not provide automatic coherency. You have the responsibility to ensure correctness and consistency of the contents of the objects in the cache.

Releasing an object copy indicates to the cache that the object is not currently being used. To free memory, release objects when they are no longer needed to make them eligible for implicit freeing.

Freeing an object copy removes it from the cache and releases its memory area.

Marking an object tells the cache that the object copy has been updated in the cache and the corresponding server object must be updated when the object copy is flushed.

Un-marking an object removes the indication that the object has been updated.

Flushing an object writes local changes made to marked copies in the cache to the corresponding objects in the server. The object copies in the cache are also unmarked at this time.

Refreshing an object copy in the cache replaces it with the latest value of the corresponding object in the server.

The navigational and associative interfaces can be used together. This is illustrated by the code in "Sample Code for Navigational Access" on page 8-25.

Use the EXEC SQL OBJECT statements, the navigational interface, to update, delete, and flush cache copies (write changes in the cache to the server).

When to Use the Navigational Interface

Use the navigational interface:

- to access a single or small set of objects where explicit joins between tables are expensive. When you use dereferencing to navigate between objects, you perform implicit joins which are less expensive than an explicit join across two entire tables.
- to make many small changes to many different objects. It is more convenient to fetch all objects to the client, make changes, mark them as updated, and flush all the changes back to the server.

Rules Used in the Navigational Statements

Embedded SQL OBJECT statements introduced in Oracle8 are described below with these assumptions:

- If an AT clause is absent, the default (unnamed) connection is assumed.
- Host variables can be arrays, except where specifically noted.
- Use the FOR clause to explicitly specify the array dimension. If absent, the minimum dimension of the pertinent host variables is used.
- After execution of the statement, if the SQLCA is provided as a status variable, the number of elements processed is returned in sqlca.sqlerrd[2].
- Parameters have IN or OUT (or both) specified to signify input or output.

The SQL OBJECT statements are described in Appendix F, "Embedded SQL Commands and Directives" in alphabetical order. Syntax diagrams are provided there.

OBJECT CREATE

```
EXEC SQL [AT [:]database] [FOR [:]count] OBJECT CREATE :obj [INDICATOR]
:obj_ind [TABLE tab] [RETURNING REF INTO :ref] ;
```

where tab is:

{:hv | [schema.]table}

Use this statement to create a referenceable object in the object cache. The type of the object corresponds to the host variable *obj*. When optional type host variables (:obj_ind, :ref, :ref_ind) are supplied, they must all correspond to the same type.

The referenceable object can be either persistent (TABLE clause is supplied) or transient (TABLE clause is absent). Persistent objects are implicitly pinned and marked as updated. Transient objects are implicitly pinned.

The host variables are:

obj (OUT)

The object instance host variable, *obj*, must be a pointer to a structure generated by OTT. This variable is used to determine the referenceable object that is created in the object cache. After a successful execution, *obj* will point to the newly created object.

obj_ind (OUT)

This variable points to an OTT-generated indicator structure. Its type must match that of the object instance host variable. After a successful execution, *obj_ind* will be a pointer to the parallel indicator structure for the referenceable object.

tab (IN)

Use the table clause to create persistent objects. The table name can be specified as a host variable, *hv*, or as an undeclared SQL identifier. It can be qualified with a schema name. Do not use trailing spaces in host variables containing the table name.

hv (IN)

A host variable specifying a table. If a host variable is used, *it must not* be an array. It must not be blank-padded. It is case-sensitive. When an array of persistent objects is created, they are all associated with the same table.

table (IN)

An undeclared SQL identifier which is case-sensitive.

ref (OUT)

The reference host variable must be a pointer to the OTT-generated reference type. The type of *ref* must match that of the object instance host variable. After execution, *ref* contains a pointer to the ref for the newly created object.

Note that attributes are initially set to null.

OBJECT DEREF

```
EXEC SQL [AT [:]database] [FOR [:]count] OBJECT DEREF :ref INTO :obj
[[INDICATOR] :obj_ind] [FOR UPDATE] ;
```

Given an object reference, *ref*, the OBJECT DEREF statement pins the corresponding object or array of objects in the object cache. Pointers to these objects are returned in the variables *obj* and *obj_ind*.

The host variables are:

ref (IN)

This is the object reference variable, which must be a pointer to the OTT-generated reference type. This variable (or array of variables) is dereferenced, returning a pointer to the corresponding object in the cache.

obj (OUT)

The object instance host variable, *obj*, must be a pointer to an OTT-generated structure. Its type must match that of the object reference host variable. After successful execution, *obj* contains a pointer to the pinned object in the object cache.

obj_ind (OUT)

The object instance indicator variable, *obj_ind*, must be a pointer to an OTT-generated indicator structure. Its type must match that of the object reference indicator variable. After successful execution, *obj_ind* contains a pointer to the parallel indicator structure for the referenceable object.

FOR UPDATE

If this clause is present, an exclusive lock is obtained for the corresponding object in the server.

OBJECT RELEASE

```
EXEC SQL [AT [:]database] [FOR [:]count] OBJECT RELEASE :obj ;
```

This statement unpins the object in the object cache. When an object is not pinned and not updated, it is eligible for implicit freeing.

If an object has been dereferenced n times, it must be released n times to be eligible for implicit freeing from the object cache. Oracle advises releasing all objects that are no longer needed.

OBJECT DELETE

```
EXEC SQL [AT [:]database] [FOR [:]count] OBJECT DELETE :obj ;
```

For persistent objects, this statement marks an object or array of objects as deleted in the object cache. The object is deleted in the server when the object is flushed or when the cache is flushed. The memory reserved in the object cache is not freed.

For transient objects, the object is marked as deleted. The memory for the object is not freed.

OBJECT UPDATE

```
EXEC SQL [AT [:]database] [FOR [:]count] OBJECT UPDATE :obj ;
```

For persistent objects, this statement marks them as updated in the object cache. The changes are written to the server when the object is flushed or when the cache is flushed.

For transient objects, this statement is a no-op.

OBJECT FLUSH

```
EXEC SQL [AT [:]database] [FOR [:]count] OBJECT FLUSH :obj ;
```

This statement flushes persistent objects that have been marked as updated, deleted, or created, to the server.

Notes:

An exclusive lock is implicitly obtained when the object is flushed.

After the statement successfully completes, the objects are unmarked.

If the object version is LATEST (see next section), then the object will be implicitly refreshed.

Navigational Access to Objects

See Figure 8–2 on page 14 for an illustration of the navigational interface.

Use the ALLOCATE statement to allocate memory in the object cache for a copy of the REF to the *person* object. The allocated REF does not contain data.

```
person *per_p;
person_ref *per_ref_p;
...
EXEC SQL ALLOCATE :per_p;
```

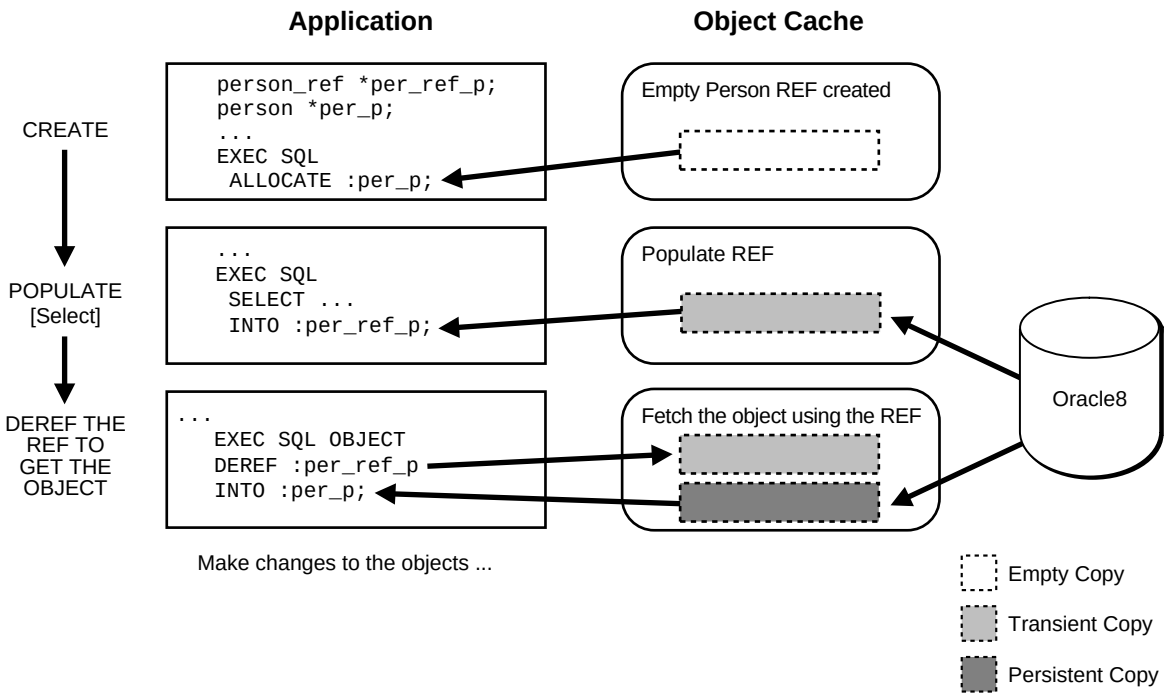
Populate the allocated memory by using a SELECT statement to retrieve the REF of the *person* object (exact format depends on the application):

```
EXEC SQL SELECT ... INTO :per_ref_p;
```

The DEREF statement is then used to pin the object in the cache, so that changes can be made in the object. The DEREF statement takes the pointer *per_ref_p* and creates an instance of the *person* object in the client-side cache. The pointer *per_p* to the *person* object is returned.

```
EXEC SQL OBJECT DEREF :per_ref_p INTO :per_p;
```

Figure 8–2 Navigational Access



Make changes to the object in the cache by using C assignment statements, or by using data conversions with the OBJECT SET statement.

Then you must mark the object as updated. See Figure 8–3 on page 15. To mark the object in the cache as updated, and eligible to be flushed to the server:

```
EXEC SQL OBJECT UPDATE :per_p;
```

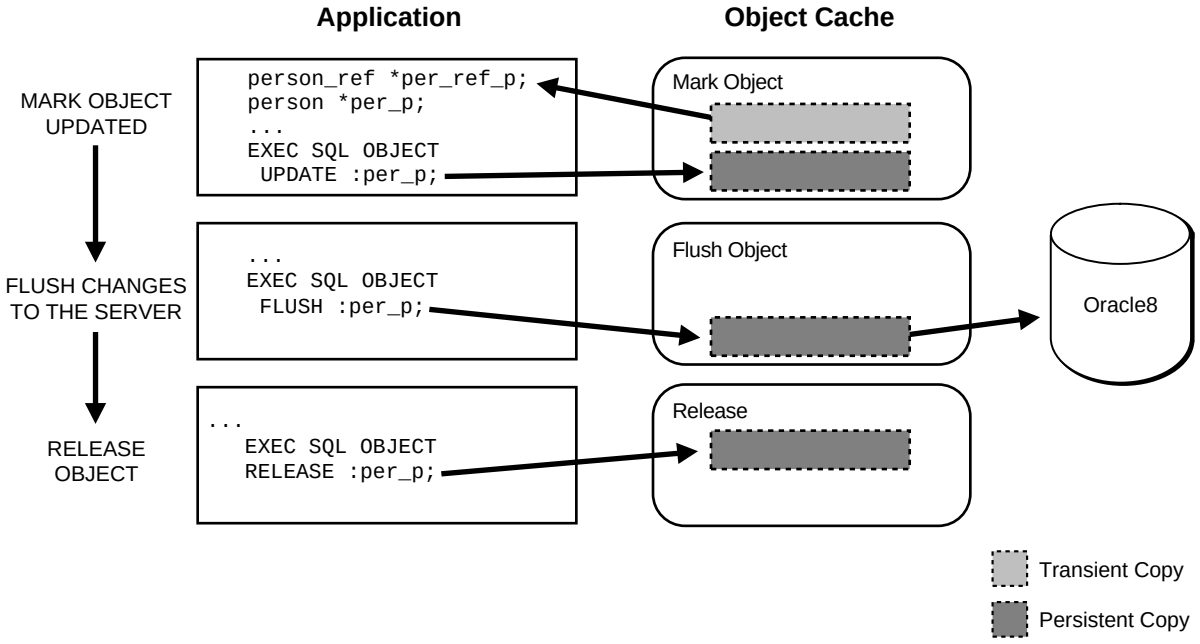
You send changes to the server by the FLUSH statement:

```
EXEC SQL OBJECT FLUSH :per_p;
```

You release the object:

```
EXEC SQL OBJECT RELEASE :per_p;
```

Figure 8–3 Navigational Access (continued)



The statements in the next section are used to make the conversions between object attributes and C types.

Converting Object Attributes and C Types

OBJECT SET

```
EXEC SQL [AT [:]database] OBJECT SET
 [{attr [,attr]} OF] :obj [[INDICATOR] :obj_ind]
 TO {:hv [[INDICATOR] :hv_ind] [, :hv [INDICATOR] :hv_ind]]} ;
```

Use this statement with objects created by both the associative and the navigational interfaces. This statement updates the attributes of the object. For persistent objects, the changes will be written to the server when the object is updated and flushed. Flushing the cache writes all changes made to updated objects to the server.

The OF clause is optional. If absent, all the attributes of *obj* are set. The host variable list can include structures that are exploded to provide values for the attributes. However, the number of attributes in *obj* must match the number of elements in the exploded variable list.

Host variables and attributes are:

attr

The attributes are not host variables, but rather simple identifiers that specify which attributes of the object will be updated. The first attribute in the list is paired with the first expression in the list, etc. The attribute must be one of either OCIString, OCINumber,OCIDate, or OCIRef.

obj (IN / OUT)

obj specifies the object to be updated. The bind variable *obj* must not be an array. It must be a pointer to an OTT-generated structure.

obj_ind (IN / OUT)

The parallel indicator structure that will be updated. It must be a pointer to an OTT-generated indicator structure.

hv (IN)

This is the bind variable used as input to the OBJECT SET statement. *hv* must be an int, float, OCIRef *, a one-dimensional char array, or a structure of these types.

hv_ind (IN)

This is the associated indicator that is used as input to the OBJECT SET statement. *hv_ind* must be a 2-byte integer scalar or a structure of 2-byte integer scalars.

Using Indicator Variables:

If a host variable indicator is present, then an object indicator must also be present.

If hv_ind is set to -1, the associated field in the obj_ind is set to -1.

The following implicit conversions are permitted:

- [OCIString | STRING | VARCHAR | CHARZ] to OCIString
- OCIRef to OCIRef
- [OCINumber | int | float | double] to OCINumber
- [OCIDate | STRING | VARCHAR | CHARZ] to OCIDate

Notes:

- Nested structures are not allowed.
- This statement cannot be used to set a referenceable object to be atomically null. Set the appropriate field of the null indicator instead.

OBJECT GET

```
EXEC SQL [AT [:]database] OBJECT GET
 [{attr [,attr]} FROM] :obj [[INDICATOR] :obj_ind]
 INTO {:hv [[INDICATOR] :hv_ind] [,:hv [[INDICATOR] :hv_ind]]} ;
```

This statement converts the attributes of an object into native C types.

The FROM clause is optional. If absent, all the attributes of *obj* are converted. The host variable list may include structures that are exploded to receive the values of the attributes. However, the number of attributes in *obj* must match the number of elements in the exploded host variable list.

Host variables and attributes:

attr

The attributes are not host variables, but simple identifiers that specify which attributes of the object will be retrieved. The first attribute in the list is paired with the first host variable in the list, etc. The attribute must represent a base type. It must be OCIString, OCINumber, OCIRef, or OCIDate.

obj (IN)

This specifies the object that serves as the source for the attribute retrieval. The bind variable *obj* must not be an array.

hv (OUT)

This is the bind variable used to hold output from the OBJECT GET statement. It can be an int, float, double, a one-dimensional char array, or a structure containing those types. The statement returns the converted attribute value in this host variable.

hv_ind (OUT)

This is the associated indicator variable for the attribute value. It is a 2-byte integer scalar or a structure of 2-byte integer scalars.

Using Indicator Variables:

If no object indicator is specified, it is assumed that the attribute is valid. *It is a program error* to convert object attributes to C types if the object is atomically null or

if the requested attribute is null and no object indicator variable is supplied. *It may not be possible to raise an Oracle error in this situation.*

If the object variable is atomically null or the requested attribute is null, and a host variable indicator (*hv_ind*) is supplied, then it is set to -1.

If the object is atomically null or the requested attribute is null, and no host variable indicator is supplied, then an error is raised.

The following implicit conversions are permitted:

- OCIString to [STRING | VARCHAR | CHARZ | OCIString]
- OCINumber to [int | float | double | OCINumber]
- OCIRef to OCIRef
- OCIDate to [STRING | VARCHAR | CHARZ | OCIDate]

Note: Nested structures are not allowed.

Object Options Set/Get

The runtime context has options which are set to default values when the runtime context is created and allocated. Set these options with this embedded SQL directive:

CONTEXT OBJECT OPTION SET

```
EXEC SQL CONTEXT OBJECT OPTION SET {option[, option]} TO {:hv[, :hv]} ;
```

where the variables are:

:hv(IN) ...

The input bind variables of type STRING, VARCHAR, or CHARZ.

option ...

Simple identifiers that specify which option of the runtime context to update. The first option is paired with the first input bind variable, etc. Here are the values supported at this time:

DATEFORMAT. The format used for conversion of the date attributes of objects.

DATELANG. The language used for conversion of date attributes of objects.

An example is:

```
char *new_format = "DD-MM-YYYY";
char *new_lang = "French";
char *new_date = "14-07-1789";
/* One of the attributes of the license type is dateofbirth */
license *aLicense;
...
/* Declaration and allocation of context ... */
EXEC SQL CONTEXT OBJECT OPTION SET DATEFORMAT, DATELANG TO :new_format,
:new_lang;
/* Navigational object obtained  */
...
EXEC SQL OBJECT SET dateofbirth OF :aLicense TO :new_date;
...
```

See “CONTEXT OBJECT OPTION SET (Executable Embedded SQL Extension)T” on page F-19.

CONTEXT OBJECT OPTION GET

The context affected is understood to be the context in use at the time. To determine the values of these options, use this directive:

```
EXEC SQL CONTEXT OBJECT OPTION GET {option[, option]} INTO {:hv[, :hv]} ;
```

Where the variables are:

option ...

Simple identifiers that specify which options of the runtime context to fetch. The first option is paired with the first expression. Here are the current values:

DATEFORMAT. The format used for conversion of the date attributes of objects.

DATELANG. The language used for conversion of date attributes of objects.

hv(OUT) ...

The bind variables used as output, of type STRING, VARCHAR, or CHARZ. The context affected is understood to be the context in use at the time.

See “CONTEXT OBJECT OPTION GET (Executable Embedded SQL Extension)” on page F-18.

New Precompiler Options for Objects

To support objects in Oracle8, we introduced these precompiler options:

VERSION

This option determines which version of the object is returned by the EXEC SQL OBJECT DEREF statement. This gives you varying levels of consistency between cache objects and server objects.

Use the EXEC ORACLE OPTION statement to set it inline. Permitted values are:

RECENT (default) If the object has been selected into the object cache in the current transaction, then return that object. If the object has not been selected, it is retrieved from the server. For transactions that are running in serializable mode, this option has the same behavior as VERSION=LATEST without incurring as many network round trips. This value can be safely used with most Pro*C/C++ applications.

LATEST If the object does not reside in the object cache, it is retrieved from the database. If it does reside in the object cache, it is refreshed from the server. Use this value with caution because it will incur the greatest number of network round trips. Use it only when it is imperative that the object cache be kept as coherent as possible with the server-side buffer.

ANY If the object already resides in the object cache, then return that object. If the object does not reside in the object cache, retrieve it from the server. This value will incur the fewest number of network round trips. Use in applications that access read-only objects or when a user will have exclusive access to the objects.

DURATION

Use this precompiler option to set the pin duration used by subsequent EXEC SQL OBJECT CREATE and EXEC SQL OBJECT DEREF statements. Objects in the cache are implicitly unpinned at the end of the duration.

Use with navigational interface only.

You can set this option in the EXEC ORACLE OPTION statement. Permitted values are:

TRANSACTION (default) Objects are implicitly unpinned when the transaction completes.

SESSION Objects are implicitly unpinned when the connection is terminated.

OBJECTS

This precompiler option allows you to use the object cache.

The OBJECTS default value, for DBMS=NATIVE | V8, is YES. The default size of the object cache is the same as the OCI default cache size, 200Kbytes.

See "OBJECTS" on page 9-29.

INTYPE

If your program uses any object types, collection object types, or REFs, you must give the INTYPE files in this command-line option.

Specify the INTYPE option using the syntax:

```
INTYPE=<filename1> INTYPE=<filename2> ...
```

where <filename1>, etc., is the name of the typefiles generated by OTT. These files are meant to be a read-only input to Pro*C/C++. The information in it, though in plain-text form, might be encoded, and might not necessarily be interpretable by you, the user.

You can provide more than one INTYPE file as input to a single Pro*C/C++ precompilation unit.

This option cannot be used inline in EXEC ORACLE statements.

OTT generates C structure declarations for object types created in the database, and writes type names and version information to a file called the *typefile*.

An object type may not necessarily have the same name as the C structure type or C++ class type that represents it. This could arise for the following reasons:

- the name of the object type specified in the server includes characters not legal in a C or C++ identifier
- the user asked OTT to use a different name for the structure or class
- the user asked OTT to change the case of names

Under these circumstances, it is impossible to infer from the structure or class declaration which object type it matches. This information, which is required by Pro*C/C++, is generated by OTT in the type file.

ERRTYPE

```
ERRTYPE=<filename>
```

Writes errors to the file specified, as well as to the screen. If omitted, errors are directed to the screen only. Only one ERRTYPE is allowed. As is usual with other single-valued command-line options, if you enter multiple values for ERRTYPE on the command line, the last one supersedes the earlier values.

This option cannot be used inline in EXEC ORACLE statements.

SQLCHECK Support for Objects

Object types and their attributes are represented in a C program according to the C binding of Oracle types. If the precompiler command-line option SQLCHECK is set to SEMANTICS or FULL, Pro*C/C++ verifies during precompilation that host variable types conform to the mandated C bindings for the types in the database schema. In addition, runtime checks are always performed to verify that Oracle types are mapped correctly during program execution.See "SQLCHECK" on page 9-33.

Relational datatypes are checked in the usual manner.

A relational SQL datatype is compatible with a host variable type if the two types are the same, or if a conversion is permitted between the two. Object types, on the other hand, are compatible only if they are the same type. They must

- have the same name
- be in the same schema (if a schema is explicitly specified)

When you specify the option SQLCHECK=SEMANTICS or FULL, during precompilation Pro*C/C++ logs onto the database using the specified userid and password, and verifies that the object type from which a structure declaration was generated is identical to the object type used in the embedded SQL statement.

Type Checking at Runtime

Pro*C/C++ gathers the type name, version, and possibly schema information for Object, collection Object, and REF host variables, for a type from the input INTYPE file, and stores this information in the code that it generates. This enables access to the type information for Object and REF bind variables at runtime. Appropriate errors are returned for type mismatches.

An Object Example in Pro*C/C++

Let us examine a simple object example. You create a type *person* and a table *person_tab*, which has a column that is also an object type, *address*:

```
create type person as object (
```

```
        lastname        varchar2(20),
        firstname       char(20),
        age             int,
        addr            address
)
/
create table person_tab of person;
```

Insert data in the table, and proceed.

Associative Access

Consider the case of how to change a *lastname* value from "Smith" to "Smythe", using Pro*C/C++.

Run the OTT to generate C structures which map to *person*. In your Pro*C/C++ program you must include the header file generated by OTT.

In your application, declare a pointer, *person_p*, to the persistent memory in the client-side cache. Then allocate memory and use the returned pointer:

```
char *new_name = "Smythe";
person *person_p;
...
EXEC SQL ALLOCATE :person_p;
```

Memory is now allocated for a copy of the persistent object. The allocated object does not yet contain data.

Populate data in the cache either by C assignment statements or by using SELECT or FETCH to retrieve an existing object:

```
EXEC SQL SELECT VALUE(p) INTO :person_p FROM person_tab p WHERE lastname =
'Smith';
```

Changes made to the copy in the cache are transmitted to the server database by use of INSERT, UPDATE, and DELETE statements:

```
EXEC SQL OBJECT SET lastname OF :person_p TO :new_name;
EXEC SQL INSERT INTO person_tab VALUES(:person_p);
```

Free cache memory in this way:

```
EXEC SQL FREE :person_p;
```

Navigational Access

Allocate memory in the object cache for a copy of the REF to the object *person*. The ALLOCATE statement returns a pointer to the REF:

```
person *person_p;
person_ref *per_ref_p;
...
EXEC SQL ALLOCATE :per_ref_p;
```

The allocated REF contains no data. To populate it with data, retrieve the REF of the object:

```
EXEC SQL SELECT ... INTO :per_ref_p;
```

Then dereference the REF to put an instance of object in the client-side cache. The dereference command takes the *per_ref_p* and creates an instance of the corresponding object in the cache:

```
EXEC SQL OBJECT DEREF :per_ref_p INTO :person_p;
```

Make changes to data in the cache by using C assignments, or by using OBJECT GET statements:

```
/* lname is a C variable to hold the result */
EXEC SQL OBJECT GET lastname FROM :person_p INTO :lname;
...
EXEC SQL OBJECT SET lastname OF :person_p TO :new_name;
/* Mark the changed object as changed with OBJECT UPDATE command */;
EXEC SQL OBJECT UPDATE :person_p;
EXEC SQL FREE :per_ref_p;
```

To make the changes permanent in the database, use FLUSH:

```
EXEC SQL OBJECT FLUSH :person_p;
```

Changes have been made to the server; the object can now be released. Objects that are released are not necessarily freed from the object cache memory immediately. They are placed on a least-recently used stack. When the cache is full, the objects are swapped out of memory.

Only the object is released; the REF to the object remains in the cache. To release the REF, use the RELEASE statement. for the REF. To release the object pointed to by person_p:

```
EXEC SQL OBJECT RELEASE :person_p;
```

Or, issue a transaction commit and all objects in the cache are released, provided the pin duration has been set appropriately.

Sample Code for Navigational Access

The sample object code creates three object types; *budoka* is a martial arts expert:

- customer
- budoka
- location

and two tables:

- person_tab
- customer_tab

The SQL file, *navdemo1.sql*, which creates the types and tables, and then inserts values into the tables, is:

```
connect scott/tiger

drop table customer_tab;
drop type customer;
drop table person_tab;
drop type budoka;
drop type location;

create type location as object (
        num     number,
        street  varchar2(60),
        city    varchar2(30),
        state   char(2),
        zip     char(10)
);
/

create type budoka as object (
        lastname        varchar2(20),
        firstname       varchar(20),
        birthdate       date,
        age             int,
        addr            location
);
```

```
/

create table person_tab of budoka;

create type customer as object (
        account_number varchar(20),
        aperson ref budoka
);
/

create table customer_tab of customer;

insert into person_tab values (
        budoka('Seagal', 'Steven', '14-FEB-1963', 34,
                location(1825, 'Aikido Way', 'Los Angeles', 'CA', 45300)));
insert into person_tab values (
        budoka('Norris', 'Chuck', '25-DEC-1952', 45,
                location(291, 'Grant Avenue', 'Hollywood', 'CA', 21003)));
insert into person_tab values (
        budoka('Wallace', 'Bill', '29-FEB-1944', 53,
                location(874, 'Richmond Street', 'New York', 'NY', 45100)));
insert into person_tab values (
        budoka('Van Damme', 'Jean Claude', '12-DEC-1964', 32,
                location(12, 'Shugyo Blvd', 'Los Angeles', 'CA', 95100)));

insert into customer_tab
        select 'AB123', ref(p)
          from person_tab p where p.lastname = 'Seagal';
insert into customer_tab
        select 'DD492', ref(p)
          from person_tab p where p.lastname = 'Norris';
insert into customer_tab
        select 'SM493', ref(p)
          from person_tab p where p.lastname = 'Wallace';
insert into customer_tab
        select 'AC493', ref(p)
          from person_tab p where p.lastname = 'Van Damme';

commit work;
```

The intype file for the OTT (Object Type Translator) is described in "The Intype File" on page 16-8. Prepare this file and then use it as input to the OTT. Here is a listing of the intype file, *navdemo1.typ*:

```
case=lower
type location
type budoka
type customer
```

The header file produced by the OTT, *navdemo1.h*, is included in the precompiler code.

The precompiler code in file *navdemo1.pc* follows:

```
/*****************************************************************
 *
 * This is a simple Pro*C/C++ program designed to illustrate the
 * Navigational access to objects in the object cache.
 *
 * To build the executable:
 *
 *   1. Execute the SQL script, navdemo1.sql in SQL*Plus
 *   2. Run OTT: (The following command should appear on one line)
 *      ott intype=navdemo1.typ hfile=navdemo1.h outtype=navdemo1_o.typ
 *          code=c user=scott/tiger
 *   3. Precompile using Pro*C/C++:
 *      proc navdemo1 intype=navdemo1_o.typ
 *   4. Compile/Link (This step is platform specific)
 *
 *****************************************************************/

#include "navdemo1.h"
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <sqlca.h>

void whoops(errcode, errtext, errtextlen)
  int   errcode;
  char *errtext;
  int   errtextlen;
{
  printf("ERROR! sqlcode=%d: text = %.*s", errcode, errtextlen, errtext);
  EXEC SQL WHENEVER SQLERROR CONTINUE;
  EXEC SQL ROLLBACK WORK RELEASE;
  exit(EXIT_FAILURE);
}
```

```
main()
{
  char *uid = "scott/tiger";

       /* The following types are generated by OTT and defined in navdemo1.h */
  customer *cust_p;                              /* Pointer to customer object */
  customer_ind *cust_ind;        /* Pointer to indicator struct for customer */
  customer_ref *cust_ref;            /* Pointer to customer object reference */
  budoka *budo_p;                                 /* Pointer to budoka object */
  budoka_ref *budo_ref;                /* Pointer to budoka object reference */
  budoka_ind *budo_ind;             /* Pointer to indicator struct for budoka */

    /* These are data declarations to be used to insert/retrieve object data */
  VARCHAR acct[21];
  struct { char lname[21], fname[21]; int age; char bDate[11]} pers;
  struct { int num; char street[61], city[31], state[3], zip[11]; } addr;

  EXEC SQL WHENEVER SQLERROR DO whoops(
    sqlca.sqlcode, sqlca.sqlerrm.sqlerrmc, sqlca.sqlerrm.sqlerrml);

  EXEC SQL CONNECT :uid;

  EXEC SQL ALLOCATE :budo_ref;
  /* Create a new budoka object with an associated indicator
   * variable returning a REF to that budoka as well.
   */
  EXEC SQL OBJECT CREATE :budo_p:budo_ind TABLE PERSON_TAB
          RETURNING REF INTO :budo_ref;

  /* Create a new customer object with an associated indicator */
  EXEC SQL OBJECT CREATE :cust_p:cust_ind TABLE CUSTOMER_TAB;

  /* Set all budoka indicators to NOT NULL.  We
   * will be setting all attributes of the budoka.
   */
  budo_ind->_atomic = budo_ind->lastname = budo_ind->firstname =
    budo_ind->age = budo_ind->birthdate = OCI_IND_NOTNULL;

  /* We will also set all address attributes of the budoka */
  budo_ind->addr._atomic = budo_ind->addr.num = budo_ind->addr.street =
    budo_ind->addr.city = budo_ind->addr.state = budo_ind->addr.zip =
      OCI_IND_NOTNULL;

  /* All customer attributes will likewise be set */
  cust_ind->_atomic = cust_ind->account_number = cust_ind->aperson =
```

```
  OCI_IND_NOTNULL;

/* Set the default CHAR semantics to type 5 (STRING) */
EXEC ORACLE OPTION (char_map=string);

strcpy((char *)pers.lname, (char *)"Chan");
strcpy((char *)pers.fname, (char *)"Jackie");
pers.age = 38;
strcpy((char *)pers.bDate, (char *)"02-29-1960");
/* Convert native C types to OTS types */
EXEC SQL OBJECT SET lastname, firstname, age, birthdate
  OF :budo_p TO :pers;

addr.num = 1893;
strcpy((char *)addr.street, (char *)"Rumble Street");
strcpy((char *)addr.city, (char *)"Bronx");
strcpy((char *)addr.state, (char *)"NY");
strcpy((char *)addr.zip, (char *)"92510");

/* Convert native C types to OTS types */
EXEC SQL OBJECT SET :budo_p->addr TO :addr;

acct.len = strlen(strcpy((char *)acct.arr, (char *)"FS926"));

/* Convert native C types to OTS types - Note also the REF type */
EXEC SQL OBJECT SET account_number, aperson OF :cust_p TO :acct, :budo_ref;

/* Mark as updated both the new customer and the budoka */
EXEC SQL OBJECT UPDATE :cust_p;
EXEC SQL OBJECT UPDATE :budo_p;

/* Now flush the changes to the server, effectively
 * inserting the data into the respective tables.
 */
EXEC SQL OBJECT FLUSH :budo_p;
EXEC SQL OBJECT FLUSH :cust_p;

/* Associative access to the REFs from CUSTOMER_TAB */
EXEC SQL DECLARE ref_cur CURSOR FOR
  SELECT REF(c) FROM customer_tab c;

EXEC SQL OPEN ref_cur;

printf("\n");
```

```
/* Allocate a REF to a customer for use below */
EXEC SQL ALLOCATE :cust_ref;

EXEC SQL WHENEVER NOT FOUND DO break;
while (1)
{
  EXEC SQL FETCH ref_cur INTO :cust_ref;

  /* Pin the customer REF, returning a pointer to a customer object */
  EXEC SQL OBJECT DEREF :cust_ref INTO :cust_p:cust_ind;

  /* Convert the OTS types to native C types */
  EXEC SQL OBJECT GET account_number FROM :cust_p INTO :acct;
  printf("Customer Account is %.*s\n", acct.len, (char *)acct.arr);

  /* Pin the budoka REF, returning a pointer to a budoka object */
  EXEC SQL OBJECT DEREF :cust_p->aperson INTO :budo_p:budo_ind;

  /* Convert the OTS types to native C types */
  EXEC SQL OBJECT GET lastname, firstname, age, birthdate
    FROM :budo_p INTO :pers;
  printf("Last Name: %s\nFirst Name: %s\nAge: %d\n",
 pers.lname, pers.fname, pers.age);

  /* Do the same for the address attributes as well */
  EXEC SQL OBJECT GET :budo_p->addr INTO :addr;
  printf("Address:\n");
  printf("  Street: %d %s\n  City: %s\n  State: %s\n  Zip: %s\n\n",
 addr.num, addr.street, addr.city, addr.state, addr.zip);

  /* Unpin the customer object and budoka objects */
  EXEC SQL OBJECT RELEASE :cust_p;
  EXEC SQL OBJECT RELEASE :budo_p;
}

EXEC SQL CLOSE ref_cur;

EXEC SQL WHENEVER NOT FOUND DO whoops(
  sqlca.sqlcode, sqlca.sqlerrm.sqlerrmc, sqlca.sqlerrm.sqlerrml);

/* Associatively select the newly created customer object */
EXEC SQL SELECT VALUE(c) INTO :cust_p FROM customer_tab c
         WHERE c.account_number = 'FS926';

/* Mark as deleted the new customer object */
```

```
  EXEC SQL OBJECT DELETE :cust_p;

  /* Flush the changes, effectively deleting the customer object */
  EXEC SQL OBJECT FLUSH :cust_p;

  /* Associatively select a REF to the newly created budoka object */
  EXEC SQL SELECT REF(p) INTO :budo_ref FROM person_tab p
           WHERE p.lastname = 'Chan';

  /* Pin the budoka REF, returning a pointer to the budoka object */
  EXEC SQL OBJECT DEREF :budo_ref INTO :budo_p;

  /* Mark the new budoka object as deleted in the object cache */
  EXEC SQL OBJECT DELETE :budo_p;

  /* Flush the changes, effectively deleting the budoka object */
  EXEC SQL OBJECT FLUSH :budo_p;

  /* Finally, free all object cache memory and log off */
  EXEC SQL OBJECT CACHE FREE ALL;

  EXEC SQL COMMIT WORK RELEASE;

  exit(EXIT_SUCCESS);
}
```

Read the comments throughout the precompiler code. The program adds one new budoka object (for Jackie Chan), then prints out all the customers in the *customer_tab* table.

When the program is executed, the result is:

```
Customer Account is AB123
Last Name: Seagal
First Name: Steven
Birthdate: 02-14-1963
Age: 34
Address:
  Street: 1825 Aikido Way
  City: Los Angeles
  State: CA
  Zip: 45300

Customer Account is DD492
```

```
Last Name: Norris
First Name: Chuck
Birthdate: 12-25-1952
Age: 45
Address:
  Street: 291 Grant Avenue
  City: Hollywood
  State: CA
  Zip: 21003

Customer Account is SM493
Last Name: Wallace
First Name: Bill
Birthdate: 02-29-1944
Age: 53
Address:
  Street: 874 Richmond Street
  City: New York
  State: NY
  Zip: 45100

Customer Account is AC493
Last Name: Van Damme
First Name: Jean Claude
Birthdate: 12-12-1965
Age: 32
Address:
  Street: 12 Shugyo Blvd
  City: Los Angeles
  State: CA
  Zip: 95100

Customer Account is FS926
Last Name: Chan
First Name: Jackie
Birthdate: 10-10-1959
Age: 38
Address:
  Street: 1893 Rumble Street
  City: Bronx
  State: NY
  Zip: 92510
```

Using C Structures

Before Oracle8, Pro*C/C++ allowed you to specify a C structure as a single host variable in a SQL SELECT statement. In such cases, each member of the structure is taken to correspond to a single database column in a relational table; that is, each member represents a single item in the select list returned by the query.

In Oracle8 an object type in the database is a single entity and can be selected as a single item. This introduces an ambiguity with the Oracle7 notation: is the structure for a group of scalar variables, or for an Object?

Pro*C/C++ uses the following rule to resolve the ambiguity:

*A host variable that is a C structure is considered to represent an object type only if its C declaration was generated using OTT, and therefore its type description appears in a typefile specified in an INTYPE option to Pro*C/C++. All other host structures are assumed to be uses of the Oracle7 syntax, even if a datatype of the same name resides in the database.*

Thus, if you use new object types that have the same names as existing structure host variable types, be aware that Pro*C/C++ uses the object type definitions in the INTYPE file. This can lead to compilation errors. To correct this, you might rename the existing host variable types, or use OTT to choose a new name for the object type.

Note also that the above rule extends *transitively* to user-defined datatypes that are aliased to OTT-generated datatypes. To illustrate, let *emptype* be a structure generated by OTT in a header file *dbtypes.h* and you have the following statements in your Pro*C/C++ program:

```
#include <dbtypes.h>
typedef emptype myemp;
myemp *employee;
```

The typename *myemp* for the variable *employee* is aliased to the OTT-generated typename *emptype* for some object type defined in the database. Therefore, Pro*C/C++ considers the variable *employee* to represent an object type.

Note that the above rules do not imply that a C structure having or aliased to an OTT-generated type cannot be used for fetches of non-object type data. The only implication is that Pro*C/C++ will not automatically expand such a structure -- the user is free to employ the “longhand syntax” and use individual fields of the structure for selecting or updating single database columns.

Using Collection Types

Starting with Oracle8, NESTED TABLE and VARRAY (varying-length array) collection types are supported. Collections may occur both in relational columns and also as embedded attributes within an object type. Note that all collections must be *named* object types in the database. For example, for varying length arrays, you must first create a named type in the database, specifying the desired array element type and maximum array dimension.

Structures for Collection Object Types

The C representation for a collection object type is a structure, and is generated when you run OTT. The host structure for a collection is essentially a "handle" or a "descriptor" through which the elements in the collection may be accessed. These descriptors do not hold the actual elements of the collection, but instead contain pointers to them. Memory for both the descriptor and its associated elements come from the object cache.

The C type for a collection object type is named according to the OTT options in effect during type translation. User typenames that are aliased to these OTT-generated typenames are also allowed. Following the usual procedure for object types, the OTT-generated typefile must be specified in the INTYPE precompiler option to Pro*C/C++ and the OTT-generated header #included in the Pro*C/C++ program. This scheme ensures that the proper type-checking for the collection object type can be performed during precompilation.

Unlike other object types, a collection object type does not require a special indicator structure to be generated by OTT; a scalar indicator is used instead. This is because an atomic null indicator is sufficient to denote whether a collection as a whole is null. The null status of each individual element in a collection may (optionally) be represented in separate indicators associated to each element. These indicators could be signed 2-byte scalar quantities or C structures, depending on the type of the collection element (i.e., whether it is a scalar type or an object type).

Declarations for Host and Indicator Variables

As for the other object types, a host variable representing a collection object type must be declared by you as a pointer to the appropriate OTT-generated type.

Unlike other object types, the indicator variable for a collection object type as a whole is declared as a scalar signed 2-byte type *OCIInd*. As always, the indicator variable is optional, but it is a good programming practice to use one for each host variable declared in Pro*C/C++.

Handling Collection Object Types

You access and manipulate individual elements in a collection (a nested table or a varying-length array) using the functions provided by OCI. Variable-length arrays and nested tables are handled in OCI through the new C types *OCIArray*, and *OCITable*, respectively. In Pro*C/C++, the OTT-generated descriptors for collection object types are typedef'd aliases to the *OCIArray* or *OCITable* descriptor structures, depending on the type of the collection object type. The prototypes of OCI manipulation functions for *OCIArray*, *OCITable*, and the "generic" collection descriptor type *OCIColl* appear in the OCI header file *oci.h*.

Using the OCI routines require an OCI environment handle as well as an error handle. The OCI environment handle may be obtained in Pro*C/C++ using the new library routine *SQLEnvGet()* provided by SQLLIB. For parameters, usage, etc., see "SQLEnvGet()" on page 4-57. The error handle must be declared in the Pro*C/C++ program to be of type *OCIError* * and be initialized using the *OCIHandleAlloc()* function defined in the OCI header *oci.h*.

Using REFs

The REF type denotes a reference to an object, instead of the object itself. REF types may occur in relational columns and also in attributes of an object type.

Generating a C Structure for a REF

The C representation for a REF to an object type is generated by OTT during type translation. For example, a reference to a user-defined PERSON type in the database may be represented in C as the type "Person_ref". The exact type name is determined by the OTT options in effect during type translation. The OTT-generated typefile must be specified in the INTYPE option to Pro*C/C++ and the OTT-generated header #included in the Pro*C/C++ program. This scheme ensures that the proper type-checking for the REF can be performed by Pro*C/C++ during precompilation.

A REF type does not require a special indicator structure to be generated by OTT; a scalar signed 2-byte indicator is used instead.

Declaring REFs

A host variable representing a REF in Pro*C/C++ must be declared as a pointer to the appropriate OTT-generated type.

Unlike object types, the indicator variable for a REF is declared as the signed 2-byte scalar type *OCIInd*. As always, the indicator variable is optional, but it is a good programming practice to use one for each host variable declared.

Using REFs in Embedded SQL

REFs reside in the object cache. However, indicators for REFs are scalars and cannot be allocated in the cache. They generally reside in the user stack.

Prior to using the host structure for a REF in embedded SQL, allocate space for it in the object cache by using the EXEC SQL ALLOCATE command. After use, free using the EXEC SQL FREE or EXEC SQL CACHE FREE ALL commands described in "Navigational Interface" on page 8-8.

Note that memory for scalar indicator variables is not allocated in the object cache, and hence indicators are not permitted to appear in the ALLOCATE and FREE commands for REF types. Scalar indicators declared as *OCIInd* reside on the program stack. At runtime, the ALLOCATE statement causes space to be allocated in the object cache for the specified host variable. For the navigational interface, use EXEC SQL GET and EXEC SQL SET, not C assignments.

Pro*C/C++ supports REF host variables in associative SQL statements and in embedded PL/SQL blocks.

Using OCIDate, OCIString, OCINumber, and OCIRaw

These OCI types are new C representations for a date, a varying-length zero-terminated string, an Oracle number, and varying-length binary data respectively. In certain cases, these types provide more functionality than earlier C representations of these quantities. For example, the OCIDate type provides client-side routines to perform DATE arithmetic, which in earlier releases required SQL statements at the server.

Declaring OCIDate, OCIString, OCINumber, OCIRaw

The OCI* types appear as object type attributes in OTT-generated structures, and you use them as part of object types in Pro*C/C++ programs. Other than their use in object types, Oracle recommends that the beginner-level C and Pro*C/C++ user avoid declaring individual host variables of these types. An experienced Pro*C/C++ user may wish to declare C host variables of these types to take advantage of the advanced functionality these types provide. The host variables must be declared as pointers to these types, e.g., *OCIString *s*. The associated

(optional) indicators are scalar signed 2-byte quantities, declared e.g., as *OCIInd s_ind*.

Use of the OCI Types in Embedded SQL

Space for host variables of these types may be allocated in the object cache using EXEC SQL ALLOCATE. Note that (scalar) indicator variables are not permitted to appear in the ALLOCATE and FREE commands for these types. You allocate such indicators statically on the stack, or dynamically on the heap. De-allocation of space can be done using the statement EXEC SQL FREE, EXEC SQL CACHE FREE ALL, or automatically at the end of the session. These are described in "Navigational Interface" on page 8-8.

Manipulating the OCI Types

Except for *OCIDate*, which is a structure type with individual fields for various date components: year, month, day, hour etc., the other OCI types are encapsulated, and are meant to be opaque to an external user. In contrast to the way existing C types like VARCHAR are currently handled in Pro*C/C++, you include the OCI header file *oci.h* and employ its functions to perform DATE arithmetic, and to convert these types to and from native C types such as *int*, *char*, etc.

Summarizing the New Database Types in Pro*C/C++

Table 8–1 lists the new database types for Object support:

Table 8–1 Using New Database Types in Pro*C/C++

Operations --- **Database Type**	**DECLARE**	**ALLOCATE**	**FREE**	**MANIPULATE**
Object type	**Host**: Pointer to OTT-generated C struct **Indicator**: Pointer to OTT-generated indicator struct	Associative interface: EXEC SQL ALLOCATE Navigational interface: EXEC SQL OBJECT CREATE ... EXEC SQL OBJECT DEREF allocates memory for host var and indicator in object cache	Freed by EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	Dereference the C pointer to get each attribute. Manipulation method depends on type of attribute (see below).
COLLECTION Object type (NESTED TABLE AND VARYING ARRAY)	**Host**: Pointer to OTT-generated C struct **Indicator**: OCIInd	EXEC SQL ALLOCATE allocates memory for host var in object cache.	Freed by EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	Use OCIColl* functions (defined in oci.h) to get/set elements.
REF	**Host**: Pointer to OTT-generated C struct **Indicator:** OCIInd	EXEC SQL ALLOCATE allocates memory for host var in object cache.	Freed by EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	Use EXEC SQL OBJECT DEREF Use EXEC SQL OBJECT SET/GET for navigational interface.

Table 8–1 Using New Database Types in Pro*C/C++

LOB	**Host:** OCIBlobLocator *, OCIClobLocator *, or OCIBfileLocator *. **Indicator:** OCIInd	EXEC SQL ALLOCATE allocates memory for the host var in user heap using malloc().	Freed by EXEC SQL FREE, or automatically when all Pro*C/C++ connections are closed. EXEC SQL CACHE FREE ALL frees only LOB attributes of objects.	To read/write, (1) use embedded PL/SQL stored procedures in the dbms_lob package, or (2) use OCILob* functions defined in oci.h.
NOTE: Host arrays of these types may be declared and used in bulk fetch/insert SQL operations in Pro*C/C++.				

Table 8–2 shows how to use the new C datatypes in Pro*C/C++:

Table 8–2 Using New C Datatypes in Pro*C/C++

Operations --- C Type	**DECLARE**	**ALLOCATE**	**FREE**	**MANIPULATE**
OCIDate	**Host:** OCIDate * **Indicator:** OCIInd	EXEC SQL ALLOCATE allocates memory for host var in object cache	Freed by EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	(1) Use OCIDate* functions defined in oci.h. (2) Use EXEC SQL OBJECT GET/SET, or (3) Use OCINumber* functions defined in oci.h.

Table 8–2 Using New C Datatypes in Pro*C/C++

OCINumber	**Host:** OCINumber * **Indicator:** OCIInd	EXEC SQL ALLOCATE allocates memory for host var in object cache	Freed by EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	(1) Use EXEC SQL OBJECT GET/SET, or (2) Use OCINumber* functions defined in oci.h.
OCIRaw	**Host:** OCIRaw * **Indicator:** OCIInd	EXEC SQL ALLOCATE allocates memory for host var in object cache	Freed by EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	Use OCIRaw* functions defined in oci.h.
OCIString	**Host:** OCIString * **Indicator:** OCIInd	EXEC SQL ALLOCATE allocates memory for host var in object cache	EXEC SQL FREE, or EXEC SQL CACHE FREE ALL, or automatically at end of session.	(1) Use EXEC SQL OBJECT GET/SET, or (2) use OCIString* functions defined in oci.h.
NOTE: Host arrays of these types may not be used in bulk fetch/insert SQL operations in Pro*C/C++.				

New datatypes for Oracle8 are Ref, BLOB, NCLOB, CLOB, and BFILE. These types may be used in objects or in relational columns. In either case, they are mapped to host variables according to the C bindings shown in "Using New Database Types in Pro*C/C++" on page 8-38.

Restrictions on Using Oracle8 Datatypes in Dynamic SQL

Pro*C/C++ currently supports four different types of dynamic SQL methods: methods 1, 2, 3, and 4. Detailed descriptions of these methods are in Chapter 13, “Using Dynamic SQL” and Chapter 14, “Using Dynamic SQL: Advanced Concepts”.

The dynamic methods 1, 2, and 3 will handle all Pro*C/C++ extensions mentioned above, including the new object types, REF, Nested Table, Varying Array, NCHAR, NCHAR Varying and LOB types.

Dynamic SQL method 4 is generally restricted to the Oracle types supported by Pro*C/C++ prior to release 8.0. It does allow host variables of the NCHAR, NCHAR Varying and LOB datatypes. Dynamic method 4 is not available for object types, Nested Table, Varying Array, and REF types.

9

Running the Pro*C/C++ Precompiler

This chapter tells you how to run the Pro*C/C++ precompiler, and describes the extensive set of precompiler options in detail.

Topics are:

- The Precompiler Command
- Precompiler Options
- What Occurs during Precompilation?
- Scope of Options
- Entering Options
- Using the Precompiler Options
- Conditional Precompilations
- Guidelines for Precompiling Separately
- Compiling and Linking

The Precompiler Command

To run the Pro*C/C++ precompiler, you issue the following command:

```
proc ...
```

The location of the precompiler differs from system to system. The system or database administrator usually defines logicals or aliases, or uses other system-specific means to make the Pro*C/C++ executable accessible.

The INAME= argument specifies the source file to be precompiled. For example, the command

```
proc INAME=test_proc
```

precompiles the file *test_proc.pc* in the current directory, since the precompiler assumes that the filename extension is *.pc*. The INAME option does not have to be the first option on the command line, but if it is, you can omit the option specification. So, the command

```
proc myfile
```

is equivalent to

```
proc INAME=myfile
```

> **Note:** The option names, and option values that do not name specific OS objects, such as filenames, are not case-sensitive. In the examples in this guide, option names are written in upper case, and option values are usually in lower case. When you enter filenames, including the name of the Pro*C/C++ precompiler executable itself, always follow the case conventions used by your operating system.

Precompiler Options

Many useful options are available at precompile time. They enable you to control how resources are used, how errors are reported, how input and output are formatted, and how cursors are managed.

The value of an option is a string literal, which represent text or numeric values. For example, for the option

```
... INAME=my_test
```

the value is a string literal that specifies a filename. But for the option MAXOPENCURSORS

```
...MAXOPENCURSORS=20
```

the value is numeric.

Some options take Boolean values, and you can represent these with the strings *yes* or *no*, *true* or *false*, or with the integer literals 1 or 0 respectively. For example, the option

```
... SELECT_ERROR=yes
```

is equivalent to

```
... SELECT_ERROR=true
```

or

```
... SELECT_ERROR=1
```

all of which mean that SELECT errors should be flagged at run time.

The option value is always separated from the option name by an equals sign, with no whitespace around the equals sign.

Default Values

Many of the options have default values. The value of an option is determined by:

- a value built in to the precompiler
- a value set in the Pro*C / C++ *system configuration file*
- a value set in a Pro*C / C++ *user configuration file*
- a value set in the command line
- a value set inline

For example, the option MAXOPENCURSORS specifies the maximum number of cached open cursors. The built-in precompiler default value for this option is 10. However, if MAXOPENCURSORS=32 is specified in the system configuration file, the default now becomes 32. The user configuration file could set it to yet another value, which then overrides the system configuration value. If this option is set on the command line, the new command-line value takes precedence over the precompiler default, the system configuration file specification, and the user configuration file specification.

Finally, an inline specification takes precedence over all preceding defaults. See the section "Configuration Files" on page 9-5 for more information about configuration files.

Some options, such as USERID, do not have a precompiler default value. The built-in default values for options that do have them are listed in Table 9–1 , and in "Using the Precompiler Options" on page 9-10.

Attention: Check your system-specific documentation for the precompiler default values; they may be changed for your platform.

Determining Current Values

You can interactively determine the current value for one or more options by using a question mark on the command line. For example, if you issue the command

```
proc ?
```

the complete set of options, along with their current values, is printed to your terminal. (On a UNIX system running the C shell, escape the '?' with a backslash.) In this case, the values are those built into the precompiler, overridden by any values in the system configuration file. But if you issue the command

```
proc config=my_config_file.h ?
```

and there is a file named *my_config_file.h* in the current directory, all options are listed. Values in the user configuration file supply missing values, and supersede values built-in to the Pro*C/C++ precompiler, or values specified in the system configuration file.

Note that a configuration file must have only one option per line. Any other options entered after the first are ignored.

You can also determine the current value of a single option, by simply specifying that option name, followed by =?. For example:

```
proc maxopencursors=?
```

prints the current default value for the MAXOPENCURSORS option.

Entering:

```
proc
```

will give a short summary which resembles Table 9–1 .

Case Sensitivity

In general, you can use either uppercase or lowercase for precompiler option names and values. However, if your operating system is case sensitive, like UNIX, you must specify filename values, including the name of the Pro*C/C++ executable, using the correct combination of upper and lowercase letters.

Configuration Files

A configuration file is a text file that contains precompiler options. Each record (line) in the file contains only one option, with its associated value or values. *Any options entered on a line after the first option are ignored.* A configuration file can contain the lines

```
FIPS=YES
MODE=ANSI
CODE=ANSI_C
```

to set defaults for the FIPS, MODE, and CODE options.

There is a single system configuration file for each Oracle installation. The name of the system configuration file is *pcscfg.cfg*. The location of the file is system specific.

Each Pro*C/C++ user can have one or more private configuration files. The name of the configuration file must be specified using the CONFIG= precompiler option. See "Using the Precompiler Options" on page 9-10.

> **Note:** You cannot nest configuration files. This means that CONFIG= is not a valid option inside a configuration file.

What Occurs during Precompilation?

During precompilation, Pro*C/C++ generates C or C++ code that replaces the SQL statements embedded in your host program. The generated code contains data structures that indicate the datatype, length, and address of host variables, as well as other information required by the Oracle runtime library, SQLLIB. The generated code also contains the calls to SQLLIB routines that perform the embedded SQL operations.

> **Note:** The precompiler does *not* generate calls to Oracle Call Interface (OCI) routines.

The precompiler can issue warnings and error messages. These messages have the prefix PCC-, and are described in the *Oracle8 Error Messages* manual.

Table 9–1 is a quick reference to the major precompiler options. It summarizes the section "Using the Precompiler Options" on page 9-10. The options that are accepted, but do not have any affect, are not included in this table.

Scope of Options

A precompilation unit is a file containing C code and one or more embedded SQL statements. The options specified for a given precompilation unit affect only that unit; they have no effect on other units. For example, if you specify HOLD_CURSOR=YES and RELEASE_CURSOR=YES for unit A, but not for unit B, SQL statements in unit A run with these HOLD_CURSOR and RELEASE_CURSOR values, but SQL statements in unit B run with the default values.

Table 9–1 Precompiler Options

Syntax	Default	Specifics
AUTO_CONNECT=YES|NO	NO	Automatic OPS$ logon
CHAR_MAP=VARCHAR2|CHARZ |STRING|CHARF	CHARZ	mapping of character arrays and strings
CODE=ANSI_C | KR_C | CPP	KR_C	kind of C code generated
COMP_CHARSET= MULTI_BYTE|SINGLE_BYTE	MULTI_BYTE	the character set type the C/C++ compiler supports
CONFIG=<filename>	none	user's private configuration file
CPP_SUFFIX=<extension>	none	specify the default filename extension for output files
DBMS= V7 | NATIVE	NATIVE	compatibility (Oracle7, or the database version to which you are connected at precompile time)
DEFINE=<name>	none	define a name for use by the Pro*C/C++ precompiler
DEF_SQLCODE=YES|NO	NO	generate a macro to #define SQLCODE
DURATION	TRANSACTION	set pin duration for objects in the cache
ERRORS=YES | NO	YES	where to direct error messages (NO means only to listing file, and not to terminal)
ERRTYPE	none	name of the listing file for intype file error messages
FIPS=NONE | SQL89 | SQL2	none	whether to flag ANSI/ISO non-compliance

Table 9–1 Precompiler Options

Syntax	Default	Specifics
HOLD_CURSOR=YES | NO	NO	how cursor cache handles SQL statement
INAME=<filename>	none	name of the input file
INCLUDE=<pathname>	none	directory path for EXEC SQL INCLUDE or #include statements
INTYPE=<filename>	none	name of the input file for type information
LINES=YES | NO	NO	whether #line directives are generated
LNAME=<filename>	none	name of listing file
LTYPE=NONE|SHORT| LONG	SHORT	type of listing file to be generated, if any
MAXLITERAL=10..1024	1024	maximum length (bytes) of string literals in generated C code
MAXOPENCURSORS=5..255	10	number of concurrent cached open cursors
MODE=ANSI|ISO|ORACLE	ORACLE	ANSI/ISO or Oracle behavior
NLS_CHAR=(<var1>, ..., <varn>)	none	specify NLS character variables
NLS_LOCAL=YES|NO	NO	control NLS character semantics
OBJECTS=YES|NO	YES	support object types
ONAME=<filename>	NONE	name of the output (code) file
ORACA=YES|NO	NO	whether to use the ORACA
PAGELEN	80	the page length of the listing file
PARSE=NONE | PARTIAL | FULL	FULL	whether Pro*C/C++ parses (with a C parser) the .pc source.
RELEASE_CURSOR=YES|NO	NO	control release of cursors from cursor cache
SELECT_ERROR=YES|NO	YES	flagging of SELECT errors
SQLCHECK=SEMANTICS|SYNTAX	SYNTAX	kind of precompile time SQL checking
SYS_INCLUDE=<pathname>	none	directory where system header files, such as iostream.h, are found
THREADS=YES|NO	NO	indicates a multi-threaded application

Table 9–1 Precompiler Options

Syntax	Default	Specifics
UNSAFE_NULL=YES | NO	NO	UNSAFE_NULL=YES disables the ORA-01405 message
USERID=<username> / <password>	none	username / password[@dbname] connect string
VARCHAR=YES | NO	NO	allow the use of implicit VARCHAR structures
VERSION	RECENT	which version of an object is to be returned

Entering Options

You can enter any precompiler option in the command line. Many can also be entered inline in the precompiler program source file, using the EXEC ORACLE OPTION statement.

On the Command Line

You enter precompiler options in the command line using the following syntax:

```
... [OPTION_NAME=value] [OPTION_NAME=value] ...
```

Separate each option=value specification with one or more spaces. For example, you might enter the following:

```
... CODE=ANSI_C MODE=ANSI
```

Inline

You enter options inline by coding EXEC ORACLE statements, using the following syntax:

```
EXEC ORACLE OPTION (OPTION_NAME=value);
```

For example, you might code the following:

```
EXEC ORACLE OPTION (RELEASE_CURSOR=yes);
```

Uses for EXEC ORACLE

The EXEC ORACLE feature is especially useful for changing option values during precompilation. For example, you might want to change HOLD_CURSOR and RELEASE_CURSOR on a statement-by-statement basis. Appendix C,

"Performance Tuning" shows you how to optimize runtime performance using inline options.

Specifying options inline or in a configuration file is also helpful if your operating system limits the number of characters you can enter on the command line.

Scope of EXEC ORACLE

An EXEC ORACLE statement stays in effect until textually superseded by another EXEC ORACLE statement specifying the same option. In the following example, HOLD_CURSOR=NO stays in effect until superseded by HOLD_CURSOR=YES:

```
char emp_name[20];
int  emp_number, dept_number;
float salary;

EXEC SQL WHENEVER NOT FOUND DO break;
EXEC ORACLE OPTION (HOLD_CURSOR=NO);

EXEC SQL DECLARE emp_cursor CURSOR FOR
SELECT empno, deptno FROM emp;

EXEC SQL OPEN emp_cursor;
printf(
"Employee Number  Department\n-------------------------\n");
for (;;)
{
   EXEC SQL FETCH emp_cursor INTO :emp_number, :dept_number;
   printf("%d\t%d\n", emp_number, dept_number);
}

EXEC SQL WHENEVER NOT FOUND CONTINUE;
for (;;)
{
   printf("Employee number: ");
   scanf("%d", &emp_number);
   if (emp_number == 0)
      break;
   EXEC ORACLE OPTION (HOLD_CURSOR=YES);
   EXEC SQL SELECT ename, sal
      INTO :emp_name, :salary
      FROM emp WHERE empno = :emp_number;
   printf("Salary for %s is %6.2f.\n", emp_name, salary);
```

Using the Precompiler Options

This section is organized for easy reference. It lists the precompiler options alphabetically, and for each option gives its purpose, syntax, and default value. Usage notes that help you understand how the option works are also provided.

AUTO_CONNECT

Purpose

Allows automatic connection to the OPS$ account.

Syntax

AUTO_CONNECT={YES | NO}

Default

NO

Usage Notes

Can be entered only on the command line or in a configuration file.

If AUTO_CONNECT=YES, and the application is not already connected to a database when it processes the first executable SQL statement, it attempts to connect using the userid

```
OPS$<username>
```

where *username* is your current operating system user or task name and OPS$username is a valid Oracle userid.

When AUTO_CONNECT=NO, you must use the CONNECT statement in your program to connect to Oracle.

CHAR_MAP

Purpose

Specifies the default mapping of C host variables of type char or char[n], and pointers to them, into SQL.

Syntax

CHAR_MAP={VARCHAR2 | CHARZ | STRING | CHARF}

Default

CHARZ

Usage Note

Before Oracle8, you had to declare char or char[n] host variables as CHAR, using the SQL DECLARE statement.The external datatypes VARCHAR2 and CHARZ were the default character mappings of Oracle7.

See "National Language Support" on page 4-2 for a table of CHAR_MAP settings, descriptions of the datatype, and where they are the default. An example of usage of CHAR_MAP in Pro*C/C++ is found in "Inline Usage of the CHAR_MAP Option" on page 3-51.

CODE

Purpose

Specifies the format of C function prototypes generated by the Pro*C/C++ precompiler. (A *function prototype* declares a function and the datatypes of its arguments.) The precompiler generates function prototypes for SQL library routines, so that your C compiler can resolve external references. The CODE option lets you control the prototyping.

Syntax

CODE={ANSI_C|KR_C | CPP}

Default

KR_C

Usage Notes

Can be entered on the command line, but not inline.

ANSI C standard X3.159-1989 provides for function prototyping. When CODE=ANSI_C, Pro*C/C++ generates full function prototypes, which conform to the ANSI C standard. An example follows:

```
extern void sqlora(long *, void *);
```

The precompiler can also generate other ANSI-approved constructs such as the **const** type qualifier.

When CODE=KR_C (the default), the precompiler Comments out the argument lists of generated function prototypes, as shown here:

```
extern void sqlora(/*_ long *, void * _*/);
```

So, specify CODE=KR_C if your C compiler is not compliant with the X3.159 standard.

When CODE=CPP, the precompiler generates C++ compatible code.

COMP_CHARSET

Purpose

Indicates to the Pro*C/C++ Precompiler whether multi-byte character sets are (or are not) supported by the compiler to be used. It is intended for use by developers working in a multi-byte client-side environment (for example, when NLS_LANG is set to a multi-byte character set).

Syntax

COMP_CHARSET={MULTI_BYTE | SINGLE_BYTE}

Default

MULTI_BYTE

Usage Notes

Can be entered only on the command line.

With COMP_CHARSET=MULTI_BYTE (default), Pro*C/C++ generates C code that is to be compiled by a compiler that supports multi-byte NLS character sets.

With COMP_CHARSET=SINGLE_BYTE, Pro*C/C++ generates C code for single-byte compilers that addresses a complication that *may* arise from the ASCII equivalent of a backslash (\) character in the second byte of a double-byte character in a multi-byte string. In this case, the backslash (\) character is “escaped" with another backslash character preceding it.

> **Note:** The need for this feature is common when developing in a Shift-JIS environment with older C compilers.

This option has no effect when NLS_LANG is set to a single-byte character set.

CONFIG

Purpose

Specifies the name of a user configuration file.

Syntax

CONFIG=<filename>

Default

None

Usage Notes

Can be entered only on the command line.

This option is the only way you can inform Pro*C/C++ of the name and location of user configuration files.

CPP_SUFFIX

Purpose

The CPP_SUFFIX option allows you to specify the filename extension that the precompiler appends to the C++ output file generated when the CODE=CPP option is specified.

Syntax

CPP_SUFFIX=<filename extension>

Default

System-specific.

Usage Notes

Most C compilers expect a default extension of ".c" for their input files. Different C++ compilers, however, can expect different filename extensions. The CPP_SUFFIX option allows you to specify the filename extension that the precompiler generates. The value of this option is a string, without the quotes or the period. For example, CPP_SUFFIX=cc, or CPP_SUFFIX=C.

DBMS

Purpose

Specifies whether Oracle follows the semantic and syntactic rules of Oracle8, Oracle7, or the native version of Oracle (that is, the version to which the application is connected).

Syntax

DBMS={NATIVE | V7 | V6_CHAR | V8}

Default

NATIVE

Usage Notes

Can be entered only on the command line, or in a configuration file.

The DBMS option lets you control the version-specific behavior of Oracle. When DBMS=NATIVE (the default), Oracle follows the semantic and syntactic rules of the database version to which the application is connected.

When DBMS=V8, or DBMS=V7, Oracle follows the respective rules for Oracle8 (which remain the same as for Oracle7). V6_CHAR is deprecated in Oracle8 and its

functionality is provided by the precompiler option CHAR_MAP (which see on "CHAR_MAP" on page 9-10).

Table 9–2 How DBMS and MODE Interact

Situation	DBMS=V7|V8 MODE=ANSI	DBMS=V7|V8 MODE=ORACLE
"no data found" warning code	+100	+1403
fetch nulls without using indicator variables	error -1405	error -1405
fetch truncated values without using indicator variables	no error but SQLWARN(2) is set	no error but SQLWARN(2) is set
cursors closed by COMMIT or ROLLBACK	all explicit	CURRENT OF only
open an already OPENed cursor	error -2117	no error
close an already CLOSEd cursor	error -2114	no error
SQL group function ignores nulls	no warning	no warning
when SQL group function in multirow query is called	FETCH time	FETCH time
declare SQLCA structure	optional	required
declare SQLCODE or SQLSTATE status variable	required	optional but Oracle ignores
integrity constraints	enabled	enabled
PCTINCREASE for rollback segments	not allowed	not allowed
MAXEXTENTS storage parameters	not allowed	not allowed

DEF_SQLCODE

Purpose

Controls whether the Pro*C/C++ precompiler generates **#define**'s for SQLCODE.

Syntax

DEF_SQLCODE={NO | YES}

Default

NO

Usage Notes

Can be used only on the command line or in a configuration file.

When DEF_SQLCODE=YES, the precompiler defines SQLCODE in the generated source code as follows:

```
#define SQLCODE sqlca.sqlcode
```

You can then use SQLCODE to check the results of executable SQL statement. The DEF_SQLCODE option is supplied for compliance with standards that require the use of SQLCODE.

In addition, you must also include the SQLCA using one of the following entries in your source code:

```
#include <sqlca.h>
```

or

```
EXEC SQL INCLUDE SQLCA;
```

If the SQLCA is not included, using this option causes a precompile time error.

DEFINE

Purpose

Defines a name that can be used in **#ifdef** and **#ifndef** Pro*C/C++ precompiler directives. The defined name can also be used by the EXEC ORACLE IFDEF and EXEC ORACLE IFNDEF statements.

Syntax

DEFINE=*name*

Default

None

Usage Notes

Can be entered on the command line or inline. You can only use DEFINE to define a name—you cannot define macros with it. For example, the following use of define is not valid:

```
proc my_prog DEFINE=LEN=20
```

Using DEFINE in the correct way, you could do

```
proc my_prog DEFINE=XYZZY
```

And then in *my_prog.pc*, code

```
#ifdef XYZZY
...
#else
...
#endif
```

Or, you could just as well code

```
EXEC ORACLE IFDEF XYZZY;
...
EXEC ORACLE ELSE;
...
EXEC ORACLE ENDIF;
```

The following example is *invalid*:

```
#define XYZZY
...
EXEC ORACLE IFDEF XYZZY
...
EXEC ORACLE ENDIF;
```

EXEC ORACLE conditional statements are *valid* only if the macro is defined using EXEC ORACLE DEFINE or the DEFINE option.

If you define a name using DEFINE=, and then conditionally include (or exclude) a code section using the Pro*C/C++ precompiler **#ifdef** (or **#ifndef**) directives, you must also make sure that the name is defined when you run the C compiler. For example, for UNIX *cc*, you must use the -D option to define the name for the C compiler.

DURATION

Purpose

Sets the pin duration used by subsequent EXEC SQL OBJECT CREATE and EXEC SQL OBJECT DEREF statements. Objects in the cache are implicitly unpinned at the end of the duration.

Syntax

DURATION={TRANSACTION | SESSION}

Default

TRANSACTION

Usage Notes

Can be entered inline by use of the EXEC ORACLE OPTION statement.

TRANSACTION means that objects are implicitly unpinned when the transaction completes.

SESSION means that objects are implicitly unpinned when the connection is terminated.

ERRORS

Purpose

Specifies whether error messages are sent to the terminal as well as the listing file (YES), or just to the listing file (NO).

Syntax

ERRORS={YES | NO}

Default

YES

Usage Notes

Can be entered only on the command line, or in a configuration file.

ERRTYPE

Purpose

Specifies an output file in which errors generated in processing type files are written. If omitted, errors are output to the screen. (See more about "INTYPE" on page 9-23.)

Syntax

ERRTYPE=<filename>

Default

None

Usage Notes

Only one error file will be produced. If multiple values are entered, the last one is used by the precompiler.

FIPS

Purpose

Specifies whether extensions to ANSI SQL are flagged (by the FIPS Flagger). An extension is any SQL element that violates ANSI format or syntax rules, except privilege enforcement rules.

Syntax

FIPS={NONE | SQL89 | SQL2 | YES | NO}

Default

None

Usage Notes

Can be entered inline or on the command line.

When FIPS=YES, the FIPS Flagger is enabled, and warning (not error) messages are issued if you use an Oracle extension to ANSI SQL, or use an ANSI SQL feature in a nonconforming manner. Extensions to ANSI SQL that are flagged at precompile time include the following:

- array interface including the FOR clause
- SQLCA, ORACA, and SQLDA data structures
- dynamic SQL including the DESCRIBE statement
- embedded PL/SQL blocks
- automatic datatype conversion
- DATE, NUMBER, RAW, LONGRAW, VARRAW, ROWID, VARCHAR2, and VARCHAR datatypes
- pointer host variables
- Oracle OPTION statement for specifying runtime options
- IAF statements in user exits
- CONNECT statement
- TYPE and VAR datatype equivalencing statements
- AT <db_name> clause
- DECLARE...DATABASE, ...STATEMENT, and ...TABLE statements
- SQLWARNING condition in WHENEVER statement
- DO *function_name()* and DO **break** actions in
- WHENEVER statement
- COMMENT and FORCE TRANSACTION clauses in
- COMMIT statement
- FORCE TRANSACTION and TO SAVEPOINT clauses in ROLLBACK statement
- RELEASE parameter in COMMIT and ROLLBACK statements
- optional colon-prefixing of WHENEVER...GOTO labels, and of host variables in the INTO clause

HOLD_CURSOR

Purpose

Specifies how the cursors for SQL statements and PL/SQL blocks are handled in the cursor cache.

Syntax

HOLD_CURSOR={YES | NO}

Default

NO

Usage Notes

Can be entered inline or on the command line.

You can use HOLD_CURSOR to improve the performance of your program. For more information, see Appendix C

When a SQL data manipulation statement is executed, its associated cursor is linked to an entry in the cursor cache. The cursor cache entry is in turn linked to an Oracle private SQL area, which stores information needed to process the statement. HOLD_CURSOR controls what happens to the link between the cursor and cursor cache.

When HOLD_CURSOR=NO, after Oracle executes the SQL statement and the cursor is closed, the precompiler marks the link as reusable. The link is reused as soon as the cursor cache entry to which it points is needed for another SQL statement. This frees memory allocated to the private SQL area and releases parse locks.

When HOLD_CURSOR=YES and RELEASE_CURSOR=NO, the link is maintained; the precompiler does not reuse it. This is useful for SQL statements that are executed often because it speeds up subsequent executions. There is no need to reparse the statement or allocate memory for an Oracle private SQL area.

For inline use with implicit cursors, set HOLD_CURSOR before executing the SQL statement. For inline use with explicit cursors, set HOLD_CURSOR before CLOSEing the cursor.

Note that RELEASE_CURSOR=YES overrides HOLD_CURSOR=YES and that HOLD_CURSOR=NO overrides RELEASE_CURSOR=NO. For information showing how these two options interact, see Table 0–2 .

INAME

Purpose

Specifies the name of the input file.

Syntax

INAME=<path and filename>

Default

None

Usage Notes

Can be entered only on the command line.

You can omit the filename extension if it is *.pc*. If the input filename is the first option on the command line, you can omit the INAME= part of the option. For example:

```
proc sample1 MODE=ansi
```

to precompile the file *sample1.pc*, using ANSI mode. This command is the same as

```
proc INAME=sample1 MODE=ansi
```

INCLUDE

Purpose

Specifies a directory path for files included using the **#include** or EXEC SQL INCLUDE directives.

Syntax

INCLUDE=*pathname* or INCLUDE=(*path_1*,*path_2*,...,*path_n*)

Default

Current directory and paths built into Pro*C/C++.

Usage Notes

Can be entered inline or on the command line.

You use INCLUDE to specify a directory path for included files. The precompiler searches directories in the following order:

1. the current directory
2. the system directory specified in a SYS_INCLUDE precompiler option
3. the directories specified by the INCLUDE option, in the order they are entered

4. the built-in directories for standard header files

You normally do not need to specify a directory path for Oracle-specific header files such as *sqlca.h* and *sqlda.h*.

> **Note:** If you specify an Oracle-specific filename without an extension for inclusion, Pro*C/C++ assumes an extension of *.h*. So,included files should have an extension, even if it is not *.h*.
>
> For all other header files, the precompiler does *not* assume a *.h* extension.

You must still use INCLUDE to specify directory paths for non-standard files, unless they are stored in the current directory. You can specify more than one path on the command line, as follows:

```
... INCLUDE=path_1 INCLUDE=path_2 ...
```

> **Warning:** If the file you want to include resides in another directory, make sure that there is no file with the same name in the current directory.

The syntax for specifying a directory path using the INCLUDE option is system specific. Follow the conventions used for your operating system

INTYPE

Purpose

Specifies one or more OTT-generated type files (only needed if Object types are used in the application).

Syntax

INTYPE=(*file_1*,*file_2*,...,*file_n*)

Default

None

Usage Notes

There will be one type file for each Object type in the Pro*C/C++ code.

LINES

Purpose

Specifies whether the Pro*C/C++ precompiler adds **#line** preprocessor directives to its output file.

Syntax

LINES={YES | NO}

Default

NO

Usage Notes

Can be entered only on the command line.

The LINES option helps with debugging. When LINES=YES, the Pro*C/C++ precompiler adds **#line** preprocessor directives to its output file.

Normally, your C compiler increments its line count after each input line is processed. The **#line** directives force the compiler to reset its input line counter so that lines of precompiler-generated code are not counted. Moreover, when the name of the input file changes, the next **#line** directive specifies the new filename.

The C compiler uses the line numbers and filenames to show the location of errors. Thus, error messages issued by the C compiler always refer to your original source files, not the modified source file.

When LINES=NO (the default), the precompiler adds no **#line** directives to its output file.

> **Note:** In "Directives Ignored" on page 3-3, it is stated that the Pro*C/C++ precompiler does not support the **#line** directive. This means that you cannot directly code **#line** directives in the precompiler source. But you can still use the LINES= option to have the precompiler insert **#line** directives for you.

LNAME

Purpose

Specifies the name of the listing file.

Syntax

LNAME=<filename>

Default

None

Usage Notes

Can be entered only on the command line.

The default filename extension for the listing file is *.lis*.

LTYPE

Purpose

Specifies the type of listing file generated.

Syntax

LTYPE={NONE|SHORT|LONG}

Default

SHORT

Usage Notes

Can be entered on the command line or in a configuration file.

When a listing file is generated, the LONG format is the default. With LTYPE=LONG specified, all of the source code is listed as it is parsed and messages listed as they are generated. In addition, the Pro*C/C++ options currently in effect are listed.

With LTYPE=SHORT specified, only the generated messages are listed—no source code—with line references to the source file to help you locate the code that generated the message condition.

With LTYPE=NONE specified, no list file is produced *unless* the LNAME option explicitly specifies a name for a list file. Under the latter condition, the list file *is* generated with LTYPE=LONG assumed.

MAXLITERAL

Purpose

Specifies the maximum length of string literals generated by the precompiler, so that compiler limits are not exceeded.

Syntax

MAXLITERAL=integer, range is 10 to 1024

Default

1024

Usage Notes

Cannot be entered inline.

The maximum value of MAXLITERAL is compiler dependent. For example, some C compilers cannot handle string literals longer than 512 characters, so you would specify MAXLITERAL=512.

Strings that exceed the length specified by MAXLITERAL are divided during precompilation, then recombined (concatenated) at run time.

MAXOPENCURSORS

Purpose

Specifies the number of concurrently open cursors that the precompiler tries to keep cached.

Syntax

MAXOPENCURSORS=*integer*

Default

10

Usage Notes

Can be entered inline or on the command line.

You can use MAXOPENCURSORS to improve the performance of your program. For more information, see Appendix C.

When precompiling separately, use MAXOPENCURSORS as described in "Guidelines for Precompiling Separately" on page 9-40.

MAXOPENCURSORS specifies the *initial* size of the SQLLIB cursor cache. If a new cursor is needed, and there are no free cache entries, Oracle tries to reuse an entry. Its success depends on the values of HOLD_CURSOR and RELEASE_CURSOR, and, for explicit cursors, on the status of the cursor itself. Oracle allocates an additional cache entry if it cannot find one to reuse.

If necessary, Oracle keeps allocating additional cache entries until it runs out of memory or reaches the limit set by OPEN_CURSORS. MAXOPENCURSORS must be lower than OPEN_CURSORS by at least 6 to avoid a “maximum open cursors exceeded” Oracle error.

As your program’s need for concurrently open cursors grows, you might want to respecify MAXOPENCURSORS to match the need. A value of 45 to 50 is not uncommon, but remember that each cursor requires another private SQL area in the user process memory space. The default value of 10 is adequate for most programs.

MODE

Purpose

Specifies whether your program observes Oracle practices or complies with the current ANSI/ISO SQL standards.

Syntax

MODE={ANSI | ISO | ORACLE}

Default

ORACLE

Usage Notes

Can be entered only on the command line or in a configuration file.

ISO is a synonym for ANSI.

When MODE=ORACLE (the default), your embedded SQL program observes Oracle practices. When MODE=ANSI, your program complies *fully* with the ANSI SQL standard, and the following changes go into effect:

- Issuing a COMMIT or ROLLBACK closes all explicit cursors.

- You cannot OPEN an already open cursor or CLOSE an already closed cursor. (When MODE=ORACLE, you can reOPEN an open cursor to avoid reparsing.)
- You must declare a either a *long* variable named *SQLCODE* or a *char* SQLSTATE[6] variable (uppercase is required for both variables) that is in scope of every EXEC SQL statement. The same *SQLCODE* or *SQLSTATE* variable need not be used in each case; that is, the variable need not be global.
- Declaring the SQLCA is optional. You need not include the SQLCA.
- The "no data found" Oracle warning code returned to SQLCODE becomes +100 instead of +1403. The message text does not change.

NLS_CHAR

Purpose

Specifies which C host character variables are treated by the precompiler as National Language Support (NLS) multi-byte character variables.

Syntax

NLS_CHAR=*varname* or NLS_CHAR=(*var_1*,*var_2*,...,*var_n*)

Default

None.

Usage Notes

Can be entered only on the command line, or in a configuration file.

This option allows you to specify at precompile time a list of the names of one or more host variables that the precompiler must treat as National Language character variables. You can specify only C *char* variables or Pro*C/C++ VARCHARs using this option.

If you specify in the option list a variable that is not declared in your program, then the precompiler generates no error.

NLS_LOCAL

Purpose

Determines whether NLS character conversions are performed by the precompiler runtime library, SQLLIB, or by the Oracle8 Server.

Syntax

NLS_LOCAL={NO | YES}

Default

NO

Usage Notes

When set to YES, local multi-byte support is provided by Pro*C/C++ and the SQLLIB library. The option NLS_CHAR must be used to indicate which C host variables are multi-byte. When set to NO, Pro*C/C++ will use the Oracle8 server support for multi-byte objects. Set to NO for all new applications.

Can be entered only on the command line, or in a configuration file.

OBJECTS

Purpose

Requests support for Object types in Oracle8.

Syntax

OBJECTS={YES | NO}

Default

YES

Usage Notes

Can only be entered in the command line.

ONAME

Purpose

Specifies the name of the output file. The output file is the C code file that the precompiler generates.

Syntax

ONAME=<path and filename>

Default

INAME with an extension determined by CPP_SUFFIX.

Usage Notes

Can be entered only on the command line. Use this option to specify the full pathname of the output file, where the pathname differs from that of the input (*.pc*) file. For example, if you issue the command:

```
proc iname=my_test
```

the default output filename is *my_test.c*. If you want the output filename to be *my_test_1.c*, issue the command

```
proc iname=my_test oname=my_test_1.c
```

Note that you should add the *.c* extension to files specified using ONAME.

The default extension with the ONAME option is platform-specific, but you can override it using the CODE and CPP_SUFFIX options. When CODE=KR_C or ANSI_C, the extension is *c*. When CODE=CPP, you can use the CPP_SUFFIX option to override the platform-specific default.

> ***Attention:*** Oracle recommends that you not let the output filename default, but rather name it explicitly using ONAME.

ORACA

Purpose

Specifies whether a program can use the Oracle Communications Area (ORACA).

Syntax

ORACA={YES | NO}

Default

NO

Usage Notes

Can be entered inline or on the command line.

When ORACA=YES, you must place either the EXEC SQL INCLUDE ORACA or **#include** *oraca.h* statement in your program.

PARSE

Purpose

Specifies the way that the Pro*C/C++ precompiler parses the source file.

Syntax

PARSE={FULL | PARTIAL | NONE}

Default

FULL

Usage Notes

To generate C++ compatible code, the PARSE option must be either NONE or PARTIAL. If PARSE=FULL, the C parser is used, and it does not understand C++ constructs, such as classes, in your code.

See "Parsing Code" on page 7-4 for more information on the PARSE option.

With PARSE=FULL or PARSE=PARTIAL Pro*C/C++ fully supports C preprocessor directives, such as **#define**, **#ifdef**, and so on. However, with PARSE=NONE conditional preprocessing is supported by EXEC ORACLE statements as described in "Conditional Precompilations" on page 9-39.

Note that some platforms have the default value of PARSE as other than FULL. See your system-dependent documentation.

RELEASE_CURSOR

Purpose

Specifies how the cursors for SQL statements and PL/SQL blocks are handled in the cursor cache.

Syntax

RELEASE_CURSOR={YES | NO}

Default

NO

Usage Notes

Can be entered inline or on the command line.

You can use RELEASE_CURSOR to improve the performance of your program. For more information, see Appendix C.

When a SQL data manipulation statement is executed, its associated cursor is linked to an entry in the cursor cache. The cursor cache entry is in turn linked to an Oracle private SQL area, which stores information needed to process the statement. RELEASE_CURSOR controls what happens to the link between the cursor cache and private SQL area.

When RELEASE_CURSOR=YES, after Oracle executes the SQL statement and the cursor is closed, the precompiler immediately removes the link. This frees memory allocated to the private SQL area and releases parse locks. To make sure that associated resources are freed when you CLOSE a cursor, you must specify RELEASE_CURSOR=YES.

When RELEASE_CURSOR=NO and HOLD_CURSOR=YES, the link is maintained. The precompiler does not reuse the link unless the number of open cursors exceeds the value of MAXOPENCURSORS. This is useful for SQL statements that are executed often because it speeds up subsequent executions. There is no need to reparse the statement or allocate memory for an Oracle private SQL area.

For inline use with implicit cursors, set RELEASE_CURSOR before executing the SQL statement. For inline use with explicit cursors, set RELEASE_CURSOR before CLOSEing the cursor.

Note that RELEASE_CURSOR=YES overrides HOLD_CURSOR=YES and that HOLD_CURSOR=NO overrides RELEASE_CURSOR=NO. For a table showing how these two options interact, see Appendix C.

SELECT_ERROR

Purpose

Specifies whether your program generates an error when a SELECT statement returns more than one row, or more rows than a host array can accommodate.

Syntax

SELECT_ERROR={YES | NO}

Default

YES

Usage Notes

Can be entered inline or on the command line.

When SELECT_ERROR=YES, an error is generated when a single-row SELECT returns too many rows, or when an array SELECT returns more rows than the host array can accommodate. The result of the SELECT is indeterminate.

When SELECT_ERROR=NO, no error is generated when a single-row SELECT returns too many rows, or when an array SELECT returns more rows than the host array can accommodate.

Whether you specify YES or NO, a random row is selected from the table. The only way to ensure a specific ordering of rows is to use the ORDER BY clause in your SELECT statement. When SELECT_ERROR=NO and you use ORDER BY, Oracle returns the first row, or the first *n* rows when you are SELECTing into an array. When SELECT_ERROR=YES, whether or not you use ORDER BY, an error is generated when too many rows are returned.

SQLCHECK

Purpose

Specifies the type and extent of syntactic and semantic checking.

Syntax

SQLCHECK={SEMANTICS | FULL | SYNTAX

Default

SYNTAX

Usage Notes

Can be entered inline or the command line.

The Pro*C / C++ precompiler can help you debug a program by checking the syntax and semantics of embedded SQL statements and PL / SQL blocks. You control the level of checking by entering the SQLCHECK option inline and / or on the command line. However, the level of checking you specify inline cannot be higher than the level you specify (or accept by default) on the command line. For example, if you specify SQLCHECK=SYNTAX on the command line, you cannot specify SQLCHECK=SEMANTICS inline.

SQLCHECK=SEMANTICS|FULL

The precompiler checks the syntax and semantics of

- data manipulation statements such as INSERT and UPDATE
- PL / SQL blocks
- host variable datatypes

However, only syntactic checking is done on data manipulation statements or PL / SQL blocks that use the AT *db_name* clause. No syntax or semantics checking is performed on DDL statements, such as CREATE and ALTER.

Any errors found are reported at precompile time.

The precompiler gets information needed for a semantic check by using embedded DECLARE TABLE statements, or if you specify the USERID option on the command line, by connecting to Oracle and accessing the data dictionary. You need not connect to Oracle if every table referenced in a data manipulation statement or PL / SQL block is defined in a DECLARE TABLE statement.

If you connect to Oracle, but some needed information cannot be found in the data dictionary, you must use DECLARE TABLE statements to supply the missing information. A DECLARE TABLE definition overrides a data dictionary definition if they conflict.

If you embed PL/SQL blocks in a host program, you *must* specify SQLCHECK=SEMANTICS and the USERID option as well.

SQLCHECK=SYNTAX

The precompiler checks the syntax of

- declarative SQL statements (such as EXEC SQL WHENEVER...)
- Data Manipulation Language statements
- host variables and host variable datatypes

and any errors found are reported at precompile time.

But no semantic checking is done. DECLARE TABLE statements are ignored, and PL/SQL blocks are not allowed.

Specifying the SYNTAX value generates a usable output (code) file, however semantic errors can still occur at runtime.

See Appendix D, "Syntactic and Semantic Checking" for more information.

SYS_INCLUDE

Purpose

Specifies the location of system header files.

Syntax

SYS_INCLUDE=<pathname>

Default

System-specific.

Usage Notes

Pro*C/C++ searches for standard system header files, such as *stdio.h*, in standard locations that are platform specific. For example, on almost all UNIX systems, the file *stdio.h* has the full pathname */usr/include/stdio.h*.

But C++ compilers can have system header files, such as *stdio.h*, that are not in the standard system locations. You can use the SYS_INCLUDE command line option to specify a list of directory paths that Pro*C/C++ searches to look for system header files. For example:

```
SYS_INCLUDE=(/usr/lang/SC2.0.1/include,/usr/lang/SC2.1.1/include)
```

The search path that you specify using SYS_INCLUDE overrides the default header location

If PARSE=NONE, the value specified in SYS_INCLUDE is irrelevant for the precompilation, since there is no need for Pro*C/C++ to include system header files in the precompilation. (You must, of course, still include Oracle-specific headers, such as *sqlca.h*. and system header files, with #include directives for pre-processing by the compiler.)

The precompiler searches directories in the following order:

1. the current directory
2. the system directory specified in the SYS_INCLUDE precompiler option
3. the directories specified by the INCLUDE option, in the order entered
4. the built-in directory for standard header files

Because of step 3, you normally do not need to specify a directory path for standard header files such as *sqlca.h* and *sqlda.h*.

THREADS

Purpose

When THREADS=YES, the precompiler searches for context declarations.

Syntax

THREADS={YES | NO}

Default

NO

Usage Notes

Cannot be entered inline.

This precompiler option is required for any program that requires multi-threaded support.

With THREADS=YES, the precompiler generates an error if no EXEC SQL CONTEXT USE directive is encountered before the first context is visible and an

executable SQL statement is found. For more information, see "Developing Multi-threaded Applications" on page 4-37.

UNSAFE_NULL

Purpose

Specifying UNSAFE_NULL=YES prevents generation of ORA-01405 messages when fetching NULLs without using indicator variables.

Syntax

UNSAFE_NULL={YES | NO}

Default

NO

Usage Notes

Cannot be entered inline.

The UNSAFE_NULL=YES is allowed only when MODE=ORACLE and DBMS=V7 or V6_CHAR.

The UNSAFE_NULL option has no effect on host variables in an embedded PL/SQL block. You *must* use indicator variables to avoid ORA-01405 errors.

USERID

Purpose

Specifies an Oracle username and password.

Syntax

USERID=username/password

Default

None

Usage Notes

Can be entered only on the command line.

Do not specify this option when using the automatic connect feature, which accepts your Oracle username prefixed with OPS$. The actual value of the "OPS$" string is set as a parameter in the INIT.ORA file.

When SQLCHECK=SEMANTICS, if you want the precompiler to get needed information by connecting to Oracle and accessing the data dictionary, you must also specify USERID.

VARCHAR

Purpose

Instructs the Pro*C/C++ precompiler to interpret some structs as VARCHAR host variables.

Syntax

VARCHAR={NO | YES}

Default

NO

Usage Notes

Can be entered only on the command line.

When VARCHAR=YES, a C struct that you code as

```
struct {
    short <len>;
    char  <arr>[n];
} name;
```

is interpreted by the precompiler as a VARCHAR[n] host variable.

VERSION

Purpose

Determines which version of the object will be returned by the EXEC SQL OBJECT DEREF statement.

Syntax

VERSION={RECENT | LATEST | ANY}

Default

RECENT

Usage Notes

Can be entered inline by use of the EXEC ORACLE OPTION statement.

RECENT means that if the object has been selected into the object cache in the current transaction, then that object is returned. For transactions running in serializable mode, this option has the same effect as LATEST without incurring as many network roundtrips. Most applications should use RECENT.

LATEST means that if the object does not reside in the object cache, it is retrieved from the database. If It does reside in the object cache, it is refreshed from the server. Use LATEST with caution because it incurs the greatest number of network roundtrips. Use LATEST only when it is imperative that the object cache is kept as coherent as possible with the server buffer cache

ANY means that if the object already resides in the object cache, return that object. If not, retrieve the object from the server. ANY incurs the fewest network roundtrips. Use in applications that access read-only objects or when a user will have exclusive access to the objects.

Conditional Precompilations

Conditional precompilation includes (or excludes) sections of code in your C program based on certain conditions. For example, you might want to include one section of code when precompiling under UNIX and another when precompiling under VMS. Conditional precompiling lets you write programs that can run in different environments.

Conditional sections of code are marked by statements that define the environment and actions to take. You can code C statements as well as EXEC SQL statements in these sections. The following statements let you exercise conditional control over precompilation:

```
EXEC ORACLE DEFINE symbol;    -- define a symbol
EXEC ORACLE IFDEF symbol;     -- if symbol is defined
EXEC ORACLE IFNDEF symbol;    -- if symbol is not defined
EXEC ORACLE ELSE;             -- otherwise
EXEC ORACLE ENDIF;            -- end this control block
```

All EXEC ORACLE statements must be terminated with a semi-colon.

Defining Symbols

You can define a symbol in two ways. Either include the statement

```
EXEC ORACLE DEFINE symbol;
```

in your host program or define the symbol on the command line using the syntax

```
... INAME=filename ... DEFINE=symbol
```

where *symbol* is not case-sensitive.

> **Warning:** The **#define** preprocesssor directive is not the same as the EXEC ORACLE DEFINE command

Some port-specific symbols are predefined for you when the Pro*C/C++ precompiler is installed on your system. For example, predefined operating system symbols include CMS, MVS, MS-DOS, UNIX, and VMS.

An Example

In the following example, the SELECT statement is precompiled only when the symbol *site2* is defined:

```
EXEC ORACLE IFDEF site2;
    EXEC SQL SELECT DNAME
        INTO :dept_name
        FROM DEPT
        WHERE DEPTNO = :dept_number;
EXEC ORACLE ENDIF;
```

Blocks of conditions can be nested as shown in the following example:

```
EXEC ORACLE IFDEF outer;
    EXEC ORACLE IFDEF inner;
    ...
    EXEC ORACLE ENDIF;
EXEC ORACLE ENDIF;
```

You can "Comment out" C or embedded SQL code by placing it between IFDEF and ENDIF and *not* defining the symbol.

Guidelines for Precompiling Separately

The following guidelines will help you avoid some common problems.

Referencing Cursors

Cursor names are SQL identifiers, whose scope is the precompilation unit. Hence, cursor operations cannot span precompilation units (files). That is, you cannot DECLARE a cursor in one file, and OPEN or FETCH from it in another file. So, when doing a separate precompilation, make sure all definitions and references to a given cursor are in one file.

Specifying MAXOPENCURSORS

When you precompile the program module that CONNECTs to Oracle, specify a value for MAXOPENCURSORS that is high enough for any of the program modules. If you use MAXOPENCURSORS for another program module, one that does not do a CONNECT, then that value for MAXOPENCURSORS is ignored. Only the value in effect for the CONNECT is used at run time.

Using a Single SQLCA

If you want to use just one SQLCA, you must declare it as global in one of the program modules and as external in the other modules. Use the *extern* storage class, and the following define in your code:

```
#define SQLCA_STORAGE_CLASS extern
```

which tells the precompiler to look for the SQLCA in another program module. Unless you declare the SQLCA as external, each program module uses its own local SQLCA.

Note: All source files in an application must be uniquely named.

Compiling and Linking

To get an executable program, you must compile the output *.c* source files produced by the precompiler, then link the resulting object modules with modules needed from SQLLIB and system-specific Oracle libraries. If you are mixing precompiler code and OCI calls, be sure to also link in the OCI runtime library (*liboci.a* on UNIX systems).

The linker resolves symbolic references in the object modules. If these references conflict, the link fails. This can happen when you try to link third-party software into a precompiled program. Not all third-party software is compatible with Oracle. So, linking your program *shared* might cause an obscure problem. In some cases, linking *stand-alone* or *two-task* might solve the problem.

Compiling and linking are system dependent. On most platforms, example *makefiles* or batch files are supplied that you can use to precompile, compile, and link a Pro*C/C++ application. See your system-specific Oracle documentation.

10

Defining and Controlling Transactions

This chapter explains how to do transaction processing. You learn the basic techniques that safeguard the consistency of your database, including how to control whether changes to Oracle data are made permanent or undone. The following topics are discussed:

- Some Terms You Should Know
- How Transactions Guard Your Database
- How to Begin and End Transactions
- Using the COMMIT Statement
- Using the SAVEPOINT Statement
- Using the ROLLBACK Statement
- Using the RELEASE Option
- Using the SET TRANSACTION Statement
- Overriding Default Locking
- Fetching Across COMMITs
- Handling Distributed Transactions
- Guidelines

Some Terms You Should Know

Before delving into the subject of transactions, you should know the terms defined in this section.

The jobs or tasks that Oracle manages are called *sessions*. A *user session* is invoked when you run an application program or a tool such as SQL*Forms, and connect to Oracle.

Oracle allows user sessions to work "simultaneously" and share computer resources. To do this, Oracle must control *concurrency*, the accessing of the same data by many users. Without adequate concurrency controls, there might be a loss of *data integrity*. That is, changes to data or structures might be made in the wrong order.

Oracle uses *locks* (sometimes called *enqueues*) to control concurrent access to data. A lock gives you temporary ownership of a database resource such as a table or row of data. Thus, data cannot be changed by other users until you finish with it.

You need never explicitly lock a resource, because default locking mechanisms protect Oracle data and structures. However, you can request *data locks* on tables or rows when it is to your advantage to override default locking. You can choose from several *modes* of locking such as *row share* and *exclusive*.

A *deadlock* can occur when two or more users try to access the same database object. For example, two users updating the same table might wait if each tries to update a row currently locked by the other. Because each user is waiting for resources held by another user, neither can continue until Oracle breaks the deadlock. Oracle signals an error to the participating transaction that had completed the least amount of work, and the "deadlock detected while waiting for resource" Oracle error code is returned to *sqlcode* in the SQLCA.

When a table is being queried by one user and updated by another at the same time, Oracle generates a *read-consistent* view of the table's data for the query. That is, once a query begins and as it proceeds, the data read by the query does not change. As update activity continues, Oracle takes *snapshots* of the table's data and records changes in a *rollback segment*. Oracle uses information in the rollback segment to build read-consistent query results and to undo changes if necessary.

How Transactions Guard Your Database

Oracle is transaction oriented; that is, it uses transactions to ensure data integrity. A transaction is a series of one or more logically related SQL statements you define to accomplish some task. Oracle treats the series of SQL statements as a unit so that all the changes brought about by the statements are either *committed* (made

permanent) or *rolled back* (undone) at the same time. If your application program fails in the middle of a transaction, the database is automatically restored to its former (pre-transaction) state.

The coming sections show you how to define and control transactions. Specifically, you learn how to

- begin and end transactions
- use the COMMIT statement to make transactions permanent
- use the SAVEPOINT statement with the ROLLBACK TO statement to undo parts of transactions
- use the ROLLBACK statement to undo whole transactions
- specify the RELEASE option to free resources and log off the database
- use the SET TRANSACTION statement to set read-only transactions
- use the FOR UPDATE clause or LOCK TABLE statement to override default locking

For details about the SQL statements discussed in this chapter, see *Oracle8 SQL Reference*.

How to Begin and End Transactions

You begin a transaction with the first executable SQL statement (other than CONNECT) in your program. When one transaction ends, the next executable SQL statement automatically begins another transaction. Thus, every executable statement is part of a transaction. Because they cannot be rolled back and need not be committed, declarative SQL statements are not considered part of a transaction.

You end a transaction in one of the following ways:

- Code a COMMIT or ROLLBACK statement, with or without the RELEASE option. This *explicitly* makes permanent or undoes changes to the database.
- Code a data definition statement (ALTER, CREATE, or GRANT, for example), which issues an automatic COMMIT before *and* after executing. This *implicitly* makes permanent changes to the database.

A transaction also ends when there is a system failure or your user session stops unexpectedly because of software problems, hardware problems, or a forced interrupt. Oracle rolls back the transaction.

If your program fails in the middle of a transaction, Oracle detects the error and rolls back the transaction. If your operating system fails, Oracle restores the database to its former (pre-transaction) state.

Using the COMMIT Statement

If you do not subdivide your program with the COMMIT or ROLLBACK statement, Oracle treats the whole program as a single transaction (unless the program contains data definition statements, which issue automatic COMMITS).

You use the COMMIT statement to make changes to the database permanent. Until changes are COMMITted, other users cannot access the changed data; they see it as it was before your transaction began. Specifically, the COMMIT statement

- makes permanent all changes made to the database during the current transaction
- makes these changes visible to other users
- erases all savepoints (see the next section)
- releases all row and table locks, but not parse locks
- closes cursors referenced in a CURRENT OF clause or, when MODE=ANSI, closes *all* explicit cursors for the connection specified in the COMMIT statement
- ends the transaction

The COMMIT statement has no effect on the values of host variables or on the flow of control in your program.

When MODE=ORACLE, explicit cursors that are not referenced in a CURRENT OF clause remain open across COMMITs. This can boost performance. For an example, see "Fetching Across COMMITs" on page 10-12.

Because they are part of normal processing, COMMIT statements should be placed inline, on the main path through your program. Before your program terminates, it must explicitly COMMIT pending changes. Otherwise, Oracle rolls them back. In the following example, you commit your transaction and disconnect from Oracle:

```
EXEC SQL COMMIT WORK RELEASE;
```

The optional keyword WORK provides ANSI compatibility. The RELEASE option frees all Oracle resources (locks and cursors) held by your program and logs off the database.

You need not follow a data definition statement with a COMMIT statement because data definition statements issue an automatic COMMIT before *and* after executing. So, whether they succeed or fail, the prior transaction is committed.

Using the SAVEPOINT Statement

You use the SAVEPOINT statement to mark and name the current point in the processing of a transaction. Each marked point is called a *savepoint*. For example, the following statement marks a savepoint named *start_delete*:

```
EXEC SQL SAVEPOINT start_delete;
```

Savepoints let you divide long transactions, giving you more control over complex procedures. For example, if a transaction performs several functions, you can mark a savepoint before each function. Then, if a function fails, you can easily restore the Oracle data to its former state, recover, then re-execute the function.

To undo part of a transaction, you use savepoints with the ROLLBACK statement and its TO SAVEPOINT clause. In the following example, you access the table MAIL_LIST to insert new listings, update old listings, and delete (a few) inactive listings. After the delete, you check the third element of *sqlerrd* in the SQLCA for the number of rows deleted. If the number is unexpectedly large, you roll back to the savepoint *start_delete*, undoing just the delete.

```
...
for (;;)
{
     printf("Customer number? ");
    gets(temp);
    cust_number = atoi(temp);
     printf("Customer name? ");
     gets(cust_name);
     EXEC SQL INSERT INTO mail_list (custno, cname, stat)
         VALUES (:cust_number, :cust_name, 'ACTIVE');
...
}

for (;;)
{
    printf("Customer number? ");
    gets(temp);
    cust_number = atoi(temp);
     printf("New status? ");
     gets(new_status);
     EXEC SQL UPDATE mail_list
```

```
        SET stat = :new_status
        WHERE custno = :cust_number;
}
/* mark savepoint */
EXEC SQL SAVEPOINT start_delete;

EXEC SQL DELETE FROM mail_list
     WHERE stat = 'INACTIVE';
if (sqlca.sqlerrd[2] < 25)  /* check number of rows deleted */
     printf("Number of rows deleted is  %d\n", sqlca.sqlerrd[2]);
else
{
     printf("Undoing deletion of %d rows\n", sqlca.sqlerrd[2]);
     EXEC SQL WHENEVER SQLERROR GOTO sql_error;
     EXEC SQL ROLLBACK TO SAVEPOINT start_delete;
}

EXEC SQL WHENEVER SQLERROR CONTINUE;
EXEC SQL COMMIT WORK RELEASE;
exit(0);
sql_error:
EXEC SQL WHENEVER SQLERROR CONTINUE;
EXEC SQL ROLLBACK WORK RELEASE;
printf("Processing error\n");
exit(1);
```

Rolling back to a savepoint erases any savepoints marked after that savepoint. The savepoint to which you roll back, however, is not erased. For example, if you mark five savepoints, then roll back to the third, only the fourth and fifth are erased.

If you give two savepoints the same name, the earlier savepoint is erased. A COMMIT or ROLLBACK statement erases all savepoints.

Using the ROLLBACK Statement

You use the ROLLBACK statement to undo pending changes made to the database. For example, if you make a mistake, such as deleting the wrong row from a table, you can use ROLLBACK to restore the original data. The TO SAVEPOINT clause lets you roll back to an intermediate statement in the current transaction, so you do not have to undo all your changes.

If you start a transaction that you cannot finish (a SQL statement might not execute successfully, for example), ROLLBACK lets you return to the starting point, so that

the database is not left in an inconsistent state. Specifically, the ROLLBACK statement

- undoes all changes made to the database during the current transaction
- erases all savepoints
- ends the transaction
- releases all row and table locks, but not parse locks
- closes cursors referenced in a CURRENT OF clause or, when MODE=ANSI, closes *all* explicit cursors

The ROLLBACK statement has no effect on the values of host variables or on the flow of control in your program.

When MODE=ORACLE, explicit cursors not referenced in a CURRENT OF clause remain open across ROLLBACKs.

Specifically, the ROLLBACK TO SAVEPOINT statement

- undoes changes made to the database since the specified savepoint was marked
- erases all savepoints marked after the specified savepoint
- releases all row and table locks acquired since the specified savepoint was marked

Note that you cannot specify the RELEASE option in a ROLLBACK TO SAVEPOINT statement.

Because they are part of exception processing, ROLLBACK statements should be placed in error handling routines, off the main path through your program. In the following example, you roll back your transaction and disconnect from Oracle:

```
EXEC SQL ROLLBACK WORK RELEASE;
```

The optional keyword WORK provides ANSI compatibility. The RELEASE option frees all resources held by your program and disconnects from the database.

If a WHENEVER SQLERROR GOTO statement branches to an error handling routine that includes a ROLLBACK statement, your program might enter an infinite loop if the ROLLBACK fails with an error. You can avoid this by coding WHENEVER SQLERROR CONTINUE before the ROLLBACK statement, as shown in the following example:

```
EXEC SQL WHENEVER SQLERROR GOTO sql_error;

for (;;)
```

```
{
     printf("Employee number? ");
    gets(temp);
    emp_number = atoi(temp);
     printf("Employee name? ");
     gets(emp_name);
     EXEC SQL INSERT INTO emp (empno, ename)
         VALUES (:emp_number, :emp_name);
...
}
...
sql_error:
EXEC SQL WHENEVER SQLERROR CONTINUE;
EXEC SQL ROLLBACK WORK RELEASE;
printf("Processing error\n");
exit(1);
```

Oracle automatically rolls back transactions if your program terminates abnormally. Refer to "Using the RELEASE Option" on page 10-8.

Statement-Level Rollbacks

Before executing any SQL statement, Oracle marks an implicit savepoint (not available to you). Then, if the statement fails, Oracle automatically rolls it back and returns the applicable error code to *sqlcode* in the SQLCA. For example, if an INSERT statement causes an error by trying to insert a duplicate value in a unique index, the statement is rolled back.

Oracle can also roll back single SQL statements to break deadlocks. Oracle signals an error to one of the participating transactions and rolls back the current statement in that transaction.

Only work started by the failed SQL statement is lost; work done before that statement in the current transaction is saved. Thus, if a data definition statement fails, the automatic commit that precedes it is not undone.

Before executing a SQL statement, Oracle must parse it, that is, examine it to make sure it follows syntax rules and refers to valid database objects. Errors detected while executing a SQL statement cause a rollback, but errors detected while parsing the statement do not.

Using the RELEASE Option

Oracle automatically rolls back changes if your program terminates abnormally. Abnormal termination occurs when your program does not explicitly commit or

roll back work and disconnect from Oracle using the RELEASE option. Normal termination occurs when your program runs its course, closes open cursors, explicitly commits or rolls back work, disconnects from Oracle, and returns control to the user.

Your program will exit gracefully if the last SQL statement it executes is either

```
EXEC SQL COMMIT RELEASE;
```

or

```
EXEC SQL ROLLBACK RELEASE;
```

Otherwise, locks and cursors acquired by your user session are held after program termination until Oracle recognizes that the user session is no longer active. This might cause other users in a multiuser environment to wait longer than necessary for the locked resources.

Using the SET TRANSACTION Statement

You use the SET TRANSACTION statement to begin a read-only transaction. Because they allow "repeatable reads," read-only transactions are useful for running multiple queries against one or more tables while other users update the same tables. An example of the SET TRANSACTION statement follows:

```
EXEC SQL SET TRANSACTION READ ONLY;
```

The SET TRANSACTION statement must be the first SQL statement in a read-only transaction and can appear only once in a transaction. The READ ONLY parameter is required. Its use does not affect other transactions.

Only the SELECT, COMMIT, and ROLLBACK statements are allowed in a read-only transaction. For example, including an INSERT, DELETE, or SELECT FOR UPDATE OF statement causes an error.

During a read-only transaction, all queries refer to the same snapshot of the database, providing a multitable, multiquery, read-consistent view. Other users can continue to query or update data as usual.

A COMMIT, ROLLBACK, or data definition statement ends a read-only transaction. (Recall that data definition statements issue an implicit COMMIT.)

In the following example, as a store manager, you check sales activity for the day, the past week, and the past month by using a read-only transaction to generate a summary report. The report is unaffected by other users updating the database during the transaction.

```
EXEC SQL SET TRANSACTION READ ONLY;
EXEC SQL SELECT sum(saleamt) INTO :daily FROM sales
     WHERE saledate = SYSDATE;
EXEC SQL SELECT sum(saleamt) INTO :weekly FROM sales
     WHERE saledate > SYSDATE - 7;
EXEC SQL SELECT sum(saleamt) INTO :monthly FROM sales
     WHERE saledate > SYSDATE - 30;
EXEC SQL COMMIT WORK;
     /* simply ends the transaction since there are no changes
        to make permanent */
/* format and print report */
```

Overriding Default Locking

By default, Oracle implicitly (automatically) locks many data structures for you. However, you can request specific data locks on rows or tables when it is to your advantage to override default locking. Explicit locking lets you share or deny access to a table for the duration of a transaction or ensure multitable and multiquery read consistency.

With the SELECT FOR UPDATE OF statement, you can explicitly lock specific rows of a table to make sure they do not change before an UPDATE or DELETE is executed. However, Oracle automatically obtains row-level locks at UPDATE or DELETE time. So, use the FOR UPDATE OF clause only if you want to lock the rows *before* the UPDATE or DELETE.

You can explicitly lock entire tables using the LOCK TABLE statement.

Using FOR UPDATE OF

When you DECLARE a cursor that is referenced in the CURRENT OF clause of an UPDATE or DELETE statement, you use the FOR UPDATE OF clause to acquire exclusive row locks. SELECT FOR UPDATE OF identifies the rows that will be updated or deleted, then locks each row in the active set. This is useful, for example, when you want to base an update on the existing values in a row. You must make sure the row is not changed by another user before your update.

The FOR UPDATE OF clause is optional. For example, instead of coding

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
     SELECT ename, job, sal FROM emp WHERE deptno = 20
         FOR UPDATE OF sal;
```

you can drop the FOR UPDATE OF clause and simply code

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
     SELECT ename, job, sal FROM emp WHERE deptno = 20;
```

The CURRENT OF clause signals the precompiler to add a FOR UPDATE clause if necessary. You use the CURRENT OF clause to refer to the latest row FETCHed from a cursor. For an example, see "Using the CURRENT OF Clause" on page 5-16.

Restrictions

If you use the FOR UPDATE OF clause, you cannot reference multiple tables.

An explicit FOR UPDATE OF or an implicit FOR UPDATE acquires exclusive row locks. All rows are locked at the OPEN, not as they are FETCHed. Row locks are released when you COMMIT or ROLLBACK (except when you ROLLBACK to a savepoint). Therefore, you cannot FETCH from a FOR UPDATE cursor after a COMMIT.

Using LOCK TABLE

You use the LOCK TABLE statement to lock one or more tables in a specified lock mode. For example, the statement below locks the EMP table in *row share* mode. Row share locks allow concurrent access to a table; they prevent other users from locking the entire table for exclusive use.

```
EXEC SQL LOCK TABLE EMP IN ROW SHARE MODE NOWAIT;
```

The lock mode determines what other locks can be placed on the table. For example, many users can acquire row share locks on a table at the same time, but only one user at a time can acquire an *exclusive* lock. While one user has an exclusive lock on a table, no other users can INSERT, UPDATE, or DELETE rows in that table.

For more information about lock modes, see *Oracle8 Concepts*.

The optional keyword NOWAIT tells Oracle not to wait for a table if it has been locked by another user. Control is immediately returned to your program, so it can do other work before trying again to acquire the lock. (You can check *sqlcode* in the SQLCA to see if the LOCK TABLE failed.) If you omit NOWAIT, Oracle waits until the table is available; the wait has no set limit.

A table lock never keeps other users from querying a table, and a query never acquires a table lock. So, a query never blocks another query or an update, and an update never blocks a query. Only if two different transactions try to update the same row will one transaction wait for the other to complete.

Table locks are released when your transaction issues a COMMIT or ROLLBACK.

Fetching Across COMMITs

If you want to intermix COMMITs and FETCHes, do not use the CURRENT OF clause. Instead, SELECT the ROWID of each row, then use that value to identify the current row during the update or delete. An example follows:

```
...
EXEC SQL DECLARE emp_cursor CURSOR FOR
     SELECT ename, sal, ROWID FROM emp WHERE job = 'CLERK';
...
EXEC SQL OPEN emp_cursor;
EXEC SQL WHENEVER NOT FOUND GOTO ...
for (;;)
{
     EXEC SQL FETCH emp_cursor INTO :emp_name, :salary, :row_id;
     ...
     EXEC SQL UPDATE emp SET sal = :new_salary
         WHERE ROWID = :row_id;
     EXEC SQL COMMIT;
...
}
```

Note, however, that the FETCHed rows are *not* locked. So, you might get inconsistent results if another user modifies a row after you read it but before you update or delete it.

Handling Distributed Transactions

A *distributed database* is a single logical database comprising multiple physical databases at different nodes. A *distributed statement* is any SQL statement that accesses a remote node using a database link. A *distributed transaction* includes at least one distributed statement that updates data at multiple nodes of a distributed database. If the update affects only one node, the transaction is non-distributed.

When you issue a COMMIT, changes to each database affected by the distributed transaction are made permanent. If instead you issue a ROLLBACK, all the changes are undone. However, if a network or machine fails during the commit or rollback, the state of the distributed transaction might be unknown or *in doubt*. In such cases, if you have FORCE TRANSACTION system privileges, you can manually commit or roll back the transaction at your local database by using the FORCE clause. The transaction must be identified by a quoted literal containing the transaction ID,

which can be found in the data dictionary view DBA_2PC_PENDING. Some examples follow:

```
EXEC SQL COMMIT FORCE '22.31.83';
...
EXEC SQL ROLLBACK FORCE '25.33.86';
```

FORCE commits or rolls back only the specified transaction and does not affect your current transaction. Note that you cannot manually roll back in-doubt transactions to a savepoint.

The COMMENT clause in the COMMIT statement lets you specify a Comment to be associated with a distributed transaction. If ever the transaction is in doubt, Oracle stores the text specified by COMMENT in the data dictionary view DBA_2PC_PENDING along with the transaction ID. The text must be a quoted literal 50 characters in length. An example follows:

```
EXEC SQL COMMIT COMMENT 'In-doubt trans; notify Order Entry';
```

For more information about distributed transactions, see *Oracle8 Concepts*.

Guidelines

The following guidelines will help you avoid some common problems.

Designing Applications

When designing your application, group logically related actions together in one transaction. A well-designed transaction includes all the steps necessary to accomplish a given task—no more and no less.

Data in the tables you reference must be left in a consistent state. So, the SQL statements in a transaction should change the data in a consistent way. For example, a transfer of funds between two bank accounts should include a debit to one account and a credit to another. Both updates should either succeed or fail together. An unrelated update, such as a new deposit to one account, should not be included in the transaction.

Obtaining Locks

If your application programs include SQL locking statements, make sure the Oracle users requesting locks have the privileges needed to obtain the locks. Your DBA can lock any table. Other users can lock tables they own or tables for which they have a privilege, such as ALTER, SELECT, INSERT, UPDATE, or DELETE.

Using PL/SQL

If a PL/SQL block is part of a transaction, COMMITs and ROLLBACKs inside the block affect the whole transaction. In the following example, the ROLLBACK undoes changes made by the UPDATE *and* the INSERT:

```
EXEC SQL INSERT INTO EMP ...
EXEC SQL EXECUTE
     BEGIN
         UPDATE emp ...
         ...
     EXCEPTION
         WHEN DUP_VAL_ON_INDEX THEN
             ROLLBACK;
         ...
     END;
END-EXEC;
...
```

11

Handling Runtime Errors

An application program must anticipate runtime errors and attempt to recover from them. This chapter provides an in-depth discussion of error reporting and recovery. You learn how to handle errors and status changes using the SQLSTATE status variable, as well as the SQL Communications Area (SQLCA) and the WHENEVER statement. You also learn how to diagnose problems using the Oracle Communications Area (ORACA). The following topics are discussed:

- The Need for Error Handling
- Error Handling Alternatives
- The SQLSTATE Status Variable
- Declaring SQLCODE
- Key Components of Error Reporting Using the SQLCA
- Using the SQL Communications Area (SQLCA)
- Getting the Full Text of Error Messages
- Using the WHENEVER Statement
- Obtaining the Text of SQL Statements
- Using the Oracle Communications Area (ORACA)

The Need for Error Handling

A significant part of every application program must be devoted to error handling. The main reason for error handling is that it allows your program to continue operating in the presence of errors. Errors arise from design faults, coding mistakes, hardware failures, invalid user input, and many other sources.

You cannot anticipate all possible errors, but you can plan to handle certain kinds of errors meaningful to your program. For the Pro*C/C++ Precompiler, error handling means detecting and recovering from SQL statement execution errors.

You can also prepare to handle warnings such as “value truncated" and status changes such as “end of data.”

It is especially important to check for error and warning conditions after every SQL data manipulation statement, because an INSERT, UPDATE, or DELETE statement might fail before processing all eligible rows in a table.

Error Handling Alternatives

There are several alternatives that you can use to detect errors and status changes in the application. This chapter describes these alternatives, however, no specific recommendations are made about what method you should use. The method is, after all, dictated by the design of the application program or tool that you are building.

Status Variables

You can declare a separate status variable, SQLSTATE or SQLCODE, examine its value after each executable SQL statement, and take appropriate action. The action might be calling an error-reporting function, then exiting the program if the error is unrecoverable. Or, you might be able to adjust data, or control variables, and retry the action. See the sections "The SQLSTATE Status Variable" on page 11-3 and the "Declaring SQLCODE" on page 11-14 in this chapter for complete information about these status variables.

The SQL Communications Area

Another alternative that you can use is to include the SQL Communications Area structure (*sqlca*) in your program. This structure contains components that are filled in at runtime after the SQL statement is processed by Oracle.

> **Note:** In this guide, the *sqlca* structure is commonly referred to using the acronym for *SQL Communications Area* (SQLCA). When this guide refers to a specific component in the C **struct**, the structure name (*sqlca*) is used.

The SQLCA is defined in the header file *sqlca.h*, which you include in your program using either of the following statements:

- EXEC SQL INCLUDE SQLCA;
- #include <sqlca.h>

Oracle updates the SQLCA after every *executable* SQL statement. (SQLCA values are unchanged after a declarative statement.) By checking Oracle return codes stored in the SQLCA, your program can determine the outcome of a SQL statement. This can be done in the following two ways:

- implicit checking with the WHENEVER statement
- explicit checking of SQLCA components

You can use WHENEVER statements, code explicit checks on SQLCA components, or do both.

The most frequently-used components in the SQLCA are the status variable (*sqlca.sqlcode*), and the text associated with the error code (*sqlca.sqlerrm.sqlerrmc*). Other components contain warning flags and miscellaneous information about the processing of the SQL statement. For complete information about the SQLCA structure, see the "Using the SQL Communications Area (SQLCA)" on page 11-16.

> **Note:** SQLCODE (upper case) always refers to a separate status variable, not a component of the SQLCA. SQLCODE is declared as a **long integer**. When referring to the component of the SQLCA named *sqlcode*, the fully-qualified name *sqlca.sqlcode* is always used.

When more information is needed about runtime errors than the SQLCA provides, you can use the ORACA. The ORACA is a C **struct** that handles Oracle communication. It contains cursor statistics, information about the current SQL statement, option settings, and system statistics. See the "Using the Oracle Communications Area (ORACA)" on page 11-34 for complete information about the ORACA.

The SQLSTATE Status Variable

The precompiler command line option MODE governs ANSI/ISO compliance. When MODE=ANSI, declaring the SQLCA data structure is optional. However, you must declare a separate status variable named SQLCODE. SQL92 specifies a

similar status variable named SQLSTATE, which you can use with or without SQLCODE.

After executing a SQL statement, the Oracle Server returns a status code to the SQLSTATE variable currently in scope. The status code indicates whether the SQL statement executed successfully or raised an exception (error or warning condition). To promote *interoperability* (the ability of systems to exchange information easily), SQL92 predefines all the common SQL exceptions.

Unlike SQLCODE, which stores only error codes, SQLSTATE stores error and warning codes. Furthermore, the SQLSTATE reporting mechanism uses a standardized coding scheme. Thus, SQLSTATE is the preferred status variable. Under SQL92, SQLCODE is a "deprecated feature" retained only for compatibility with SQL89 and likely to be removed from future versions of the standard.

Declaring SQLSTATE

When MODE=ANSI, you must declare SQLSTATE or SQLCODE. Declaring the SQLCA is optional. When MODE=ORACLE, if you declare SQLSTATE, it is not used.

Unlike SQLCODE, which stores signed integers and can be declared outside the Declare Section, SQLSTATE stores 5-character null-terminated strings and must be declared inside the Declare Section. You declare SQLSTATE as

```
char  SQLSTATE[6];  /* Upper case is required. */
```

Note: SQLSTATE must be declared with a dimension of *exactly* 6 characters.

SQLSTATE Values

SQLSTATE status codes consist of a 2-character *class code* followed by a 3-character *subclass code*. Aside from class code 00 ("successful completion"), the class code denotes a category of exceptions. And, aside from subclass code 000 ("not applicable"), the subclass code denotes a specific exception within that category. For example, the SQLSTATE value '22012' consists of class code 22 ("data exception") and subclass code 012 ("division by zero").

Each of the five characters in a SQLSTATE value is a digit (0..9) or an uppercase Latin letter (A..Z). Class codes that begin with a digit in the range 0..4 or a letter in the range A..H are reserved for predefined conditions (those defined in SQL92). All other class codes are reserved for implementation-defined conditions. Within predefined classes, subclass codes that begin with a digit in the range 0..4 or a letter in the range A..H are reserved for predefined subconditions. All other subclass

codes are reserved for implementation-defined subconditions. Figure 11–1 shows the coding scheme.

Figure 11–1 SQLSTATE Coding Scheme

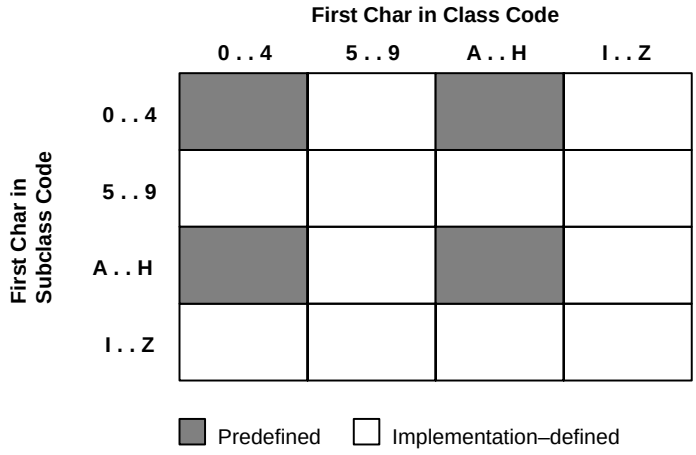


Table 11–1 shows the classes predefined by SQL92.

Table 11–1 Predefined Classes

Class	Condition
00	success completion
01	warning
02	no data
07	dynamic SQL error
08	connection exception
0A	feature not supported
21	coordinately violation
22	data exception
23	integrity constraint violation

Table 11–1 Predefined Classes

Class	Condition
24	invalid cursor state
25	invalid transaction state
26	invalid SQL statement name
27	triggered data change violation
28	invalid authorization specification
2A	direct SQL syntax error or access rule violation
2B	dependent privilege descriptors still exist
2C	invalid character set name
2D	invalid transaction termination
2E	invalid connection name
33	invalid SQL descriptor name
34	invalid cursor name
35	invalid condition number
37	dynamic SQL syntax error or access rule violation
3C	ambiguous cursor name
3D	invalid catalog name
3F	invalid schema name
40	transaction rollback
42	syntax error or access rule violation
44	with check option violation
HZ	remote database access

Note: The class code HZ is reserved for conditions defined in International Standard ISO / IEC DIS 9579-2, *Remote Database Access.*

Table 11–2 shows how SQLSTATE status codes and conditions are mapped to Oracle errors. Status codes in the range 60000 . 99999 are implementation-defined.

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
00000	successful completion	ORA-00000
01000	warning	
01001	cursor operation conflict	
01002	disconnect error	
01003	null value eliminated in set function	
01004	string data-right truncation	
01005	insufficient item descriptor areas	
01006	privilege not revoked	
01007	privilege not granted	
01008	implicit zero-bit padding	
01009	search condition too long for info schema	
0100A	query expression too long for info schema	
02000	no data	ORA-01095 ORA-01403
07000	dynamic SQL error	
07001	using clause does not match parameter specs	
07002	using clause does not match target specs	
07003	cursor specification cannot be executed	
07004	using clause required for dynamic parameters	
07005	prepared statement not a cursor specification	
07006	restricted datatype attribute violation	
07007	using clause required for result components invalid descriptor count	
07008	invalid descriptor count	SQL-02126
07009	invalid descriptor index	

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
08000	connection exception	
08001	SQL-client unable to establish SQL-connection	
08002	connection name is use	
08003	connection does not exist	SQL-02121
08004	SQL-server rejected SQL-connection	
08006	connection failure	
08007	transaction resolution unknown	
0A000	feature not supported	ORA-03000..03099
0A001	multiple server transactions	
21000	cardinality violation	ORA-01427 SQL-02112
22000	data exception	
22001	string data - right truncation	ORA-01406
22002	null value-no indicator parameter	SQL-02124
22003	numeric value out of range	ORA-01426
22005	error in assignment	
22007	invalid datetime format	
22008	datetime field overflow	ORA-01800..01899
22009	invalid time zone displacement value	
22011	substring error	
22012	division by zero	ORA-01476
22015	interval field overflow	
22018	invalid character value for cast	
22019	invalid escape character	ORA-00911
22021	character not in repertoire	
22022	indicator overflow	ORA-01411

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
22023	invalid parameter value	ORA-01025 ORA-04000..04019
22024	unterminated C string	ORA-01479 ORA-01480
22025	invalid escape sequence	ORA-01424 ORA-01425
22026	string data-length mismatch	ORA-01401
22027	trim error	
23000	integrity constraint violation	ORA-02290..02299
24000	invalid cursor state	ORA-001002 ORA-001003 SQL-02114 SQL-02117
25000	invalid transaction state	SQL-02118
26000	invalid SQL statement name	
27000	triggered data change violation	
28000	invalid authorization specification	
2A000	direct SQL syntax error or access rule violation	
2B000	dependent privilege descriptors still exist	
2C000	invalid character set name	
2D000	invalid transaction termination	
2E000	invalid connection name	
33000	invalid SQL descriptor name	
34000	invalid cursor name	
35000	invalid condition number	
37000	dynamic SQL syntax error or access rule violation	

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
3C000	ambiguous cursor name	
3D000	invalid catalog name	
3F000	invalid schema name	
40000	transaction rollback	ORA-02091 ORA-02092
40001	serialization failure	
40002	integrity constraint violation	
40003	statement completion unknown	
42000	syntax error or access rule violation	ORA-00022 ORA-00251 ORA-00900..00999 ORA-01031 ORA-01490..01493 ORA-01700..01799 ORA-01900..02099 ORA-02140..02289 ORA-02420..02424 ORA-02450..02499 ORA-03276..03299 ORA-04040..04059 ORA-04070..04099
44000	with check option violation	ORA-01402
60000	system error	ORA-00370..00429 ORA-00600..00899 ORA-06430..06449 ORA-07200..07999 ORA-09700..09999

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
61000	multi-threaded server and detached process errors	ORA-00018..00035 ORA-00050..00068 ORA-02376..02399 ORA-04020..04039
62000	multi-threaded server and detached process errors	ORA-00100..00120 ORA-00440..00569
63000	Oracle*XA and two-task interface errors	ORA-00150..00159 ORA-02700..02899 ORA-03100..03199 ORA-06200..06249 SQL-02128
64000	control file, database file, and redo file errors; archival and media recovery errors	ORA-00200..00369 ORA-01100..01250
65000	PL/SQL errors	ORA-06500..06599
66000	SQL*Net driver errors	ORA-06000..06149 ORA-06250..06429 ORA-06600..06999 ORA-12100..12299 ORA-12500..12599
67000	licensing errors	ORA-00430..00439
69000	SQL*Connect errors	ORA-00570..00599 ORA-07000..07199

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
72000	SQL execute phase errors	ORA-00001 ORA-01000..01099 ORA-01400..01489 ORA-01495..01499 ORA-01500..01699 ORA-02400..02419 ORA-02425..02449 ORA-04060..04069 ORA-08000..08190 ORA-12000..12019 ORA-12300..12499 ORA-12700..21999
82100	out of memory (could not allocate)	SQL-02100
82101	inconsistent cursor cache (UCE/CUC mismatch)	SQL-02101
82102	inconsistent cursor cache (no CUC entry for UCE)	SQL-02102
82103	inconsistent cursor cache (out-or-range CUC ref)	SQL-02103
82104	inconsistent cursor cache (no CUC available)	SQL-02104
82105	inconsistent cursor cache (no CUC entry in cache)	SQL-02105
82106	inconsistent cursor cache (invalid cursor number)	SQL-02106
82107	program too old for runtime library; re-precompile	SQL-02107
82108	invalid descriptor passed to runtime library	SQL-02108
82109	inconsistent host cache (out-or-range SIT ref)	SQL-02109

Table 11–2 SQLSTATE Status Codes

Code	Condition	Oracle Error(s)
82110	inconsistent host cache (invalid SQL type)	SQL-02110
82111	heap consistency error	SQL-02111
82113	code generation internal consistency failed	SQL-02115
82114	reentrant code generator gave invalid context	SQL-02116
82117	invalid OPEN or PREPARE for this connection	SQL-02122
82118	application context not found	SQL-02123
82119	unable to obtain error message text	SQL-02125
82120	Precompiler / SQLLIB version mismatch	SQL-02127
82121	NCHAR error; fetched number of bytes is odd	SQL-02129
82122	EXEC TOOLS interface not available	SQL-02130
82123	runtime context in use	SQL-02131
82124	unable to allocate runtime context	SQL-02132
82125	unable to initialize process for use with threads	SQL-02133
82126	invalid runtime context	SQL-02134
HZ000	remote database access	

Using SQLSTATE

The following rules apply to using SQLSTATE with SQLCODE or the SQLCA when you precompile with the option setting MODE=ANSI. SQLSTATE must be declared inside a Declare Section; otherwise, it is ignored.

If you declare SQLSTATE

- Declaring SQLCODE is optional. If you declare SQLCODE inside the Declare Section, the Oracle Server returns status codes to SQLSTATE and SQLCODE after every SQL operation. However, if you declare SQLCODE outside the Declare Section, Oracle returns a status code only to SQLSTATE.

- Declaring the SQLCA is optional. If you declare the SQLCA, Oracle returns status codes to SQLSTATE and the SQLCA. In this case, to avoid compilation errors, do *not* declare SQLCODE.

If you do *not* declare SQLSTATE

- You must declare SQLCODE inside or outside the Declare Section. The Oracle Server returns a status code to SQLCODE after every SQL operation.
- Declaring the SQLCA is optional. If you declare the SQLCA, Oracle returns status codes to SQLCODE and the SQLCA.

You can learn the outcome of the most recent executable SQL statement by checking SQLSTATE explicitly with your own code or implicitly with the WHENEVER SQLERROR statement. Check SQLSTATE only after executable SQL statements and PL/SQL statements.

Declaring SQLCODE

When MODE=ANSI, and you have not declared a SQLSTATE status variable, you must declare a **long** integer variable named SQLCODE inside or outside the Declare Section. An example follows:

```
/* declare host variables */
EXEC SQL BEGIN DECLARE SECTION;
int  emp_number, dept_number;
char emp_name[20];
EXEC SQL END DECLARE SECTION;

/* declare status variable--must be upper case */
long SQLCODE;
```

When MODE=ORACLE, if you declare SQLCODE, it is not used.

You can declare more than one SQLCODE. Access to a local SQLCODE is limited by its scope within your program.

After every SQL operation, Oracle returns a status code to the SQLCODE currently in scope. So, your program can learn the outcome of the most recent SQL operation by checking SQLCODE explicitly, or implicitly with the WHENEVER statement.

When you declare SQLCODE instead of the SQLCA in a particular compilation unit, the precompiler allocates an internal SQLCA for that unit. Your host program cannot access the internal SQLCA. If you declare the SQLCA *and* SQLCODE, Oracle returns the same status code to both after every SQL operation.

Key Components of Error Reporting Using the SQLCA

Error reporting depends on variables in the SQLCA. This section highlights the key components of error reporting. The next section takes a close look at the SQLCA.

Status Codes

Every executable SQL statement returns a status code to the SQLCA variable *sqlcode*, which you can check implicitly with the WHENEVER statement or explicitly with your own code.

A zero status code means that Oracle executed the statement without detecting an error or exception. A positive status code means that Oracle executed the statement but detected an exception. A negative status code means that Oracle did not execute the SQL statement because of an error.

Warning Flags

Warning flags are returned in the SQLCA variables *sqlwarn[0]* through *sqlwarn[7]*, which you can check implicitly or explicitly. These warning flags are useful for runtime conditions not considered errors by Oracle. If no indicator variable is available, Oracle issues an error message.

Rows-Processed Count

The number of rows processed by the most recently executed SQL statement is returned in the SQLCA variable *sqlca.sqlerrd[2]*, which you can check explicitly.

Strictly speaking, this variable is not for error reporting, but it can help you avoid mistakes. For example, suppose you expect to delete about ten rows from a table. After the deletion, you check *sqlca.sqlerrd[2]* and find that 75 rows were processed. To be safe, you might want to roll back the deletion and examine your WHERE-clause search condition.

Parse Error Offset

Before executing a SQL statement, Oracle must *parse* it, that is, examine it to make sure it follows syntax rules and refers to valid database objects. If Oracle finds an error, an offset is stored in the SQLCA variable *sqlca.sqlerrd[4]*, which you can check explicitly. The offset specifies the character position in the SQL statement at which the parse error begins. As in a normal C string, the first character occupies position zero. For example, if the offset is 9, the parse error begins at the 10*th* character.

By default, static SQL statements are checked for syntactic errors at precompile time. So, *sqlca.sqlerrd[4]* is most useful for debugging dynamic SQL statements, which your program accepts or builds at run time.

Parse errors arise from missing, misplaced, or misspelled keywords, invalid options, nonexistent tables, and the like. For example, the dynamic SQL statement

```
"UPDATE emp SET jib = :job_title WHERE empno = :emp_number"
```

causes the parse error

```
ORA-00904: invalid column name
```

because the column name JOB is misspelled. The value of *sqlca.sqlerrd[4]* is 15 because the erroneous column name JIB begins at the 16*th* character.

If your SQL statement does not cause a parse error, Oracle sets *sqlca.sqlerrd[4]* to zero. Oracle also sets *sqlca.sqlerrd[4]* to zero if a parse error begins at the first character (which occupies position zero). So, check *sqlca.sqlerrd[4]* only if *sqlca.sqlcode* is negative, which means that an error has occurred.

Error Message Text

The error code and message for Oracle errors are available in the SQLCA variable SQLERRMC. At most, the first 70 characters of text are stored. To get the full text of messages longer than 70 characters, you use the *sqlglm()* function. See the section "Getting the Full Text of Error Messages" on page 11-23.

Using the SQL Communications Area (SQLCA)

The SQLCA is a data structure. Its components contain error, warning, and status information updated by Oracle whenever a SQL statement is executed. Thus, the SQLCA always reflects the outcome of the most recent SQL operation. To determine the outcome, you can check variables in the SQLCA.

Your program can have more than one SQLCA. For example, it might have one global SQLCA and several local ones. Access to a local SQLCA is limited by its scope within the program. Oracle returns information only to the SQLCA that is in scope.

> **Note:** When your application uses SQL*Net to access a combination of local and remote databases concurrently, all the databases write to one SQLCA. There is *not* a different SQLCA for each database. For more information, see the section "Concurrent Connections" on page 4-23.

Declaring the SQLCA

When MODE=ORACLE, declaring the SQLCA is required. To declare the SQLCA, you should copy it into your program with the INCLUDE or **#include** statement, as follows:

```
EXEC SQL INCLUDE SQLCA;
```

or

```
#include <sqlca.h>
```

If you use a Declare Section, the SQLCA must be declared *outside* the Declare Section. Not declaring the SQLCA results in compile-time errors.

When you precompile your program, the INCLUDE SQLCA statement is replaced by several variable declarations that allow Oracle to communicate with the program.

When MODE=ANSI, declaring the SQLCA is optional. But in this case you must declare a SQLCODE or SQLSTATE status variable. The type of SQLCODE (upper case is required) is **long**. If you declare SQLCODE or SQLSTATE instead of the SQLCA in a particular compilation unit, the precompiler allocates an internal SQLCA for that unit. Your Pro*C/C++ program cannot access the internal SQLCA. If you declare the SQLCA *and* SQLCODE, Oracle returns the same status code to both after every SQL operation.

> **Note:** Declaring the SQLCA is optional when MODE=ANSI, but you cannot use the WHENEVER SQLWARNING statement without the SQLCA. So, if you want to use the WHENEVER SQLWARNING statement, you must declare the SQLCA.
>
> **Note:** This Guide uses SQLCODE when referring to the SQLCODE status variable, and *sqlca.sqlcode* when explicitly referring to the component of the SQLCA structure.

What's in the SQLCA?

The SQLCA contains the following runtime information about the outcome of SQL statements:

- Oracle error codes
- warning flags
- event information
- rows-processed count

- diagnostics

The *sqlca.h* header file is:

```
/*
NAME
  SQLCA : SQL Communications Area.
FUNCTION
  Contains no code. Oracle fills in the SQLCA with status info
  during the execution of a SQL stmt.
NOTES
  **************************************************************
  ***                                                        ***
  *** This file is SOSD.  Porters must change the data types ***
  *** appropriately on their platform.  See notes/pcport.doc ***
  *** for more information.                                  ***
  ***                                                        ***
  **************************************************************

  If the symbol SQLCA_STORAGE_CLASS is defined, then the SQLCA
  will be defined to have this storage class. For example:

    #define SQLCA_STORAGE_CLASS extern

  will define the SQLCA as an extern.

  If the symbol SQLCA_INIT is defined, then the SQLCA will be
  statically initialized. Although this is not necessary in order
  to use the SQLCA, it is a good programing practice not to have
  unitialized variables. However, some C compilers/OS's don't
  allow automatic variables to be initialized in this manner.
  Therefore, if you are INCLUDE'ing the SQLCA in a place where it
  would be an automatic AND your C compiler/OS doesn't allow this
  style of initialization, then SQLCA_INIT should be left
  undefined -- all others can define SQLCA_INIT if they wish.

  If the symbol SQLCA_NONE is defined, then the SQLCA
  variable will not be defined at all.  The symbol SQLCA_NONE
  should not be defined in source modules that have embedded SQL.
  However, source modules that have no embedded SQL, but need to
  manipulate a sqlca struct passed in as a parameter, can set the
  SQLCA_NONE symbol to avoid creation of an extraneous sqlca
  variable.
*/
#ifndef SQLCA
#define SQLCA 1
```

```
struct   sqlca
         {
         /* ub1 */ char    sqlcaid[8];
         /* b4  */ long    sqlabc;
         /* b4  */ long    sqlcode;
         struct
           {
           /* ub2 */ unsigned short sqlerrml;
           /* ub1 */ char           sqlerrmc[70];
           } sqlerrm;
         /* ub1 */ char    sqlerrp[8];
         /* b4  */ long    sqlerrd[6];
         /* ub1 */ char    sqlwarn[8];
         /* ub1 */ char    sqlext[8];
         };
#ifndef SQLCA_NONE
#ifdef   SQLCA_STORAGE_CLASS
SQLCA_STORAGE_CLASS struct sqlca sqlca
#else
         struct sqlca sqlca
#endif
#ifdef  SQLCA_INIT
         = {
         {'S', 'Q', 'L', 'C', 'A', ' ', ' ', ' '},
         sizeof(struct sqlca),
         0,
         { 0, {0}},
         {'N', 'O', 'T', ' ', 'S', 'E', 'T', ' '},
         {0, 0, 0, 0, 0, 0},
         {0, 0, 0, 0, 0, 0, 0, 0},
         {0, 0, 0, 0, 0, 0, 0, 0}
         }
#endif
         ;
#endif
#endif
```

Structure of the SQLCA

This section describes the structure of the SQLCA, its components, and the values they can store.

sqlcaid

This string component is initialized to "SQLCA" to identify the SQL Communications Area.

sqlcabc

This integer component holds the length, in bytes, of the SQLCA structure.

sqlcode

This integer component holds the status code of the most recently executed SQL statement. The status code, which indicates the outcome of the SQL operation, can be any of the following numbers

0	Means that Oracle executed the statement without detecting an error or exception.
>0	Means that Oracle executed the statement but detected an exception. This occurs when Oracle cannot find a row that meets your WHERE-clause search condition or when a SELECT INTO or FETCH returns no rows.

When MODE=ANSI, +100 is returned to *sqlcode* after an INSERT of no rows. This can happen when a subquery returns no rows to process.

<0	Means that Oracle did not execute the statement because of a database, system, network, or application error. Such errors can be fatal. When they occur, the current transaction should, in most cases, be rolled back.

Negative return codes correspond to error codes listed in *Oracle8 Error Messages*.

sqlerrm

This embedded struct contains the following two components:

sqlerrml	This integer component holds the length of the message text stored in sqlerrmc.
sqlerrmc	This string component holds the message text corresponding to the error code stored in sqlcode. The string is not null terminated. Use the sqlerrml component to determine the length.

This component can store up to 70 characters. To get the full text of messages longer than 70 characters, you must use the *sqlglm* function (discussed later).

Make sure *sqlcode* is negative *before* you reference *sqlerrmc*. If you reference *sqlerrmc* when *sqlcode* is zero, you get the message text associated with a prior SQL statement.

sqlerrp

This string component is reserved for future use.

sqlerrd

This array of binary integers has six elements. Descriptions of the components in *sqlerrd* follow:

sqlerrd[0]	This component is reserved for future use.
sqlerrd[1]	This component is reserved for future use.
sqlerrd[2]	This component holds the number of rows processed by the most recently executed SQL statement. However, if the SQL statement failed, the value of sqlca.sqlerrd[2] is undefined, with one exception. If the error occurred during an array operation, processing stops at the row that caused the error, so sqlca.sqlerrd[2] gives the number of rows processed successfully.

The rows-processed count is zeroed after an OPEN statement and incremented after a FETCH statement. For the EXECUTE, INSERT, UPDATE, DELETE, and SELECT INTO statements, the count reflects the number of rows processed successfully. The count does *not* include rows processed by an UPDATE or DELETE CASCADE. For example, if 20 rows are deleted because they meet WHERE-clause criteria, and 5 more rows are deleted because they now (after the primary delete) violate column constraints, the count is 20 not 25.

sqlerrd[3]	This component is reserved for future use.
sqlerrd[4]	This component holds an offset that specifies the character position at which a parse error begins in the most recently executed SQL statement. The first character occupies position zero.
sqlerrd[5]	This component is reserved for future use.

sqlwarn

This array of single characters has eight elements. They are used as warning flags. Oracle sets a flag by assigning it a "W" (for warning) character value.

The flags warn of exceptional conditions. For example, a warning flag is set when Oracle assigns a truncated column value to an output host variable.

Descriptions of the components in *sqlwarn* follow:

sqlwarn[0]	This flag is set if another warning flag is set.
sqlwarn[1]	This flag is set if a truncated column value was assigned to an output host variable. This applies only to character data. Oracle truncates certain numeric data without setting a warning or returning a negative sqlcode.

To find out if a column value was truncated and by how much, check the indicator variable associated with the output host variable. The (positive) integer returned by an indicator variable is the original length of the column value. You can increase the length of the host variable accordingly.

sqlwarn[2]	This flag is set if a NULL column is not used in the result of a SQL group function, such as AVG() or SUM().
sqlwarn[3]	This flag is set if the number of columns in a query select list does not equal the number of host variables in the INTO clause of the SELECT or FETCH statement. The number of items returned is the lesser of the two.
sqlwarn[4]	This flag is set if every row in a table was processed by an UPDATE or DELETE statement without a WHERE clause. An update or deletion is called unconditional if no search condition restricts the number of rows processed. Such updates and deletions are unusual, so Oracle sets this warning flag. That way, you can roll back the transaction if necessary.
sqlwarn[5]	This flag is set when an EXEC SQL CREATE {PROCEDURE | FUNCTION | PACKAGE | PACKAGE BODY} statement fails because of a PL/SQL compilation error.
sqlwarn[6]	This flag is no longer in use.
sqlwarn[7]	This flag is no longer in use.

sqlext

This string component is reserved for future use.

PL/SQL ConsiderationsPL/SQL

When the precompiler application executes an embedded PL/SQL block, not all components of the SQLCA are set. For example, if the block fetches several rows, the rows-processed count (*sqlerrd[2]*) is set to only 1. You should depend only on the *sqlcode* and *sqlerrm* components of the SQLCA after execution of a PL/SQL block.

Getting the Full Text of Error Messages

The SQLCA can accommodate error messages up to 70 characters long. To get the full text of longer (or nested) error messages, you need the *sqlglm* function. The syntax of the *sqlglm()* is

```
void sqlglm(char   *message_buffer,
            size_t *buffer_size,
            size_t *message_length);
```

where:

message_buffer	Is the text buffer in which you want Oracle to store the error message (Oracle blank-pads to the end of this buffer).
buffer_size	Is a scalar variable that specifies the maximum size of the buffer in bytes.
message_length	Is a scalar variable in which Oracle stores the actual length of the error message.

> **Note:** The types of the last two arguments for the *sqlglm()* function are shown here generically as *size_t* pointers. However on your platform they might have a different type. For example, on many UNIX workstation ports, they are *unsigned int* *****.
>
> You should check the file *sqlcpr.h*, which is in the standard include directory on your system, to determine the datatype of these parameters.

The maximum length of an Oracle error message is 512 characters including the error code, nested messages, and message inserts such as table and column names. The maximum length of an error message returned by *sqlglm* depends on the value you specify for *buffer_size*.

The following example calls *sqlglm* to get an error message of up to 200 characters in length:

```
EXEC SQL WHENEVER SQLERROR DO sql_error();
...
/* other statements */
...
sql_error()
{
    char msg[200];
    size_t buf_len, msg_len;

    buf_len = sizeof (msg);
    sqlglm(msg, &buf_len, &msg_len);   /* note use of pointers */
    printf("%.*s\n\n", msg_len, msg);
    exit(1);
}
```

Notice that *sqlglm* is called only when a SQL error has occurred. Always make sure SQLCODE (or *sqlca.sqlcode*) is non-zero *before* calling *sqlglm*. If you call *sqlglm* when SQLCODE is zero, you get the message text associated with a prior SQL statement.

Using the WHENEVER Statement

By default, precompiled programs ignore Oracle error and warning conditions and continue processing if possible. To do automatic condition checking and error handling, you need the WHENEVER statement.

With the WHENEVER statement you can specify actions to be taken when Oracle detects an error, warning condition, or “not found” condition. These actions include continuing with the next statement, calling a routine, branching to a labeled statement, or stopping.

You code the WHENEVER statement using the following syntax:

```
EXEC SQL WHENEVER <condition> <action>;
```

Conditions

You can have Oracle automatically check the SQLCA for any of the following conditions.

SQLWARNING

sqlwarn[0] is set because Oracle returned a warning (one of the warning flags, *sqlwarn[1]* through *sqlwarn[7]*, is also set) or SQLCODE has a positive value other

than +1403. For example, *sqlwarn[0]* is set when Oracle assigns a truncated column value to an output host variable.

Declaring the SQLCA is optional when MODE=ANSI. To use WHENEVER SQLWARNING, however, you *must* declare the SQLCA.

SQLERROR

SQLCODE has a negative value because Oracle returned an error.

NOT FOUND

SQLCODE has a value of +1403 (+100 when MODE=ANSI) because Oracle could not find a row that meets your WHERE-clause search condition, or a SELECT INTO or FETCH returned no rows.

When MODE=ANSI, +100 is returned to SQLCODE after an INSERT of no rows.

Actions

When Oracle detects one of the preceding *conditions*, you can have your program take any of the following actions.

CONTINUE

Your program continues to run with the next statement if possible. This is the default action, equivalent to not using the WHENEVER statement. You can use it to turn off condition checking.

DO

Your program transfers control to an error handling function in the program. When the end of the routine is reached, control transfers to the statement that follows the failed SQL statement.

The usual rules for entering and exiting a function apply. You can pass parameters to the error handler invoked by an EXEC SQL WHENEVER ... DO ... statement, and the function can return a value.

DO BREAK

An actual "break" statement is placed in your program. Use this action in loops.When the WHENEVER condition is met, your program exits the loop it is inside.

DO CONTINUE

An actual "continue" statement is placed in your program. Use this action in loops. When the WHENEVER condition is met, your program continues with the next iteration of the loop it is inside.

GOTO label_name

Your program branches to a labeled statement.

STOP

Your program stops running and uncommitted work is rolled back.

STOP in effect just generates an *exit()* call whenever the condition occurs. Be careful. The STOP action displays no messages before disconnecting from Oracle.

Some Examples

If you want your program to

- go to *close_cursor* if a “no data found” condition occurs,
- continue with the next statement if a warning occurs, and
- go to *error_handler* if an error occurs

simply code the following WHENEVER statements before the first executable SQL statement:

```
EXEC SQL WHENEVER NOT FOUND GOTO close_cursor;
EXEC SQL WHENEVER SQLWARNING CONTINUE;
EXEC SQL WHENEVER SQLERROR GOTO error_handler;
```

In the following example, you use WHENEVER...DO statements to handle specific errors:

```
...
EXEC SQL WHENEVER SQLERROR DO handle_insert_error("INSERT error");
EXEC SQL INSERT INTO emp (empno, ename, deptno)
     VALUES (:emp_number, :emp_name, :dept_number);
EXEC SQL WHENEVER SQLERROR DO handle_delete_error("DELETE error");
EXEC SQL DELETE FROM dept WHERE deptno = :dept_number;
...
handle_insert_error(char *stmt)
{   switch(sqlca.sqlcode)
    {
    case -1:
```

```
        /* duplicate key value */
            ...
            break;
        case -1401:
        /* value too large */
            ...
            break;
        default:
        /* do something here too */
            ...
            break;
        }
    }

    handle_delete_error(char *stmt)
    {
        printf("%s\n\n", stmt);
        if (sqlca.sqlerrd[2] == 0)
        {
            /* no rows deleted */
            ...
        }
        else
        {   ...
        }
        ...
    }
```

Notice how the procedures check variables in the SQLCA to determine a course of action.

Use of DO BREAK and DO CONTINUE

This example illustrates how to display employee name, salary, and commission for only those employees who receive commissions:

```
#include <sqlca.h>
#include <stdio.h>

main()
{
    char *uid = “scott/tiger”;
```

```
    struct { char ename[12]; float sal; float comm; } emp;

    /* Trap any connection error that might occur. */
    EXEC SQL WHENEVER SQLERROR GOTO whoops;
    EXEC SQL CONNECT :uid;

    EXEC SQL DECLARE c CURSOR FOR
        SELECT ename, sal, comm FROM EMP ORDER BY ENAME ASC;

    EXEC SQL OPEN c;

    /* Set up 'BREAK' condition to exit the loop. */
    EXEC SQL WHENEVER NOT FOUND DO BREAK;
   /* The DO CONTINUE makes the loop start at the next iteration when an error occurs.*/
    EXEC SQL WHENEVER SQLERROR DO CONTINUE;

    while (1)
      {
          EXEC SQL FETCH c INTO :emp;
   /* An ORA-1405 would cause the 'continue' to occur. So only employees with */
   /* non-NULL commissions will be displayed. */
          printf("%s  %7.2f  %9.2f\n", emp.ename, emp.sal, emp.comm);
       }

/* This 'CONTINUE' shuts off the 'DO CONTINUE' allowing the program to
   proceed if any further errors do occur, specifically, with the CLOSE */
    EXEC SQL WHENEVER SQLERROR CONTINUE;

    EXEC SQL CLOSE c;

    exit(EXIT_SUCCESS);

whoops:
    printf("%.*s\n", sqlca.sqlerrm.sqlerrml, sqlca.sqlerrm.sqlerrmc);
    exit(EXIT_FAILURE);
}
```

Scope of WHENEVER

Because WHENEVER is a declarative statement, its scope is positional, not logical. That is, it tests all executable SQL statements that *physically* follow it in the source file, not in the flow of program logic. So, code the WHENEVER statement before the first executable SQL statement you want to test.

A WHENEVER statement stays in effect until superseded by another WHENEVER statement checking for the same condition.

In the example below, the first WHENEVER SQLERROR statement is superseded by a second, and so applies only to the CONNECT statement. The second WHENEVER SQLERROR statement applies to both the UPDATE and DROP statements, despite the flow of control from *step1* to *step3*.

```
step1:
     EXEC SQL WHENEVER SQLERROR STOP;
     EXEC SQL CONNECT :username IDENTIFIED BY :password;
     ...
     goto step3;
step2:
     EXEC SQL WHENEVER SQLERROR CONTINUE;
     EXEC SQL UPDATE emp SET sal = sal * 1.10;
     ...
step3:
     EXEC SQL DROP INDEX emp_index;
     ...
```

Guidelines

The following guidelines will help you avoid some common pitfalls.

Placing the Statements

In general, code a WHENEVER statement before the first executable SQL statement in your program. This ensures that all ensuing errors are trapped because WHENEVER statements stay in effect to the end of a file.

Handling End-of-Data Conditions

Your program should be prepared to handle an end-of-data condition when using a cursor to fetch rows. If a FETCH returns no data, the program should exit the fetch loop, as follows:

```
EXEC SQL WHENEVER NOT FOUND DO break;
for (;;)
{
    EXEC SQL FETCH...
}
EXEC SQL CLOSE my_cursor;
...
```

Avoiding Infinite Loops

If a WHENEVER SQLERROR GOTO statement branches to an error handling routine that includes an executable SQL statement, your program might enter an infinite loop if the SQL statement fails with an error. You can avoid this by coding WHENEVER SQLERROR CONTINUE before the SQL statement, as shown in the following example:

```
EXEC SQL WHENEVER SQLERROR GOTO sql_error;
...
sql_error:
     EXEC SQL WHENEVER SQLERROR CONTINUE;
     EXEC SQL ROLLBACK WORK RELEASE;
     ...
```

Without the WHENEVER SQLERROR CONTINUE statement, a ROLLBACK error would invoke the routine again, starting an infinite loop.

Careless use of WHENEVER can cause problems. For example, the following code enters an infinite loop if the DELETE statement sets NOT FOUND because no rows meet the search condition:

```
/* improper use of WHENEVER */
...
EXEC SQL WHENEVER NOT FOUND GOTO no_more;
for (;;)
{
     EXEC SQL FETCH emp_cursor INTO :emp_name, :salary;
     ...
}

no_more:
     EXEC SQL DELETE FROM emp WHERE empno = :emp_number;
      ...
```

The next example handles the NOT FOUND condition properly by resetting the GOTO target:

```
/* proper use of WHENEVER */
```

```
...
EXEC SQL WHENEVER NOT FOUND GOTO no_more;
for (;;)
{
     EXEC SQL FETCH emp_cursor INTO :emp_name, :salary;
     ...
}
no_more:
     EXEC SQL WHENEVER NOT FOUND GOTO no_match;
     EXEC SQL DELETE FROM emp WHERE empno = :emp_number;
     ...
no_match:
     ...
```

Maintaining Addressability

Make sure all SQL statements governed by a WHENEVER GOTO statement can branch to the GOTO label. The following code results in a compile-time error because *labelA* in *func1* is not within the scope of the INSERT statement in *func2*:

```
func1()
{

     EXEC SQL WHENEVER SQLERROR GOTO labelA;
     EXEC SQL DELETE FROM emp WHERE deptno = :dept_number;
     ...
labelA:
...
}
func2()
{

     EXEC SQL INSERT INTO emp (job) VALUES (:job_title);
     ...
}
```

The label to which a WHENEVER GOTO statement branches must be in the same precompilation file as the statement.

Returning after an Error

If your program must return after handling an error, use the DO *routine_call* action. Alternatively, you can test the value of *sqlcode*, as shown in the following example:

```
...
EXEC SQL UPDATE emp SET sal = sal * 1.10;
```

```
if (sqlca.sqlcode < 0)
{  /* handle error  */

EXEC SQL DROP INDEX emp_index;
```

Just make sure no WHENEVER GOTO or WHENEVER STOP statement is active.

Obtaining the Text of SQL Statements

In many precompiler applications it is convenient to know the text of the statement being processed, its length, and the SQL command (such as INSERT or SELECT) that it contains. This is especially true for applications that use dynamic SQL.

The *sqlgls()* function—part of the SQLLIB runtime library—returns the following information:

- the text of the most recently parsed SQL statement
- the effective length of the statement
- a function code for the SQL command used in the statement

You can call *sqlgls()* after issuing a static SQL statement. For dynamic SQL Method 1, call *sqlgls()* after the SQL statement is executed. For dynamic SQL Methods 2, 3, and 4, you can call *sqlgls()* as soon as the statement has been PREPAREd.

The prototype for *sqlgls()* is

```
int sqlgls(char *sqlstm, size_t *stmlen, size_t *sqlfc);
```

The *sqlstm* parameter is a character buffer that holds the returned text of the SQL statement. Your program must statically declare the buffer or dynamically allocate memory for the buffer.

The *stmlen* parameter is a long integer. Before calling *sqlgls()*, set this parameter to the actual size, in bytes, of the *sqlstm* buffer. When *sqlgls()* returns, the *sqlstm* buffer contains the SQL statement text, blank padded to the length of the buffer. The *stmlen* parameter returns the actual number of bytes in the returned statement text, not counting blank padding.

The *sqlfc* parameter is a long integer that returns the SQL function code for the SQL command in the statement. Table 11–3 shows the SQL function codes for the commands.

Table 11–3 SQL Codes

Code	SQL Function	Code	SQL Function	Code	SQL Function
01	CREATE TABLE	26	ALTER TABLE	51	DROP TABLESPACE
02	SET ROLE	27	EXPLAIN	52	ALTER SESSION
03	INSERT	28	GRANT	53	ALTER USER
04	SELECT	29	REVOKE	54	COMMIT
05	UPDATE	30	CREATE SYNONYM	55	ROLLBACK
06	DROP ROLE	31	DROP SYNONYM	56	SAVEPOINT
07	DROP VIEW	32	ALTER SYSTEM SWITCH LOG	57	CREATE CONTROL FILE
08	DROP TABLE	33	SET TRANSACTION	58	ALTER TRACING
09	DELETE	34	PL/SQL EXECUTE	59	CREATE TRIGGER
10	CREATE VIEW	35	LOCK TABLE	60	ALTER TRIGGER
11	DROP USER	36	(NOT USED)	61	DROP TRIGGER
12	CREATE ROLE	37	RENAME	62	ANALYZE TABLE
13	CREATE SEQUENCE	38	COMMENT	63	ANALYZE INDEX
14	ALTER SEQUENCE	39	AUDIT	64	ANALYZE CLUSTER
15	(NOT USED)	40	NOAUDIT	65	CREATE PROFILE
16	DROP SEQUENCE	41	ALTER INDEX	66	DROP PROFILE
17	CREATE SCHEMA	42	CREATE EXTERNAL DATABASE	67	ALTER PROFILE
18	CREATE CLUS-TER	43	DROP EXTERNAL DATABASE	68	DROP PROCEDURE
19	CREATE USER	44	CREATE DATABASE	69	(NOT USED)
20	CREATE INDEX	45	ALTER DATABASE	70	ALTER RESOURCE COST
21	DROP INDEX	46	CREATE ROLLBACK SEGMENT	71	CREATE SNAPSHOT LOG
22	DROP CLUSTER	47	ALTER ROLLBACK SEGMENT	72	ALTER SNAPSHOT LOG
23	VALIDATE INDEX	48	DROP ROLLBACK SEGMENT	73	DROP SNAPSHOT LOG

Table 11–3 SQL Codes

Code	SQL Function	Code	SQL Function	Code	SQL Function
24	CREATE PRO-CEDURE	49	CREATE TABLESPACE	74	CREATE SNAPSHOT
25	ALTER PROCE-DURE	50	ALTER TABLESPACE	75	ALTER SNAPSHOT
				76	DROP SNAPSHOT

The *sqlgls()* function returns an **int**. The return value is zero (FALSE) if an error occurred, or is one (TRUE) if there was no error. The length parameter (*stmlen*) returns a zero if an error occurred. Possible error conditions are:

- no SQL statement has been parsed
- you passed an invalid parameter (for example, a negative length parameter)
- an internal exception occurred in SQLLIB

Restrictions

sqlgls() does not return the text for statements that contain the following commands:

- CONNECT
- COMMIT
- ROLLBACK
- FETCH

There are no SQL function codes for these commands.

Sample Program

The sample program *sqlvcp.pc*, which is listed in Chapter 3, “Developing a Pro*C/C++ Application”, demonstrates how you can use the *sqlgls()* function. This program is also available on-line, in your *demo* directory.

Using the Oracle Communications Area (ORACA)

The SQLCA handles standard SQL communications; the ORACA handles Oracle communications. When you need more information about runtime errors and status changes than the SQLCA provides, use the ORACA. It contains an extended

set of diagnostic tools. However, use of the ORACA is optional because it adds to runtime overhead.

Besides helping you to diagnose problems, the ORACA lets you monitor your program's use of Oracle resources such as the SQL Statement Executor and the cursor cache.

Your program can have more than one ORACA. For example, it might have one global ORACA and several local ones. Access to a local ORACA is limited by its scope within the program. Oracle returns information only to the ORACA that is in scope.

Declaring the ORACA

To declare the ORACA, copy it into your program with the INCLUDE statement or the **#include** preprocessor directive, as follows:

```
EXEC SQL INCLUDE ORACA;
```

or

```
#include <oraca.h>
```

If your ORACA must be of the **extern** storage class, define ORACA_STORAGE_CLASS in your program as follows:

```
#define ORACA_STORAGE_CLASS extern
```

If the program uses a Declare Section, the ORACA must be defined *outside* it.

Enabling the ORACA

To enable the ORACA, you must specify the ORACA option, either on the command line with

```
ORACA=YES
```

or inline with

```
EXEC ORACLE OPTION (ORACA=YES);
```

Then, you must choose appropriate runtime options by setting flags in the ORACA.

What's in the ORACA?

The ORACA contains option settings, system statistics, and extended diagnostics such as

- SQL statement text (you can specify when to save the text)
- the name of the file in which an error occurred (useful when using subroutines)
- location of the error in a file
- cursor cache errors and statistics

A partial listing of *oraca.h* is

```
/*
NAME
  ORACA : Oracle Communications Area.

  If the symbol ORACA_NONE is defined, then there will be no ORACA
  *variable*, although there will still be a struct defined.  This
  macro should not normally be defined in application code.

  If the symbol ORACA_INIT is defined, then the ORACA will be
  statically initialized. Although this is not necessary in order
  to use the ORACA, it is a good pgming practice not to have
  unitialized variables. However, some C compilers/OS's don't
  allow automatic variables to be init'd in this manner. Therefore,
  if you are INCLUDE'ing the ORACA in a place where it would be
  an automatic AND your C compiler/OS doesn't allow this style
  of initialization, then ORACA_INIT should be left undefined --
  all others can define ORACA_INIT if they wish.
*/

#ifndef  ORACA
#define  ORACA      1

struct    oraca
{
    char oracaid[8];   /* Reserved               */
    long oracabc;      /* Reserved               */

/*    Flags which are setable by User. */

   long  oracchf;      /* <> 0 if "check cur cache consistncy"*/
   long  oradbgf;      /* <> 0 if "do DEBUG mode checking"    */
   long  orahchf;      /* <> 0 if "do Heap consistency check" */
```

```
   long  orastxtf;     /* SQL stmt text flag            */
#define  ORASTFNON 0   /* = don't save text of SQL stmt       */
#define  ORASTFERR 1   /* = only save on SQLERROR         */
#define  ORASTFWRN 2   /* = only save on SQLWARNING/SQLERROR  */
#define  ORASTFANY 3      /* = always save             */
    struct
      {
  unsigned short orastxtl;
  char  orastxtc[70];
      } orastxt;         /* text of last SQL stmt          */
    struct
      {
  unsigned short orasfnml;
  char      orasfnmc[70];
      } orasfnm;        /* name of file containing SQL stmt    */
  long   oraslnr;        /* line nr-within-file of SQL stmt     */
  long   orahoc;         /* highest max open OraCurs requested  */
  long   oramoc;         /* max open OraCursors required         */
  long   oracoc;         /* current OraCursors open         */
  long   oranor;         /* nr of OraCursor re-assignments      */
  long   oranpr;         /* nr of parses               */
  long   oranex;         /* nr of executes            */
    };

#ifndef ORACA_NONE

#ifdef ORACA_STORAGE_CLASS
ORACA_STORAGE_CLASS struct oraca oraca
#else
struct oraca oraca
#endif
#ifdef ORACA_INIT
    =
    {
    {'O','R','A','C','A',' ',' ',' '},
    sizeof(struct oraca),
    0,0,0,0,
    {0,{0}},
    {0,{0}},
    0,
    0,0,0,0,0,0
    }
#endif
    ;
```

```
#endif

#endif
/* end oraca.h */
```

Choosing Runtime Options

The ORACA includes several option flags. Setting these flags by assigning them non-zero values allows you to

- save the text of SQL statements
- enable DEBUG operations
- check cursor cache consistency (the *cursor cache* is a continuously updated area of memory used for cursor management)
- check heap consistency (the *heap* is an area of memory reserved for dynamic variables)
- gather cursor statistics

The descriptions below will help you choose the options you need.

Structure of the ORACA

This section describes the structure of the ORACA, its components, and the values they can store.

oracaid

This string component is initialized to “ORACA" to identify the Oracle Communications Area.

oracabc

This integer component holds the length, in bytes, of the ORACA data structure.

oracchf

If the master DEBUG flag (*oradbgf)* is set, this flag enables the gathering of cursor cache statistics and lets you check the cursor cache for consistency before every cursor operation.

The Oracle runtime library does the consistency checking and might issue error messages, which are listed in the manual *Oracle8 Error Messages*. They are returned to the SQLCA just like Oracle error messages.

This flag has the following settings:

- Disable cache consistency checking (the default).
- Enable cache consistency checking.

oradbgf

This master flag lets you choose all the DEBUG options. It has the following settings:

Disable all DEBUG operations (the default).

Enable all DEBUG operations.

orahchf

If the master DEBUG flag (*oradbgf*) is set, this flag tells the Oracle runtime library to check the heap for consistency every time the precompiler dynamically allocates or frees memory. This is useful for detecting program bugs that upset memory.

This flag must be set before the CONNECT command is issued and, once set, cannot be cleared; subsequent change requests are ignored. It has the following settings:

- Disable heap consistency checking (the default).
- Enable heap consistency checking.

orastxtf

This flag lets you specify when the text of the current SQL statement is saved. It has the following settings:

- Never save the SQL statement text (the default).
- Save the SQL statement text on SQLERROR only.
- Save the SQL statement text on SQLERROR or SQLWARNING.
- Always save the SQL statement text.

The SQL statement text is saved in the ORACA embedded struct named *orastxt*.

Diagnostics

The ORACA provides an enhanced set of diagnostics; the following variables help you to locate errors quickly.

orastxt

This embedded struct helps you find faulty SQL statements. It lets you save the text of the last SQL statement parsed by Oracle. It contains the following two components:

orastxtl	This integer component holds the length of the current SQL statement.
orastxtc	This string component holds the text of the current SQL statement. At most, the first 70 characters of text are saved. The string is not null terminated. Use the oratxtl length component when printing the string.

Statements parsed by the precompiler, such as CONNECT, FETCH, and COMMIT, are *not* saved in the ORACA.

orasfnm

This embedded struct identifies the file containing the current SQL statement and so helps you find errors when multiple files are precompiled for one application. It contains the following two components:

orasfnml	This integer component holds the length of the filename stored in orasfnmc.
orasfnmc	This string component holds the filename. At most, the first 70 characters are stored.

oraslnr

This integer component identifies the line at (or near) which the current SQL statement can be found.

Cursor Cache Statistics

If the master DEBUG flag (*oradbgf*) and the cursor cache flag (*oracchf*) are set, the variables below let you gather cursor cache statistics. They are automatically set by every COMMIT or ROLLBACK command your program issues.

Internally, there is a set of these variables for each CONNECTed database. The current values in the ORACA pertain to the database against which the last COMMIT or ROLLBACK was executed.

orahoc

This integer component records the highest value to which MAXOPENCURSORS was set during program execution.

oramoc

This integer component records the maximum number of open Oracle cursors required by your program. This number can be higher than *orahoc* if MAXOPENCURSORS was set too low, which forced the precompiler to extend the cursor cache.

oracoc

This integer component records the current number of open Oracle cursors required by your program.

oranor

This integer component records the number of cursor cache reassignments required by your program. This number shows the degree of "thrashing" in the cursor cache and should be kept as low as possible.

oranpr

This integer component records the number of SQL statement parses required by your program.

oranex

This integer component records the number of SQL statement executions required by your program. The ratio of this number to the *oranpr* number should be kept as high as possible. In other words, avoid unnecessary reparsing. For help, see Appendix C.

An ORACA Example

The following program prompts for a department number, inserts the name and salary of each employee in that department into one of two tables, then displays diagnostic information from the ORACA. This program is available online in the *demo* directory, as *oraca.pc*.

```
/* oraca.pc
 * This sample program demonstrates how to
 * use the ORACA to determine various performance
```

```
 * parameters at runtime.
 */
#include <stdio.h>
#include <string.h>
#include <sqlca.h>
#include <oraca.h>

EXEC SQL BEGIN DECLARE SECTION;
char *userid = "SCOTT/TIGER";
char  emp_name[21];
int   dept_number;
float salary;
char SQLSTATE[6];
EXEC SQL END DECLARE SECTION;

void sql_error();

main()
{
    char temp_buf[32];

    EXEC SQL WHENEVER SQLERROR DO sql_error("Oracle error");
    EXEC SQL CONNECT :userid;

    EXEC ORACLE OPTION (ORACA=YES);

    oraca.oradbgf  = 1;             /* enable debug operations */
    oraca.oracchf  = 1;      /* gather cursor cache statistics */
    oraca.orastxtf = 3;       /* always save the SQL statement */

    printf("Enter department number: ");
    gets(temp_buf);
    dept_number = atoi(temp_buf);


    EXEC SQL DECLARE emp_cursor CURSOR FOR
      SELECT ename, sal + NVL(comm,0) AS sal_comm
        FROM emp
        WHERE deptno = :dept_number
        ORDER BY sal_comm DESC;
    EXEC SQL OPEN emp_cursor;
    EXEC SQL WHENEVER NOT FOUND DO sql_error("End of data");

    for (;;)
    {
```

```
        EXEC SQL FETCH emp_cursor INTO :emp_name, :salary;
        printf("%.10s\n", emp_name);
        if (salary < 2500)
            EXEC SQL INSERT INTO pay1 VALUES (:emp_name, :salary);         else
            EXEC SQL INSERT INTO pay2 VALUES (:emp_name, :salary);     }
}

void
sql_error(errmsg)
char *errmsg;
{
    char buf[6];

    strcpy(buf, SQLSTATE);
    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL COMMIT WORK RELEASE;

    if (strncmp(errmsg, "Oracle error", 12) == 0)
        printf("\n%s, sqlstate is %s\n\n", errmsg, buf);
    else
        printf("\n%s\n\n", errmsg);

    printf("Last SQL statement: %.*s\n",
    oraca.orastxt.orastxtl, oraca.orastxt.orastxtc);
    printf("\nAt or near line number %d\n", oraca.oraslnr);
    printf
("\nCursor Cache Statistics\n-----------------------\n");
    printf
("Maximum value of MAXOPENCURSORS:    %d\n", oraca.orahoc);
    printf
("Maximum open cursors required:      %d\n", oraca.oramoc);
    printf
("Current number of open cursors:     %d\n", oraca.oracoc);
    printf
("Number of cache reassignments:      %d\n", oraca.oranor);
    printf
("Number of SQL statement parses:     %d\n", oraca.oranpr);
    printf
("Number of SQL statement executions: %d\n", oraca.oranex);
    exit(1);
}
```

12

Using Host Arrays

This chapter looks at using arrays to simplify coding and improve program performance. You learn how to manipulate Oracle data using arrays, how to operate on all the elements of an array with a single SQL statement, and how to limit the number of array elements processed. The following issues are addressed:

- Why Use Arrays?
- Declaring Host Arrays
- Using Arrays in SQL Statements
- Selecting into Arrays
- Inserting with Arrays
- Updating with Arrays
- Deleting with Arrays
- Using the FOR Clause
- Using the WHERE Clause
- Arrays of Structs
- Mimicking CURRENT OF
- Using sqlca.sqlerrd[2]

Why Use Arrays?

Arrays reduce programming time and result in improved performance.

With arrays, you manipulate an entire array with a single SQL statement. Thus, Oracle communication overhead is reduced markedly, especially in a networked environment. A major portion of runtime is spent on network roundtrips between the client program and the server database. Arrays reduce the roundtrips.

For example, suppose you want to insert information about 300 employees into the EMP table. Without arrays your program must do 300 individual INSERTs—one for each employee. With arrays, only one INSERT needs to be done.

Declaring Host Arrays

You declare host arrays just like scalar host variables. Dimension the arrays when they are declared. The following example declares three host arrays, each with a dimension of 50 elements:

```
char  emp_name[50][10];
int   emp_number[50];
float salary[50];
```

Arrays of VARCHARs are also allowed. The following declaration is a valid host language declaration:

```
VARCHAR v_array[10][30];
```

Restrictions

You cannot declare host arrays of pointers, except for object types.

Except for character arrays (strings), host arrays that might be referenced in a SQL statement are limited to one dimension. So, the two-dimensional array declared in the following example is *invalid*:

```
int hi_lo_scores[25][25];   /* not allowed */
```

Maximum Size of Arrays

The maximum size of a host array is 32,767 divided by the size of the datatype. If you use a host array that exceeds the maximum, you get a “parameter out of range” runtime error.

Using Arrays in SQL Statements

You can use host arrays as input variables in the INSERT, UPDATE, and DELETE statements and as output variables in the INTO clause of SELECT and FETCH statements.

The embedded SQL syntax used for host arrays and simple host variables is nearly the same. One difference is the optional FOR clause, which lets you control array processing. Also, there are restrictions on mixing host arrays and simple host variables in a SQL statement.

The following sections illustrate the use of host arrays in data manipulation statements.

Referencing Host Arrays

If you use multiple host arrays in a single SQL statement, their dimensions should be the same. Otherwise, an "array size mismatch" warning message is issued at precompile time. If you ignore this warning, the precompiler uses the *smallest* dimension for the SQL operation.

In this example, only 25 rows are INSERTed:

```
int    emp_number[50];
char   emp_name[50][10];
int    dept_number[25];
/* Populate host arrays here. */

EXEC SQL INSERT INTO emp (empno, ename, deptno)
    VALUES (:emp_number, :emp_name, :dept_number);
```

It is possible to subscript host arrays in SQL statements, and use them in a loop to INSERT or fetch data. For example, you could INSERT every fifth element in an array using a loop such as:

```
for (i = 0; i < 50; i += 5)
     EXEC SQL INSERT INTO emp (empno, deptno)
         VALUES (:emp_number[i], :dept_number[i]);
```

However, if the array elements that you need to process are contiguous, you should not process host arrays in a loop. Simply use the unsubscripted array names in your SQL statement. Oracle treats a SQL statement containing host arrays of dimension *n* like the same statement executed *n* times with *n* different scalar variables.

Using Indicator Arrays

You can use indicator arrays to assign NULLs to input host arrays, and to detect NULL or truncated values in output host arrays. The following example shows how to INSERT with indicator arrays:

```
int    emp_number[50];
int    dept_number[50];
float  commission[50];
short  comm_ind[50];       /* indicator array */

/* Populate the host and indicator arrays.  To insert a null
   into the comm column, assign -1 to the appropriate
   element in the indicator array. */
    EXEC SQL INSERT INTO emp (empno, deptno, comm)
        VALUES (:emp_number, :dept_number,
        :commission INDICATOR :comm_ind);
```

Oracle Restrictions

Mixing scalar host variables with host arrays in the VALUES, SET, INTO, or WHERE clause is *not* allowed. If any of the host variables is an array, all must be arrays.

You cannot use host arrays with the CURRENT OF clause in an UPDATE or DELETE statement.

ANSI Restriction and Requirements

The array interface is an Oracle extension to the ANSI/ISO embedded SQL standard. However, when you precompile with MODE=ANSI, array SELECTs and FETCHes are still allowed. The use of arrays can be flagged using the FIPS flagger precompiler option, if desired.

When DBMS=V6, no error is generated if you SELECT or FETCH NULL columns into a host array that is not associated with an indicator array. Still, when doing array SELECTs and FETCHes, always use indicator arrays. That way, you can test for NULLs in the associated output host array.

When you precompile with the precompiler option DBMS=V7 or V8, if a NULL is selected or fetched into a host variable that has no associated indicator variable, Oracle stops processing, sets *sqlca.sqlerrd[2]* to the number of rows processed, and returns the following error:

```
ORA-01405: fetched column value is NULL
```

When DBMS=V6, if you SELECT or FETCH a truncated column value into a host array that is not associated with an indicator array, Oracle stops processing, sets *sqlca.sqlerrd[2]* to the number of rows processed, and issues the following error message:

```
ORA-01406: fetched column value was truncated
```

When DBMS=V7 or V8, Oracle does not consider truncation to be an error.

Selecting into Arrays

You can use host arrays as output variables in the SELECT statement. If you know the maximum number of rows the SELECT will return, simply dimension the host arrays with that number of elements. In the following example, you select directly into three host arrays. Knowing the SELECT will return no more than 50 rows, you dimension the arrays with 50 elements:

```
char   emp_name[50][20];
int    emp_number[50];
float  salary[50];

EXEC SQL SELECT ENAME, EMPNO, SAL
    INTO :emp_name, :emp_number, :salary
    FROM EMP
    WHERE SAL > 1000;
```

In this example, the SELECT statement returns up to 50 rows. If there are fewer than 50 eligible rows or you want to retrieve only 50 rows, this method will suffice. However, if there are more than 50 eligible rows, you cannot retrieve all of them this way. If you re-execute the SELECT statement, it just returns the first 50 rows again, even if more are eligible. You must either dimension a larger array or declare a cursor for use with the FETCH statement.

If a SELECT INTO statement returns more rows than the number of elements you dimensioned, Oracle issues the error message

```
ORA-02112: PCC: SELECT ...INTO returns too many rows
```

unless you specify SELECT_ERROR=NO. For more information about the SELECT_ERROR option, see the section "Using the Precompiler Options" on page 9-10 .

Cursor Fetches

If you do not know the maximum number of rows a SELECT will return, you can declare and open a cursor, then fetch from it in "batches."

Batch fetches within a loop let you retrieve a large number of rows with ease. Each FETCH returns the next batch of rows from the current active set. In the following example, you fetch in 20-row batches:

```
int   emp_number[20];
float salary[20];

EXEC SQL DECLARE emp_cursor CURSOR FOR
    SELECT empno, sal FROM emp;

EXEC SQL OPEN emp_cursor;

EXEC SQL WHENEVER NOT FOUND do break;
for (;;)
{
    EXEC SQL FETCH emp_cursor
        INTO :emp_number, :salary;
    /* process batch of rows */
    ...
}
```

Number of Rows Fetched

Each FETCH returns, at most, the number of rows in the array dimension. Fewer rows are returned in the following cases:

- The end of the active set is reached. The "no data found" Oracle error code is returned to SQLCODE in the SQLCA. For example, this happens if you fetch into an array of dimension 100 but only 20 rows are returned.
- Fewer than a full batch of rows remain to be fetched. For example, this happens if you fetch 70 rows into an array of dimension 20 because after the third FETCH, only 10 rows remain to be fetched.
- An error is detected while processing a row. The FETCH fails and the applicable Oracle error code is returned to SQLCODE.

The cumulative number of rows returned can be found in the third element of *sqlerrd* in the SQLCA, called *sqlerrd[2]* in this guide. This applies to each open

cursor. In the following example, notice how the status of each cursor is maintained separately:

```
EXEC SQL OPEN cursor1;
EXEC SQL OPEN cursor2;
EXEC SQL FETCH cursor1 INTO :array_of_20;
/* now running total in sqlerrd[2] is 20 */
EXEC SQL FETCH cursor2 INTO :array_of_30;
/* now running total in sqlerrd[2] is 30, not 50 */
EXEC SQL FETCH cursor1 INTO :array_of_20;
/* now running total in sqlerrd[2] is 40 (20 + 20) */
EXEC SQL FETCH cursor2 INTO :array_of_30;
/* now running total in sqlerrd[2] is 60 (30 + 30) */
```

Sample Program: Host Arrays

The demonstration program in this section shows how you can use host arrays when writing a query in Pro*C/C++. Pay particular attention to the use of the "rows processed count" in the SQLCA (*sqlca.sqlerrd[2]*). See Chapter 11, "Handling Runtime Errors" for more information about the SQLCA. This program is available on-line in the file *sample3.pc* in your *demo* directory.

```
/*
 *  sample3.pc
 *  Host Arrays
 *
 *  This program connects to ORACLE, declares and opens a cursor,
 *  fetches in batches using arrays, and prints the results using
 *  the function print_rows().
 */

#include <stdio.h>
#include <string.h>

#include <sqlca.h>

#define NAME_LENGTH   20
#define ARRAY_LENGTH   5
/* Another way to connect. */
char *username = "SCOTT";
char *password = "TIGER";

/* Declare a host structure tag. */
struct
```

```
{
    int    emp_number[ARRAY_LENGTH];
    char   emp_name[ARRAY_LENGTH][NAME_LENGTH];
    float  salary[ARRAY_LENGTH];
} emp_rec;

/* Declare this program's functions. */
void print_rows();              /* produces program output */
void sql_error();          /* handles unrecoverable errors */


main()
{
    int  num_ret;               /* number of rows returned */

/* Connect to ORACLE. */
    EXEC SQL WHENEVER SQLERROR DO sql_error("Connect error:");

    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    printf("\nConnected to ORACLE as user: %s\n", username);


    EXEC SQL WHENEVER SQLERROR DO sql_error("Oracle error:");
/* Declare a cursor for the FETCH. */
    EXEC SQL DECLARE c1 CURSOR FOR
        SELECT empno, ename, sal FROM emp;

    EXEC SQL OPEN c1;

/* Initialize the number of rows. */
    num_ret = 0;

/* Array fetch loop - ends when NOT FOUND becomes true. */
    EXEC SQL WHENEVER NOT FOUND DO break;

    for (;;)
    {
        EXEC SQL FETCH c1 INTO :emp_rec;

/* Print however many rows were returned. */
        print_rows(sqlca.sqlerrd[2] - num_ret);
        num_ret = sqlca.sqlerrd[2];        /* Reset the number. */
    }
/* Print remaining rows from last fetch, if any. */
    if ((sqlca.sqlerrd[2] - num_ret) > 0)
```

```
        print_rows(sqlca.sqlerrd[2] - num_ret);

    EXEC SQL CLOSE c1;
    printf("\nAu revoir.\n\n\n");

/* Disconnect from the database. */
    EXEC SQL COMMIT WORK RELEASE;
    exit(0);
}


void
print_rows(n)
int n;
{
    int i;

    printf("\nNumber   Employee         Salary");
    printf("\n------   --------         ------\n");

    for (i = 0; i < n; i++)
        printf("%-9d%-15.15s%9.2f\n", emp_rec.emp_number[i],
               emp_rec.emp_name[i], emp_rec.salary[i]);

}


void
sql_error(msg)
char *msg;
{
    EXEC SQL WHENEVER SQLERROR CONTINUE;

    printf("\n%s", msg);
    printf("\n% .70s \n", sqlca.sqlerrm.sqlerrmc);

    EXEC SQL ROLLBACK WORK RELEASE;
    exit(1);
}
```

Restrictions

Using host arrays in the WHERE clause of a SELECT statement is *not* allowed except in a subquery. For an example, see the section "Using the WHERE Clause" on page 12-16.

Also, you cannot mix simple host variables with host arrays in the INTO clause of a SELECT or FETCH statement. If any of the host variables is an array, all must be arrays.

Table 12–1 shows which uses of host arrays are valid in a SELECT INTO statement:

Table 12–1 Valid Host Arrays for SELECT INTO

INTO Clause	WHERE Clause	Valid?
array	array	no
scalar	scalar	yes
array	scalar	yes
scalar	array	no

Fetching Nulls

When DBMS=V6, if you SELECT or FETCH null column values into a host array not associated with an indicator array, no error is generated. So, when doing array SELECTs and FETCHes, always use indicator arrays. That way, you can test for nulls in the associated output host array.

When DBMS = V7 or V6_CHAR, if you SELECT or FETCH a null column value into a host array not associated with an indicator array, Oracle stops processing, sets *sqlerrd[2]* to the number of rows processed, and issues the following error message:

```
ORA-01405: fetched column value is NULL
```

Fetching Truncated Values

When DBMS=V6, if you SELECT or FETCH a truncated column value into a host array not associated with an indicator array, Oracle stops processing, sets *sqlerrd[2]* to the number of rows processed, and issues the following error message:

```
ORA-01406: fetched column value was truncated
```

In either case, you can check *sqlerrd[2]* for the number of rows processed before the truncation occurred. The rows-processed count includes the row that caused the truncation error.

When DBMS=V7 or V6_CHAR, truncation results in a warning message, but Oracle continues processing.

Again, when doing array SELECTs and FETCHes, always use indicator arrays. That way, if Oracle assigns one or more truncated column values to an output host array, you can find the original lengths of the column values in the associated indicator array.

Inserting with Arrays

You can use host arrays as input variables in an INSERT statement. Just make sure your program populates the arrays with data before executing the INSERT statement.

If some elements in the arrays are irrelevant, you can use the FOR clause to control the number of rows inserted. See the section "Using the FOR Clause" on page 12-14.

An example of inserting with host arrays follows:

```
char   emp_name[50][20];
int    emp_number[50];
float  salary[50];
/* populate the host arrays */
...
EXEC SQL INSERT INTO EMP (ENAME, EMPNO, SAL)
    VALUES (:emp_name, :emp_number, :salary);
```

The cumulative number of rows inserted can be found in the rows-processed count, *sqlca.sqlerrd[2]*.

In the following example, the INSERT is done one row at a time. This is much less efficient than the previous example, since a call to the server must be made for each row inserted.

```
for (i = 0; i < array_dimension; i++)
    EXEC SQL INSERT INTO emp (ename, empno, sal)
        VALUES (:emp_name[i], :emp_number[i], :salary[i]);
```

Restrictions

You cannot use an array of pointers in the VALUES clause of an INSERT statement; all array elements must be data items.

Mixing scaler host variables with host arrays in the VALUES clause of an INSERT statement is *not* allowed. If any of the host variables is an array, all must be arrays.

Updating with Arrays

You can also use host arrays as input variables in an UPDATE statement, as the following example shows:

```
int   emp_number[50];
float salary[50];
/* populate the host arrays */
EXEC SQL UPDATE emp SET sal = :salary
    WHERE EMPNO = :emp_number;
```

The cumulative number of rows updated can be found in *sqlerrd[2]*. The number does *not* include rows processed by an update cascade.

If some elements in the arrays are irrelevant, you can use the embedded SQL FOR clause to limit the number of rows updated.

The last example showed a typical update using a unique key (EMP_NUMBER). Each array element qualified just one row for updating. In the following example, each array element qualifies multiple rows:

```
char  job_title [10][20];
float commission[10];

...

EXEC SQL UPDATE emp SET comm = :commission
    WHERE job = :job_title;
```

Restrictions

Mixing simple host variables with host arrays in the SET or WHERE clause of an UPDATE statement is *not* recommended. If any of the host variables is an array, all should be arrays. Furthermore, if you use a host array in the SET clause, use one of equal dimension in the WHERE clause.

You cannot use host arrays with the CURRENT OF clause in an UPDATE statement. For an alternative, see the section "Mimicking CURRENT OF" on page 12-27.

Table 12–2 shows which uses of host arrays are valid in an

UPDATE statement:

Table 12–2 Host Arrays Valid in an UPDATE

SET Clause	WHERE Clause	Valid?
array	array	yes
scalar	scalar	yes
array	scalar	no
scalar	array	no

Deleting with Arrays

You can also use host arrays as input variables in a DELETE statement. It is like executing the DELETE statement repeatedly using successive elements of the host array in the WHERE clause. Thus, each execution might delete zero, one, or more rows from the table.

An example of deleting with host arrays follows:

```
...
int emp_number[50];

/* populate the host array */
...
EXEC SQL DELETE FROM emp
    WHERE empno = :emp_number;
```

The cumulative number of rows deleted can be found in *sqlerrd[2]*. The number does *not* include rows processed by a delete cascade.

The last example showed a typical delete using a unique key (EMP_NUMBER). Each array element qualified just one row for deletion. In the following example, each array element qualifies multiple rows:

```
...
char job_title[10][20];

/* populate the host array  */
```

```
...
EXEC SQL DELETE FROM emp
    WHERE job = :job_title;
```

Restrictions

Mixing simple host variables with host arrays in the WHERE clause of a DELETE statement is *not* allowed. If any of the host variables is an array, all must be arrays.

You cannot use host arrays with the CURRENT OF clause in a DELETE statement. For an alternative, see the section "Mimicking CURRENT OF" on page 12-27.

Using the FOR Clause

You can use the optional embedded SQL FOR clause to set the number of array elements processed by any of the following SQL statements:

- DELETE
- EXECUTE
- FETCH
- INSERT
- OPEN
- UPDATE

The FOR clause is especially useful in UPDATE, INSERT, and DELETE statements. With these statements you might not want to use the entire array. The FOR clause lets you limit the elements used to just the number you need, as the following example shows:

```
char  emp_name[100][20];
float salary[100];
int   rows_to_insert;

/* populate the host arrays */
rows_to_insert = 25;             /* set FOR-clause variable */
EXEC SQL FOR :rows_to_insert   /* will process only 25 rows */
    INSERT INTO emp (ename, sal)
    VALUES (:emp_name, :salary);
```

The FOR clause can use an integer host variable to count array elements, or an integer literal. A complex C expression that resolves to an integer *cannot* be used. For example, the following statement that uses an integer expression is illegal:

```
EXEC SQL FOR :rows_to_insert + 5                /* illegal */
    INSERT INTO emp (ename, empno, sal)
        VALUES (:emp_name, :emp_number, :salary);
```

The FOR clause variable specifies the number of array elements to be processed. Make sure the number is not larger than the smallest array dimension. Also, the number must be positive. If it is negative or zero, no rows are processed and Oracle issues an error message.

Restrictions

Two restrictions keep FOR clause semantics clear: you cannot use the FOR clause in a SELECT statement or with the CURRENT OF clause.

In a SELECT Statement

If you use the FOR clause in a SELECT statement, you get the following error message:

```
PCC-S-0056:  FOR clause not allowed on SELECT statement at ...
```

The FOR clause is not allowed in SELECT statements because its meaning is unclear. Does it mean "execute this SELECT statement *n* times"? Or, does it mean "execute this SELECT statement once, but return *n* rows"? The problem in the former case is that each execution might return multiple rows. In the latter case, it is better to declare a cursor and use the FOR clause in a FETCH statement, as follows:

```
EXEC SQL FOR :limit FETCH emp_cursor INTO ...
```

With the CURRENT OF Clause

You can use the CURRENT OF clause in an UPDATE or DELETE statement to refer to the latest row returned by a FETCH statement, as the following example shows:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
    SELECT ename, sal FROM emp WHERE empno = :emp_number;
...
EXEC SQL OPEN emp_cursor;
...
EXEC SQL FETCH emp_cursor INTO :emp_name, :salary;
...
EXEC SQL UPDATE emp SET sal = :new_salary
```

```
WHERE CURRENT OF emp_cursor;
```

However, you cannot use the FOR clause with the CURRENT OF clause. The following statements are invalid because the only logical value of *limit* is 1 (you can only update or delete the current row once):

```
EXEC SQL FOR :limit UPDATE emp SET sal = :new_salary
WHERE CURRENT OF emp_cursor;
...
EXEC SQL FOR :limit DELETE FROM emp
WHERE CURRENT OF emp_cursor;
```

Using the WHERE Clause

Oracle treats a SQL statement containing host arrays of dimension *n* like the same SQL statement executed *n* times with *n* different scalar variables (the individual array elements). The precompiler issues the following error message only when such treatment would be ambiguous:

```
PCC-S-0055: Array <name> not allowed as bind variable at ...
```

For example, assuming the declarations

```
int  mgr_number[50];
char job_title[50][20];
```

it would be ambiguous if the statement

```
EXEC SQL SELECT mgr INTO :mgr_number FROM emp
WHERE job = :job_title;
```

were treated like the imaginary statement

```
for (i = 0; i < 50; i++)
    SELECT mgr INTO :mgr_number[i] FROM emp
        WHERE job = :job_title[i];
```

because multiple rows might meet the WHERE-clause search condition, but only one output variable is available to receive data. Therefore, an error message is issued.

On the other hand, it would not be ambiguous if the statement

```
EXEC SQL UPDATE emp SET mgr = :mgr_number
    WHERE empno IN (SELECT empno FROM emp
        WHERE job = :job_title);
```

were treated like the imaginary statement

```
for (i = 0; i < 50; i++)
    UPDATE emp SET mgr = :mgr_number[i]
        WHERE empno IN (SELECT empno FROM emp
            WHERE job = :job_title[i]);
```

because there is a *mgr_number* in the SET clause for each row matching *job_title* in the WHERE clause, even if each *job_title* matches multiple rows. All rows matching each *job_title* can be SET to the same *mgr_number*. Therefore, no error message is issued.

Arrays of Structs

Prior releases of Pro*C / C++ supported the use of simple aggregate datatypes for inserting data into and fetching data from the database.

Using arrays of scalars, users can perform multi-row operations involving a single column only. Using structs of scalars allows users to perform single row operations involving multiple columns.

In order to perform multi-row operations involving multiple columns, however, users previously needed to allocate several parallel arrays of scalars either separately or encapsulated within a single struct. In many cases, it is easier to reorganize this data structure more conveniently as a single array of structs instead.

Beginning with release 8.0, Pro*C / C++ supports the use of *arrays of structs* which enable an application programmer to perform multi-row, multi-column operations using an array of C structs. With this enhancement, Pro*C / C++ can handle simple arrays of structs of scalars as bind variables in embedded SQL statements for easier processing of user data. This makes programming more intuitive, and allows users greater flexibility in organizing their data.

In addition to supporting arrays of structs as bind variables, Pro*C / C++ also supports arrays of indicator structs when used in conjunction with an array of structs declaration.

> **Note:** Binding structs to PL / SQL records and binding arrays of structs to PL / SQL tables of records are *not* part of this new functionality. Arrays of structs may also not be used within an embedded PL / SQL block. See the section "Restrictions on Arrays of Structs" on page 12-18 for further restrictions.

Since arrays of structs are intended to be used when performing multi-row operations involving multiple columns, it is generally anticipated that they will be used in the following ways.

- As output bind variables in SELECT statements or FETCH statements.

- As input bind variables in the VALUES clause of an INSERT statement.

Using Arrays of Structs

The notion of an array of structs is not new to C programmers. It does, however, present a conceptual difference for data storage when it is compared to a struct of parallel arrays.

In a struct of parallel arrays, the data for the individual columns is stored contiguously. In an array of structs, on the other hand, the column data is ***interleaved***, whereby each occurrence of a column in the array is separated by the space required by the other columns in the struct. This space is known as a '***stride***'.

Restrictions on Arrays of Structs

The following restrictions apply to the use of arrays of structs in Pro*C/C++:

- Arrays of structs (just as with ordinary structs) are not permitted inside an embedded PL/SQL block.
- Use of arrays of structs in WHERE or FROM clauses is prohibited.
- Arrays of structs may not be used with Dynamic SQL Method 4.
- Arrays of structs are not permitted in the SET clause of an UPDATE statement.

The syntax for declaring an array of structs doesn't really change. There are, however a few things to keep in mind when using an array of structs.

Declaring an Array of Structs

When declaring an array of structs which will be used in a Pro*C/C++ application, the programmer must keep in mind the following important points:

- The struct must have a structure tag. For example, in the following code segment

```
struct person {
    char name[15];
    int  VARCHARage;
} people[10];
```

  the `person` variable is the structure tag. This is so the precompiler can use the name of the struct to compute the size of the stride.

- The members of the struct must not be arrays. The only exception to this rule is for character types such as **char** or **VARCHAR** since array syntax is used when declaring variables of these types.
- **char** and **VARCHAR** members may not be two-dimensional.
- Nested structs are not permitted as members of an array of structs. This is not a new restriction, since nested structs have not been supported by previous releases of Pro*C/C++.
- The size of just the struct may not exceed the maximum value that a signed 4-byte quantity may represent. This is typically two gigabytes.

Given these restrictions regarding the use of arrays of structs, the following declaration is legal in Pro*C/C++

```
struct department {
   int deptno;
   char dname[15];
   char loc[14];
} dept[4];
```

while the following declaration is illegal.

```
struct {              /* the struct is missing a structure tag */
  int empno[15];      /* struct members may not be arrays */
  char ename[15][10]; /* character types may not be 2-dimensional */
  struct nested {
    int salary;   /* nested struct not permitted in array of structs */
  } sal_struct;
} bad[15];
```

It is also important to note that you may not apply datatype equivalencing to either the array of structs itself or to any of the individual fields within the struct. For example, assuming `empno` is not declared as an array in the above illegal struct, the following is illegal:

```
exec sql var bad[3].empno is integer(4);
```

The precompiler has no way to keep track of individual structure elements within the array of structs. One could do the following, on the other hand, to achieve the desired effect.

```
typedef int myint;
exec sql type myint is integer(4);

struct equiv {
  myint empno; /* now legally considered an integer(4) datatype */
```

```
   ...
} ok[15];
```

This should come as no surprise since equivalencing individual array items has not been supported by previous releases of Pro*C/C++. For example, the following scalar array declarations illustrate what is legal and what is not.

```
int empno[15];
exec sql var empno[3] is integer(4); /* illegal */

myint empno[15]; /* legal */
```

In summary, you may not equivalence any individual array item.

Using Indicator Variables

Indicator variables for an array of structs declaration work in much the same way as a normal struct declaration. An indicator array of structs declaration must abide by the rules for an array of structs described in the section "Declaring an Array of Structs" on page 12-18, plus the following rules.

- The number of fields in the indicator struct must be less than or equal to the number of fields in the corresponding array of structs.
- The order of the fields must match the order of the corresponding members of the array of structs.
- The datatype for all elements in the indicator struct must be **short**.
- The size of the indicator array must be at least the same size as the host variable declaration. It may be larger, but it may not be smaller.

Note that these rules generally reflect the rules for using structs as implemented in prior releases of Pro*C/C++. The array restriction is also the same as that previously used for arrays of scalars.

Given these rules, assume the following struct declaration:

```
struct department {
   int deptno;
   char dname[15];
   char loc[14];
} dept[4];
```

The following is a legal indicator variable struct declaration:

```
struct department_ind {
```

```
   short deptno_ind;
   short dname_ind;
   short loc_ind;
} dept_ind[4];
```

while the following is illegal as an indicator variable

```
struct{              /* missing indicator structure tag */
  int deptno_ind;    /* indicator variable not of type short */
  short dname_ind[15];/* array element forbidden in indicator struct */
  short loc_ind[14];  /* array element forbidden in indicator struct */
} bad_ind[2];     /* indicator array size is smaller than host array */
```

Declaring a Pointer to an Array of Structs

In some cases, it may be desirable to declare a pointer to an array of structs. This allows pointers to arrays of structs to be passed to other functions or used directly in an embedded SQL statement.

> **Note:** The length of the array referenced by a pointer to an array of structs cannot be known during precompilation. For this reason, an explicit FOR clause must be used when a bind variable whose type is a pointer to an array of structs is used in any embedded SQL statement.

Remember that FOR clauses may not be used in an embedded SQL SELECT statement. Therefore, to retrieve data into a pointer to an array of structs, an explicit cursor and FETCH statement must be used with the FOR clause.

Examples

The following examples demonstrate different uses of the array of structs functionality in Pro*C/C++.

Example 1, A Simple Array of Structs of Scalars

Given the following structure declaration,

```
struct department {
   int deptno;
   char dname[15];
   char loc[14];
} my_dept[4];
```

a user could then select the `dept` data into `my_dept` as follows:

```
exec sql select * into :my_dept from dept;
```

or the user could populate `my_dept` first and then bulk insert it into the `dept` table:

```
exec sql insert into dept values (:my_dept);
```

To use an indicator variable, a parallel indicator array of structs could be declared.

```
struct deptartment_ind {
   short deptno_ind;
   short dname_ind;
   short loc_ind;
} my_dept_ind[4];
```

Data is then be selected using the same query except for the addition of the indicator variable:

```
exec sql select * into :my_dept indicator :my_dept_ind from dept;
```

Similarly, the indicator could be used when inserting the data as well:

```
exec sql insert into dept values (:my_dept indicator :my_dept_ind);
```

Example 2, Using mixed scalar arrays with an array of structs

As in prior releases of Pro*C/C++, when using multiple arrays for bulk handling of user data, the size of the arrays must be the same. If they are not, the smallest array size is chosen leaving the remaining portions of the arrays unaffected.

Given the following declarations,

```
struct employee {
   int empno;
   char ename[11];
} emp[14];

float sal[14];
float comm[14];
```

it is possible to select multiple rows for all columns in one simple query:

```
exec sql select empno, ename, sal, comm into :emp, :sal, :comm from emp;
```

We also want to know whether the column values for the commissions are NULL or not. A single indicator array could be used given the following declaration:

```
short comm_ind[14];
...
exec sql select empno, ename, sal, comm
```

```
   into :emp, :sal, :comm indicator :comm_ind from emp;
```

Note that you could *not* declare a single indicator array of structs which encapsulated all indicator information from the query. Therefore:

```
struct employee_ind {   /* example of illegal usage */
   short empno_ind;
   short ename_ind;
   short sal_ind;
   short comm_ind;
} illegal_ind[15];

exec sql select empno, ename, sal, comm
   into :emp, :sal, :comm indicator :illegal_ind from emp;
```

is illegal (as well as undesirable). The above statement associates the indicator array with the `comm` column only, not the entire SELECT...INTO list.

Assuming the array of structs and the `sal`, `comm` and `comm_ind` arrays were populated with the desired data, insertion is straightforward:

```
exec sql insert into emp (empno, ename, sal, comm)
   values (:emp, :sal, :comm indicator :comm_ind);
```

Example 3, Using multiple arrays of structs with a cursor

For this example, we make the following declarations:

```
struct employee {
   int empno;
   char ename[11];
   char job[10];
} emp[14];

struct compensation {
   int sal;
   int comm;
} wage[14];

struct compensation_ind {
   short sal_ind;
   short comm_ind;
} wage_ind[14];
```

Our program could then make use of these arrays of structs as follows:

```
exec sql declare c cursor for
   select empno, ename, job, sal, comm from emp;

exec sql open c;

exec sql whenever not found do break;
while(1)
{
  exec sql fetch c into :emp, :wage indicator :wage_ind;
  ... process batch rows returned by the fetch ...
}

printf("%d rows selected.\n", sqlca.sqlerrd[2]);

exec sql close c;
```

Using the FOR clause Alternatively, we could have used the FOR clause to instruct the fetch on how many rows to retrieve. Recall that the FOR clause is prohibited when using the SELECT statement, but not the INSERT or FETCH statements.

We add the following to our original declarations

```
int limit = 10;
```

and code our example accordingly.

```
   exec sql for :limit
      fetch c into :emp, :wage indicator :wage_ind;
```

Example 4, Individual array and struct member referencing

Prior releases of Pro*C/C++ allowed array references to single structures in an array of structs. The following is therefore legal since the bind expression resolves to a simple struct of scalars.

```
exec sql select * into :dept[3] from emp;
```

Users can reference an individual scalar member of a specific struct in an array of structs as the following example shows.

```
exec sql select dname into :dept[3].dname from dept where ...;
```

Naturally, this requires that the query be a single row query so only one row is selected into the variable represented by this bind expression.

Example 5, Using indicator variables, a special case

Prior releases of Pro*C/C++ required that an indicator struct have the same number of fields as its associated bind struct. This restriction has been relaxed when using structs in general. By following the above guidelines for indicator arrays of structs it is possible to construct the following example.

```
struct employee {
    float comm;
    float sal;
    int empno;
    char ename[10];
} emp[14];

struct employee_ind {
    short comm;
} emp_ind[14];

exec sql select comm, sal, empno, ename
   into :emp indicator :emp_ind from emp;
```

The mapping of indicator variables to bind values is one-to-one. They map in associative sequential order starting with the first field.

Be aware, however, that if any of the other fields has a fetched value of NULL and no indicator is provided, the

```
ORA-1405: fetched column value is NULL
```

error will be raised. As an example, such is the case if `sal` was nullable because there is no indicator for `sal`.

Suppose we change the array of structs as follows,

```
struct employee {
   int empno;
   char ename[10];
   float sal;
   float comm;
} emp[15];
```

but still used the same indicator array of structs from above.

Because the indicators map in associative sequential order, the `comm` indicator maps to the `empno` field leaving the `comm` bind variable without an indicator once again leading to the ORA-1405 error.

Generally, to avoid the ORA-1405 when using indicator structs that have fewer fields than their associative bind variable structs, the nullable attributes should appear first and in sequential order.

Note that we could easily change this into a single-row fetch involving multiple columns by using non-array structs and expect it to work as though the indicator struct was declared as follows.

```
struct employee_ind {
   short comm;
   short sal;
   short empno;
   short ename;
} emp_ind;
```

Because Pro*C/C++ no longer requires that the indicator struct have the same number of fields as its associated value struct, the above example is now legal in Pro*C/C++ whereas previously it was not.

Our indicator struct could now look like the following simple struct.

```
struct employee_ind {
   short comm;
} emp_ind;
```

Using the non-array `emp` and `emp_ind` structs we are able to perform a single row fetch as follows.

```
exec sql fetch comm, sal, empno, ename
   into :emp indicator :emp_ind from emp;
```

Note once again how the `comm` indicator maps to the `comm` bind variable in this case as well.

Example 6, Using a Pointer to an Array of Structs

This example demonstrates how to use a pointer to an array of structs.

Given the following type declaration:

```
typedef struct dept {
   int deptno;
   char dname[15];
   char loc[14];
} dept;
```

we can perform a variety of things, manipulating a pointer to an array of structs of that type. For example, we can pass pointers to arrays of structs to other functions.

```
void insert_data(d, n)
   dept *d;
   int n;
{
    exec sql for :n insert into dept values (:d);
}

void fetch_data(d, n)
   dept *d;
   int n;
{
   exec sql declare c cursor for select deptno, dname, loc from dept;
   exec sql open c;
   exec sql for :n fetch c into :d;
   exec sql close c;
}
```

Such functions are invoked by passing the address of the array of structs as these examples indicate.

```
dept d[4];
dept *dptr = &d[0];
const int n = 4;

fetch_data(dptr, n);
insert_data(d, n); /* We are treating '&d[0]' as being equal to 'd' */
```

Or we can simply use such pointers to arrays of structs directly in some embedded SQL statement.

```
exec sql for :n insert into dept values (:dptr);
```

The most important thing to remember is the use of the FOR clause.

Mimicking CURRENT OF

You use the CURRENT OF *cursor* clause in a DELETE or UPDATE statement to refer to the latest row FETCHed from the cursor. (For more information, see "Using the CURRENT OF Clause" on page 5-16.) However, you cannot use CURRENT OF with host arrays. Instead, select the ROWID of each row, then use that value to identify the current row during the update or delete. An example follows:

```
char  emp_name[20][10];
```

```
char  job_title[20][10];
char  old_title[20][10];
char  row_id[20][18];
...
EXEC SQL DECLARE emp_cursor CURSOR FOR
SELECT ename, job, rowid FROM emp;
...
EXEC SQL OPEN emp_cursor;
EXEC SQL WHENEVER NOT FOUND do break;
for (;;)
{
    EXEC SQL FETCH emp_cursor
        INTO :emp_name, :job_title, :row_id;
    ...
    EXEC SQL DELETE FROM emp
        WHERE job = :old_title AND rowid = :row_id;
    EXEC SQL COMMIT WORK;
}
```

However, the fetched rows are *not* locked because no FOR UPDATE OF clause is used. (You cannot use FOR UPDATE OF without CURRENT OF.) So, you might get inconsistent results if another user changes a row after you read it but before you delete it.

Using *sqlca.sqlerrd[2]*

For INSERT, UPDATE, DELETE, and SELECT INTO statements, *sqlca.sqlerrd[2]* records the number of rows processed. For FETCH statements, it records the cumulative sum of rows processed.

When using host arrays with FETCH, to find the number of rows returned by the most recent iteration, subtract the current value of *sqlca.sqlerrd[2]* from its previous value (stored in another variable). In the following example, you determine the number of rows returned by the most recent fetch:

```
int  emp_number[100];
char emp_name[100][20];

int rows_to_fetch, rows_before, rows_this_time;
EXEC SQL DECLARE emp_cursor CURSOR FOR
    SELECT empno, ename
    FROM emp
    WHERE deptno = 30;
EXEC SQL OPEN emp_cursor;
EXEC SQL WHENEVER NOT FOUND CONTINUE;
```

```
/* initialize loop variables */
rows_to_fetch = 20;   /* number of rows in each "batch" */
rows_before = 0;      /* previous value of sqlerrd[2]  */
rows_this_time = 20;

while (rows_this_time == rows_to_fetch)
{
    EXEC SQL FOR :rows_to_fetch
    FETCH emp_cursor
        INTO :emp_number, :emp_name;
    rows_this_time = sqlca.sqlerrd[2] - rows_before;
    rows_before = sqlca.sqlerrd[2];
}
...
```

sqlca.sqlerrd[2] is also useful when an error occurs during an array operation. Processing stops at the row that caused the error, so *sqlerrd[2]* gives the number of rows processed successfully.

13

Using Dynamic SQL

This chapter shows you how to use dynamic SQL, an advanced programming technique that adds flexibility and functionality to your applications. After weighing the advantages and disadvantages of dynamic SQL, you learn four methods—from simple to complex—for writing programs that accept and process SQL statements "on the fly" at run time. You learn the requirements and limitations of each method and how to choose the right method for a given job.

Topics are:

- What Is Dynamic SQL?
- Advantages and Disadvantages of Dynamic SQL
- When to Use Dynamic SQL
- Requirements for Dynamic SQL Statements
- How Dynamic SQL Statements Are Processed
- Methods for Using Dynamic SQL
- Using Method 1
- Using Method 2
- Using Method 3
- Using Method 4
- Using the DECLARE STATEMENT Statement
- Using PL/SQL

What Is Dynamic SQL?

Most database applications do a specific job. For example, a simple program might prompt the user for an employee number, then update rows in the EMP and DEPT tables. In this case, you know the makeup of the UPDATE statement at precompile time. That is, you know which tables might be changed, the constraints defined for each table and column, which columns might be updated, and the datatype of each column.

However, some applications must accept (or build) and process a variety of SQL statements at run time. For example, a general-purpose report writer must build different SELECT statements for the various reports it generates. In this case, the statement's makeup is unknown until run time. Such statements can, and probably will, change from execution to execution. They are aptly called *dynamic* SQL statements.

Unlike static SQL statements, dynamic SQL statements are not embedded in your source program. Instead, they are stored in character strings input to or built by the program at run time. They can be entered interactively or read from a file.

Advantages and Disadvantages of Dynamic SQL

Host programs that accept and process dynamically defined SQL statements are more versatile than plain embedded SQL programs. Dynamic SQL statements can be built interactively with input from users having little or no knowledge of SQL.

For example, your program might simply prompt users for a search condition to be used in the WHERE clause of a SELECT, UPDATE, or DELETE statement. A more complex program might allow users to choose from menus listing SQL operations, table and view names, column names, and so on. Thus, dynamic SQL lets you write highly flexible applications.

However, some dynamic queries require complex coding, the use of special data structures, and more runtime processing. While you might not notice the added processing time, you might find the coding difficult unless you fully understand dynamic SQL concepts and methods.

When to Use Dynamic SQL

In practice, static SQL will meet nearly all your programming needs. Use dynamic SQL only if you need its open-ended flexibility. Its use is suggested when one of the following items is unknown at precompile time:

- text of the SQL statement (commands, clauses, and so on)

- the number of host variables
- the datatypes of host variables
- references to database objects such as columns, indexes, sequences, tables, usernames, and views

Requirements for Dynamic SQL Statements

To represent a dynamic SQL statement, a character string must contain the text of a valid SQL statement, but *not* contain the EXEC SQL clause, or the statement terminator, or any of the following embedded SQL commands:

- ALLOCATE
- CLOSE
- DECLARE
- DESCRIBE
- EXECUTE
- FETCH
- FREE
- GET
- INCLUDE
- OPEN
- PREPARE
- SET
- WHENEVER

In most cases, the character string can contain *dummy* host variables. They hold places in the SQL statement for actual host variables. Because dummy host variables are just placeholders, you do not declare them and can name them anything you like. For example, Oracle makes no distinction between the following two strings:

```
'DELETE FROM EMP WHERE MGR = :mgr_number AND JOB = :job_title'
'DELETE FROM EMP WHERE MGR = :m AND JOB = :j'
```

How Dynamic SQL Statements Are Processed

Typically, an application program prompts the user for the text of a SQL statement and the values of host variables used in the statement. Then Oracle *parses* the SQL statement. That is, Oracle examines the SQL statement to make sure it follows syntax rules and refers to valid database objects. Parsing also involves checking database access rights, reserving needed resources, and finding the optimal access path.

Next, Oracle *binds* the host variables to the SQL statement. That is, Oracle gets the addresses of the host variables so that it can read or write their values.

Then Oracle *executes* the SQL statement. That is, Oracle does what the SQL statement requested, such as deleting rows from a table.

The SQL statement can be executed repeatedly using new values for the host variables.

Methods for Using Dynamic SQL

This section introduces four methods you can use to define dynamic SQL statements. It briefly describes the capabilities and limitations of each method, then offers guidelines for choosing the right method. Later sections show you how to use the methods, and include sample programs that you can study.

The four methods are increasingly general. That is, Method 2 encompasses Method 1, Method 3 encompasses Methods 1 and 2, and so on. However, each method is most useful for handling a certain kind of SQL statement, as Table 13–1 shows:

Table 13–1 Methods for Using Dynamic SQL

Method	Kind of SQL Statement
1	non query without host variables
2	non query with known number of input host variables
3	query with known number of select-list items and input host variables
4	query with unknown number of select-list items or input host variables

Note: The term *select-list item* includes column names and expressions such as SAL * 1.10 and MAX(SAL).

Method 1

This method lets your program accept or build a dynamic SQL statement, then immediately execute it using the EXECUTE IMMEDIATE command. The SQL statement must not be a query (SELECT statement) and must not contain any placeholders for input host variables. For example, the following host strings qualify:

```
'DELETE FROM EMP WHERE DEPTNO = 20'
'GRANT SELECT ON EMP TO scott'
```

With Method 1, the SQL statement is parsed every time it is executed.

Method 2

This method lets your program accept or build a dynamic SQL statement, then process it using the PREPARE and EXECUTE commands. The SQL statement must not be a query. The number of placeholders for input host variables and the datatypes of the input host variables must be known at precompile time. For example, the following host strings fall into this category:

```
'INSERT INTO EMP (ENAME, JOB) VALUES (:emp_name, :job_title)'
'DELETE FROM EMP WHERE EMPNO = :emp_number'
```

With Method 2, the SQL statement is parsed just once, but can be executed many times with different values for the host variables. SQL data definition statements such as CREATE and GRANT are executed when they are PREPAREd.

Method 3

This method lets your program accept or build a dynamic query, then process it using the PREPARE command with the DECLARE, OPEN, FETCH, and CLOSE cursor commands. The number of select-list items, the number of placeholders for input host variables, and the datatypes of the input host variables must be known at precompile time. For example, the following host strings qualify:

```
'SELECT DEPTNO, MIN(SAL), MAX(SAL) FROM EMP GROUP BY DEPTNO'
'SELECT ENAME, EMPNO FROM EMP WHERE DEPTNO = :dept_number'
```

Method 4

This method lets your program accept or build a dynamic SQL statement, then process it using descriptors (discussed in the section "Using Method 4" on page 13-25). The number of select-list items, the number of placeholders for input host variables, and the datatypes of the input host variables can be unknown until run time. For example, the following host strings fall into this category:

```
'INSERT INTO EMP (<unknown>) VALUES (<unknown>)'
'SELECT <unknown> FROM EMP WHERE DEPTNO = 20'
```

Method 4 is required for dynamic SQL statements that contain an unknown number of select-list items or input host variables.

Guidelines

With all four methods, you must store the dynamic SQL statement in a character string, which must be a host variable or quoted literal. When you store the SQL statement in the string, omit the keywords EXEC SQL and the ';' statement terminator.

With Methods 2 and 3, the number of placeholders for input host variables and the datatypes of the input host variables must be known at precompile time.

Each succeeding method imposes fewer constraints on your application, but is more difficult to code. As a rule, use the simplest method you can. However, if a dynamic SQL statement will be executed repeatedly by Method 1, use Method 2 instead to avoid reparsing for each execution.

Method 4 provides maximum flexibility, but requires complex coding and a full understanding of dynamic SQL concepts. In general, use Method 4 only if you cannot use Methods 1, 2, or 3.

The decision logic in Figure 13–1 will help you choose the right method.

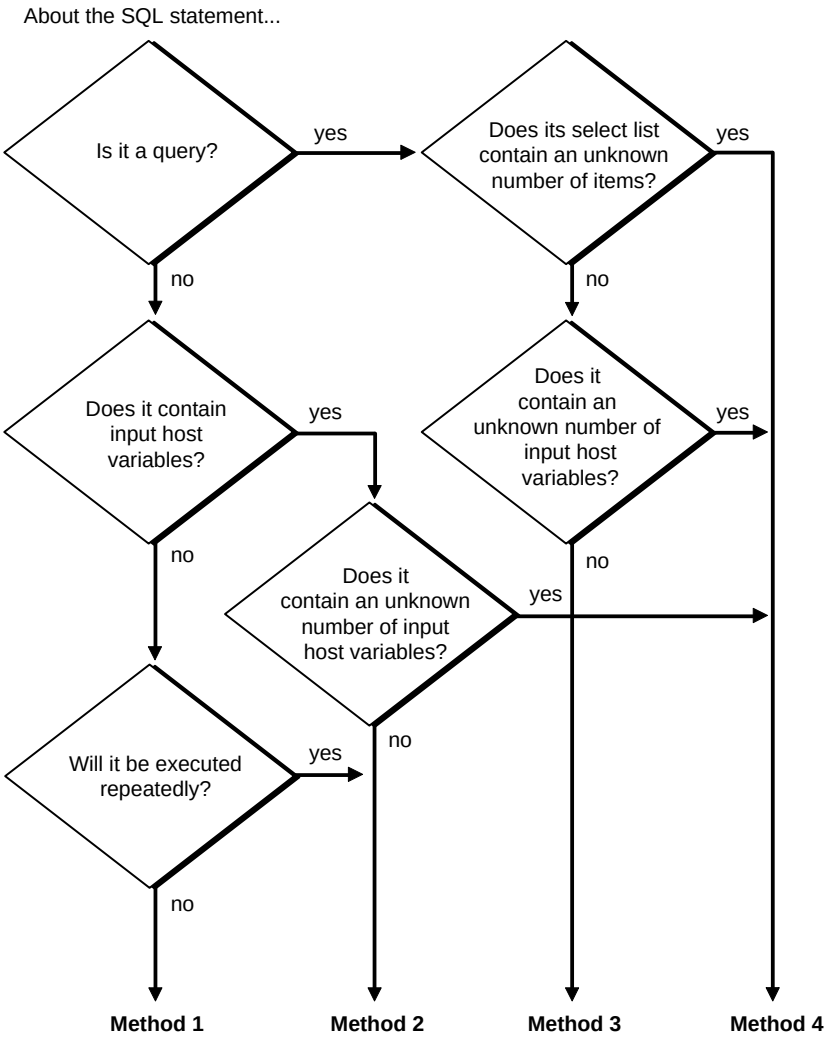
Avoiding Common Errors

If you precompile using the command-line option DBMS=V6 or DBMS=V6_CHAR, blank-pad the array before storing the SQL statement. That way, you clear extraneous characters. This is especially important when you reuse the array for different SQL statements. As a rule, always initialize (or re-initialize) the host string before storing the SQL statement. Do *not* null-terminate the host string. Oracle does not recognize the null terminator as an end-of-string sentinel. Instead, Oracle treats it as part of the SQL statement.

If you precompile with the command-line option DBMS=V8, make sure that the string is null terminated before you execute the PREPARE or EXECUTE IMMEDIATE statement.

Regardless of the value of DBMS, if you use a VARCHAR variable to store the dynamic SQL statement, make sure the length of the VARCHAR is set (or reset) correctly before you execute the PREPARE or EXECUTE IMMEDIATE statement.

Figure 13–1 Choosing the Right Method



Using Method 1

The simplest kind of dynamic SQL statement results only in “success” or “failure” and uses no host variables. Some examples follow:

```
'DELETE FROM table_name WHERE column_name = constant'
```

```
'CREATE TABLE table_name ...'
'DROP INDEX index_name'
'UPDATE table_name SET column_name = constant'
'GRANT SELECT ON table_name TO username'
'REVOKE RESOURCE FROM username'
```

Method 1 parses, then immediately executes the SQL statement using the EXECUTE IMMEDIATE command. The command is followed by a character string (host variable or literal) containing the SQL statement to be executed, which cannot be a query.

The syntax of the EXECUTE IMMEDIATE statement follows:

```
EXEC SQL EXECUTE IMMEDIATE { :host_string | string_literal };
```

In the following example, you use the host variable *dyn_stmt* to store SQL statements input by the user:

```
char dyn_stmt[132];
...
for (;;)
{
    printf("Enter SQL statement: ");
    gets(dyn_stmt);
    if (*dyn_stmt == '\0')
        break;
    /* dyn_stmt now contains the text of a SQL statement */
    EXEC SQL EXECUTE IMMEDIATE :dyn_stmt;
}
...
```

You can also use string literals, as the following example shows:

```
EXEC SQL EXECUTE IMMEDIATE 'REVOKE RESOURCE FROM MILLER';
```

Because EXECUTE IMMEDIATE parses the input SQL statement before every execution, Method 1 is best for statements that are executed only once. Data definition language statements usually fall into this category.

Sample Program: Dynamic SQL Method 1

The following program uses dynamic SQL Method 1 to create a table, insert a row, commit the insert, then drop the table. This program is available on-line in your demo directory in the file *sample6.pc*.

```
/*
```

```
 *  sample6.pc: Dynamic SQL Method 1
 *
 *  This program uses dynamic SQL Method 1 to create a table,
 *  insert a row, commit the insert, then drop the table.
 */

#include <stdio.h>
#include <string.h>

/* Include the SQL Communications Area, a structure through
 * which ORACLE makes runtime status information such as error
 * codes, warning flags, and diagnostic text available to the
 * program.
 */
#include <sqlca.h>

/* Include the ORACLE Communications Area, a structure through
 * which ORACLE makes additional runtime status information
 * available to the program.
 */
#include <oraca.h>

/* The ORACA=YES option must be specified to enable you
 * to use the ORACA.
 */

EXEC ORACLE OPTION (ORACA=YES);

/* Specifying the RELEASE_CURSOR=YES option instructs Pro*C
 * to release resources associated with embedded SQL
 * statements after they are executed.  This ensures that
 * ORACLE does not keep parse locks on tables after data
 * manipulation operations, so that subsequent data definition
 * operations on those tables do not result in a parse-lock
 * error.
 */

EXEC ORACLE OPTION (RELEASE_CURSOR=YES);

void dyn_error();


main()
{
/* Declare the program host variables. */
```

```
    char    *username = "SCOTT";
    char    *password = "TIGER";
    char    *dynstmt1;
    char     dynstmt2[10];
    VARCHAR  dynstmt3[80];

/* Call routine dyn_error() if an ORACLE error occurs. */

    EXEC SQL WHENEVER SQLERROR DO dyn_error("Oracle error:");

/* Save text of current SQL statement in the ORACA if an
 * error occurs.
 */
    oraca.orastxtf = ORASTFERR;

/* Connect to Oracle. */

    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    puts("\nConnected to ORACLE.\n");

/* Execute a string literal to create the table.  This
 * usage is actually not dynamic because the program does
 * not determine the SQL statement at run time.
 */
    puts("CREATE TABLE dyn1 (col1 VARCHAR2(4))");

    EXEC SQL EXECUTE IMMEDIATE
         "CREATE TABLE dyn1 (col1 VARCHAR2(4))";

/* Execute a string to insert a row.  The string must
 * be null-terminated.  This usage is dynamic because the
 * SQL statement is a string variable whose contents the
 * program can determine at run time.
 */
    dynstmt1 = "INSERT INTO DYN1 values ('TEST')";
    puts(dynstmt1);

    EXEC SQL EXECUTE IMMEDIATE :dynstmt1;

/* Execute a SQL statement in a string to commit the insert.
 * Pad the unused trailing portion of the array with spaces.
 * Do NOT null-terminate it.
 */
    strncpy(dynstmt2, "COMMIT    ", 10);
    printf("%.10s\n", dynstmt2);
```

```
    EXEC SQL EXECUTE IMMEDIATE :dynstmt2;

/* Execute a VARCHAR to drop the table.  Set the .len field
 * to the length of the .arr field.
 */
    strcpy(dynstmt3.arr, "DROP TABLE DYN1");
    dynstmt3.len = strlen(dynstmt3.arr);
    puts((char *) dynstmt3.arr);

    EXEC SQL EXECUTE IMMEDIATE :dynstmt3;

/* Commit any outstanding changes and disconnect from Oracle. */
    EXEC SQL COMMIT RELEASE;

    puts("\nHave a good day!\n");

    return 0;
}


void
dyn_error(msg)
char *msg;
{
/* This is the Oracle error handler.
 * Print diagnostic text containing the error message,
 * current SQL statement, and location of error.
 */
    printf("\n%.*s\n",
       sqlca.sqlerrm.sqlerrml, sqlca.sqlerrm.sqlerrmc);
    printf("in \"%.*s...\'\n",
        oraca.orastxt.orastxtl, oraca.orastxt.orastxtc);
    printf("on line %d of %.*s.\n\n",
        oraca.oraslnr, oraca.orasfnm.orasfnml,
        oraca.orasfnm.orasfnmc);

/* Disable Oracle error checking to avoid an infinite loop
 * should another error occur within this routine as a
 * result of the rollback.
 */
    EXEC SQL WHENEVER SQLERROR CONTINUE;

/* Roll back any pending changes and disconnect from Oracle. */
    EXEC SQL ROLLBACK RELEASE;
```

```
    exit(1);
}
```

Using Method 2

What Method 1 does in one step, Method 2 does in two. The dynamic SQL statement, which cannot be a query, is first PREPAREd (named and parsed), then EXECUTEd.

With Method 2, the SQL statement can contain placeholders for input host variables and indicator variables. You can PREPARE the SQL statement once, then EXECUTE it repeatedly using different values of the host variables. Furthermore, you need *not* rePREPARE the SQL statement after a COMMIT or ROLLBACK (unless you log off and reconnect).

Note that you can use EXECUTE for non-queries with Method 4.

The syntax of the PREPARE statement follows:

```
EXEC SQL PREPARE statement_name
     FROM { :host_string | string_literal };
```

PREPARE parses the SQL statement and gives it a name.

The *statement_name* is an identifier used by the precompiler, *not* a host or program variable, and should not be declared in the Declare Section. It simply designates the PREPAREd statement you want to EXECUTE.

The syntax of the EXECUTE statement is

```
EXEC SQL EXECUTE statement_name [USING host_variable_list];
```

where *host_variable_list* stands for the following syntax:

```
:host_variable1[:indicator1] [, host_variable2[:indicator2], ...]
```

EXECUTE executes the parsed SQL statement, using the values supplied for each input host variable.

In the following example, the input SQL statement contains the placeholder *n*:

```
...
int emp_number    INTEGER;
char delete_stmt[120], search_cond[40];;
...
strcpy(delete_stmt, "DELETE FROM EMP WHERE EMPNO = :n AND ");
```

```
printf("Complete the following statement's search condition--\n");
printf("%s\n", delete_stmt);
gets(search_cond);
strcat(delete_stmt, search_cond);

EXEC SQL PREPARE sql_stmt FROM :delete_stmt;
for (;;)
{

     printf("Enter employee number: ");
    gets(temp);
    emp_number = atoi(temp);
    if (emp_number == 0)
        break;
    EXEC SQL EXECUTE sql_stmt USING :emp_number;
}
...
```

With Method 2, you must know the datatypes of input host variables at precompile time. In the last example, *emp_number* was declared as an **int**. It could also have been declared as type **float**, or even a **char**, because Oracle supports all these datatype conversions to the internal Oracle NUMBER datatype.

The USING Clause

When the SQL statement is EXECUTEd, input host variables in the USING clause replace corresponding placeholders in the PREPAREd dynamic SQL statement.

Every placeholder in the PREPAREd dynamic SQL statement must correspond to a different host variable in the USING clause. So, if the same placeholder appears two or more times in the PREPAREd statement, each appearance must correspond to a host variable in the USING clause.

The names of the placeholders need not match the names of the host variables. However, the order of the placeholders in the PREPAREd dynamic SQL statement must match the order of corresponding host variables in the USING clause.

If one of the host variables in the USING clause is an array, all must be arrays.

To specify nulls, you can associate indicator variables with host variables in the USING clause. For more information, see "Using Indicator Variables" on page 5-3.

Sample Program: Dynamic SQL Method 2

The following program uses dynamic SQL Method 2 to insert two rows into the EMP table, then delete them. This program is available on-line in your demo directory, in the file *sample7.pc*.

```
/*
 *  sample7.pc: Dynamic SQL Method 2
 *
 *  This program uses dynamic SQL Method 2 to insert two rows into
 *  the EMP table, then delete them.
 */

#include <stdio.h>
#include <string.h>

#define USERNAME "SCOTT"
#define PASSWORD "TIGER"

/* Include the SQL Communications Area, a structure through
 * which ORACLE makes runtime status information such as error
 * codes, warning flags, and diagnostic text available to the
 * program.
 */
#include <sqlca.h>

/* Include the ORACLE Communications Area, a structure through
 * which ORACLE makes additional runtime status information
 * available to the program.
 */
#include <oraca.h>

/* The ORACA=YES option must be specified to enable use of
 * the ORACA.
 */
EXEC ORACLE OPTION (ORACA=YES);

char    *username = USERNAME;
char    *password = PASSWORD;
VARCHAR  dynstmt[80];
int      empno   = 1234;
int      deptno1 = 97;
int      deptno2 = 99;
```

```
/* Handle SQL runtime errors. */
void dyn_error();


main()
{
/* Call dyn_error() whenever an error occurs
 * processing an embedded SQL statement.
 */
    EXEC SQL WHENEVER SQLERROR DO dyn_error("Oracle error");

/* Save text of current SQL statement in the ORACA if an
 * error occurs.
 */
    oraca.orastxtf = ORASTFERR;

/* Connect to Oracle. */

    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    puts("\nConnected to Oracle.\n");

/* Assign a SQL statement to the VARCHAR dynstmt.  Both
 * the array and the length parts must be set properly.
 * Note that the statement contains two host-variable
 * placeholders, v1 and v2, for which actual input
 * host variables must be supplied at EXECUTE time.
 */
    strcpy(dynstmt.arr,
        "INSERT INTO EMP (EMPNO, DEPTNO) VALUES (:v1, :v2)");
    dynstmt.len = strlen(dynstmt.arr);

/* Display the SQL statement and its current input host
 * variables.
 */
    puts((char *) dynstmt.arr);
    printf("   v1 = %d,  v2 = %d\n", empno, deptno1);

/* The PREPARE statement associates a statement name with
 * a string containing a SQL statement.  The statement name
 * is a SQL identifier, not a host variable, and therefore
 * does not appear in the Declare Section.

 * A single statement name can be PREPAREd more than once,
 * optionally FROM a different string variable.
 */
```

```
    EXEC SQL PREPARE S FROM :dynstmt;

/* The EXECUTE statement executes a PREPAREd SQL statement
 * USING the specified input host variables, which are
 * substituted positionally for placeholders in the
 * PREPAREd statement.  For each occurrence of a
 * placeholder in the statement there must be a variable
 * in the USING clause.  That is, if a placeholder occurs
 * multiple times in the statement, the corresponding
 * variable must appear multiple times in the USING clause.
 * The USING clause can be omitted only if the statement
 * contains no placeholders.
 *
 * A single PREPAREd statement can be EXECUTEd more
 * than once, optionally USING different input host
 * variables.
 */
    EXEC SQL EXECUTE S USING :empno, :deptno1;

/* Increment empno and display new input host variables. */

    empno++;
    printf("   v1 = %d,  v2 = %d\n", empno, deptno2);

/* ReEXECUTE S to insert the new value of empno and a
 * different input host variable, deptno2.
 * A rePREPARE is unnecessary.
 */
    EXEC SQL EXECUTE S USING :empno, :deptno2;

/* Assign a new value to dynstmt. */

    strcpy(dynstmt.arr,
        "DELETE FROM EMP WHERE DEPTNO = :v1 OR DEPTNO = :v2");
    dynstmt.len = strlen(dynstmt.arr);

/* Display the new SQL statement and its current input host
 * variables.
 */
    puts((char *) dynstmt.arr);
    printf("   v1 = %d,    v2 = %d\n", deptno1, deptno2);

/* RePREPARE S FROM the new dynstmt. */

    EXEC SQL PREPARE S FROM :dynstmt;
```

```
/* EXECUTE the new S to delete the two rows previously
 * inserted.
 */
    EXEC SQL EXECUTE S USING :deptno1, :deptno2;

/* Commit any pending changes and disconnect from Oracle. */

    EXEC SQL COMMIT RELEASE;
    puts("\nHave a good day!\n");
    exit(0);
}


void
dyn_error(msg)
char *msg;
{
/* This is the ORACLE error handler.
 * Print diagnostic text containing error message,
 * current SQL statement, and location of error.
 */
    printf("\n%s", msg);
    printf("\n%.*s\n",
        sqlca.sqlerrm.sqlerrml, sqlca.sqlerrm.sqlerrmc);
    printf("in \"%.*s...\"\n",
        oraca.orastxt.orastxtl, oraca.orastxt.orastxtc);
    printf("on line %d of %.*s.\n\n",
        oraca.oraslnr, oraca.orasfnm.orasfnml,
        oraca.orasfnm.orasfnmc);

/* Disable ORACLE error checking to avoid an infinite loop
 * should another error occur within this routine.
 */
    EXEC SQL WHENEVER SQLERROR CONTINUE;

/* Roll back any pending changes and
 * disconnect from Oracle.
 */
    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

Using Method 3

Method 3 is similar to Method 2 but combines the PREPARE statement with the statements needed to define and manipulate a cursor. This allows your program to accept and process queries. In fact, if the dynamic SQL statement is a query, you *must* use Method 3 or 4.

For Method 3, the number of columns in the query select list and the number of placeholders for input host variables must be known at precompile time. However, the names of database objects such as tables and columns need not be specified until run time. Names of database objects cannot be host variables. Clauses that limit, group, and sort query results (such as WHERE, GROUP BY, and ORDER BY) can also be specified at run time.

With Method 3, you use the following sequence of embedded SQL statements:

```
PREPARE statement_name FROM { :host_string | string_literal };
DECLARE cursor_name CURSOR FOR statement_name;
OPEN cursor_name [USING host_variable_list];
FETCH cursor_name INTO host_variable_list;
CLOSE cursor_name;
```

Now let's look at what each statement does.

PREPARE

PREPARE parses the dynamic SQL statement and gives it a name. In the following example, PREPARE parses the query stored in the character string *select_stmt* and gives it the name *sql_stmt*:

```
char select_stmt[132] =
     "SELECT MGR, JOB FROM EMP WHERE SAL < :salary";
EXEC SQL PREPARE sql_stmt FROM :select_stmt;
```

Commonly, the query WHERE clause is input from a terminal at run time or is generated by the application.

The identifier *sql_stmt* is *not* a host or program variable, but must be unique. It designates a particular dynamic SQL statement.

DECLARE

DECLARE defines a cursor by giving it a name and associating it with a specific query. Continuing our example, DECLARE defines a cursor named *emp_cursor* and associates it with *sql_stmt*, as follows:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR sql_stmt;
```

The identifiers *sql_stmt* and *emp_cursor* are *not* host or program variables, but must be unique. If you declare two cursors using the same statement name, the precompiler considers the two cursor names synonymous.

For example, if you execute the statements

```
EXEC SQL PREPARE sql_stmt FROM :select_stmt;
EXEC SQL DECLARE emp_cursor FOR sql_stmt;
EXEC SQL PREPARE sql_stmt FROM :delete_stmt;
EXEC SQL DECLARE dept_cursor FOR sql_stmt;
```

when you OPEN *emp_cursor*, you will process the dynamic SQL statement stored in *delete_stmt*, not the one stored in *select_stmt*.

OPEN

OPEN allocates an Oracle cursor, binds input host variables, and executes the query, identifying its active set. OPEN also positions the cursor on the first row in the active set and zeroes the rows-processed count kept by the third element of *sqlerrd* in the SQLCA. Input host variables in the USING clause replace corresponding placeholders in the PREPAREd dynamic SQL statement.

In our example, OPEN allocates *emp_cursor* and assigns the host variable *salary* to the WHERE clause, as follows:

```
EXEC SQL OPEN emp_cursor USING :salary;
```

FETCH

FETCH returns a row from the active set, assigns column values in the select list to corresponding host variables in the INTO clause, and advances the cursor to the next row. If there are no more rows, FETCH returns the “no data found" Oracle error code to *sqlca.sqlcode*.

In our example, FETCH returns a row from the active set and assigns the values of columns MGR and JOB to host variables *mgr_number* and *job_title*, as follows:

```
EXEC SQL FETCH emp_cursor INTO :mgr_number, :job_title;
```

CLOSE

CLOSE disables the cursor. Once you CLOSE a cursor, you can no longer FETCH from it.

In our example, CLOSE disables *emp_cursor*, as follows:

```
EXEC SQL CLOSE emp_cursor;
```

Sample Program: Dynamic SQL Method 3

The following program uses dynamic SQL Method 3 to retrieve the names of all employees in a given department from the EMP table. This program is available on-line in your demo directory, in the file *sample8.pc*

```
/*
 *  sample8.pc:  Dynamic SQL Method 3
 *
 *  This program uses dynamic SQL Method 3 to retrieve the names
 *  of all employees in a given department from the EMP table.
 */

#include <stdio.h>
#include <string.h>

#define USERNAME "SCOTT"
#define PASSWORD "TIGER"

/* Include the SQL Communications Area, a structure through
 * which ORACLE makes runtime status information such as error
 * codes, warning flags, and diagnostic text available to the
 * program. Also include the ORACA.
 */
#include <sqlca.h>
#include <oraca.h>

/* The ORACA=YES option must be specified to enable use of
 * the ORACA.
 */
EXEC ORACLE OPTION (ORACA=YES);

char    *username = USERNAME;
char    *password = PASSWORD;
VARCHAR  dynstmt[80];
VARCHAR  ename[10];
int      deptno = 10;

void dyn_error();
```

```
main()
{
/* Call dyn_error() function on any error in
 * an embedded SQL statement.
 */
    EXEC SQL WHENEVER SQLERROR DO dyn_error("Oracle error");

/* Save text of SQL current statement in the ORACA if an
 * error occurs.
 */
    oraca.orastxtf = ORASTFERR;

/* Connect to Oracle. */

    EXEC SQL CONNECT :username IDENTIFIED BY :password;
    puts("\nConnected to Oracle.\n");

/* Assign a SQL query to the VARCHAR dynstmt.  Both the
 * array and the length parts must be set properly.  Note
 * that the query contains one host-variable placeholder,
 * v1, for which an actual input host variable must be
 * supplied at OPEN time.
 */
    strcpy(dynstmt.arr,
        "SELECT ename FROM emp WHERE deptno = :v1");
    dynstmt.len = strlen(dynstmt.arr);

/* Display the SQL statement and its current input host
 * variable.
 */
    puts((char *) dynstmt.arr);
    printf("   v1 = %d\n", deptno);
    printf("\nEmployee\n");
    printf("--------\n");

/* The PREPARE statement associates a statement name with
 * a string containing a SELECT statement.  The statement
 * name is a SQL identifier, not a host variable, and
 * therefore does not appear in the Declare Section.

 * A single statement name can be PREPAREd more than once,
 * optionally FROM a different string variable.
 */
```

```
    EXEC SQL PREPARE S FROM :dynstmt;

/* The DECLARE statement associates a cursor with a
 * PREPAREd statement.  The cursor name, like the statement
 * name, does not appear in the Declare Section.

 * A single cursor name can not be DECLAREd more than once.
 */
    EXEC SQL DECLARE C CURSOR FOR S;

/* The OPEN statement evaluates the active set of the
 * PREPAREd query USING the specified input host variables,
 * which are substituted positionally for placeholders in
 * the PREPAREd query.  For each occurrence of a
 * placeholder in the statement there must be a variable
 * in the USING clause.  That is, if a placeholder occurs
 * multiple times in the statement, the corresponding
 * variable must appear multiple times in the USING clause.

 * The USING clause can be omitted only if the statement
 * contains no placeholders.  OPEN places the cursor at the
 * first row of the active set in preparation for a FETCH.

 * A single DECLAREd cursor can be OPENed more than once,
 * optionally USING different input host variables.
 */
    EXEC SQL OPEN C USING :deptno;

/* Break the loop when all data have been retrieved. */

    EXEC SQL WHENEVER NOT FOUND DO break;

/* Loop until the NOT FOUND condition is detected. */

    for (;;)
    {
/* The FETCH statement places the select list of the
 * current row into the variables specified by the INTO
 * clause, then advances the cursor to the next row.  If
 * there are more select-list fields than output host
 * variables, the extra fields will not be returned.
 * Specifying more output host variables than select-list
 * fields results in an ORACLE error.
 */
       EXEC SQL FETCH C INTO :ename;
```

```
/* Null-terminate the array before output. */
        ename.arr[ename.len] = '\0';
        puts((char *) ename.arr);
        }

/* Print the cumulative number of rows processed by the
 * current SQL statement.
 */
    printf("\nQuery returned %d row%s.\n\n", sqlca.sqlerrd[2],
        (sqlca.sqlerrd[2] == 1) ? "" : "s");

/* The CLOSE statement releases resources associated with
 * the cursor.
 */
    EXEC SQL CLOSE C;

/* Commit any pending changes and disconnect from Oracle. */
    EXEC SQL COMMIT RELEASE;
    puts("Sayonara.\n");
    exit(0);
}

void
dyn_error(msg)
char *msg;
{
    printf("\n%s", msg);
    sqlca.sqlerrm.sqlerrmc[sqlca.sqlerrm.sqlerrml] = '\0';
    oraca.orastxt.orastxtc[oraca.orastxt.orastxtl] = '\0';
    oraca.orasfnm.orasfnmc[oraca.orasfnm.orasfnml] = '\0';
    printf("\n%s\n", sqlca.sqlerrm.sqlerrmc);
    printf("in \"%s...\"\n", oraca.orastxt.orastxtc);
    printf("on line %d of %s.\n\n", oraca.oraslnr,
       oraca.orasfnm.orasfnmc);

/* Disable ORACLE error checking to avoid an infinite loop
 * should another error occur within this routine.
 */
    EXEC SQL WHENEVER SQLERROR CONTINUE;

/* Release resources associated with the cursor. */
    EXEC SQL CLOSE C;

/* Roll back any pending changes and disconnect from Oracle. */
```

```
    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

Using Method 4

This section gives an overview of dynamic SQL Method 4. For complete details, see Chapter 14, "Using Dynamic SQL: Advanced Concepts".

There is a kind of dynamic SQL statement that your program cannot process using Method 3. When the number of select-list items or placeholders for input host variables is unknown until run time, your program must use a descriptor. A *descriptor* is an area of memory used by your program and Oracle to hold a complete description of the variables in a dynamic SQL statement.

Recall that for a multirow query, you FETCH selected column values INTO a list of declared output host variables. If the select list is unknown, the host-variable list cannot be established at precompile time by the INTO clause. For example, you know the following query returns two column values:

```
SELECT ename, empno FROM emp WHERE deptno = :dept_number;
```

However, if you let the user define the select list, you might not know how many column values the query will return.

Need for the SQLDA

To process this kind of dynamic query, your program must issue the DESCRIBE SELECT LIST command and declare a data structure called the SQL Descriptor Area (SQLDA). Because it holds descriptions of columns in the query select list, this structure is also called a *select descriptor*.

Likewise, if a dynamic SQL statement contains an unknown number of placeholders for input host variables, the host-variable list cannot be established at precompile time by the USING clause.

To process the dynamic SQL statement, your program must issue the DESCRIBE BIND VARIABLES command and declare another kind of SQLDA called a *bind descriptor* to hold descriptions of the placeholders for input host variables. (Input host variables are also called *bind variables*.)

If your program has more than one active SQL statement (it might have OPENed two or more cursors, for example), each statement must have its own SQLDA(s). However, non-concurrent cursors can reuse SQLDAs. There is no set limit on the number of SQLDAs in a program.

The DESCRIBE Statement

DESCRIBE initializes a descriptor to hold descriptions of select-list items or input host variables.

If you supply a select descriptor, the DESCRIBE SELECT LIST statement examines each select-list item in a PREPAREd dynamic query to determine its name, datatype, constraints, length, scale, and precision. It then stores this information in the select descriptor.

If you supply a bind descriptor, the DESCRIBE BIND VARIABLES statement examines each placeholder in a PREPAREd dynamic SQL statement to determine its name, length, and the datatype of its associated input host variable. It then stores this information in the bind descriptor for your use. For example, you might use placeholder names to prompt the user for the values of input host variables.

What Is a SQLDA?

A SQLDA is a host-program data structure that holds descriptions of select-list items or input host variables.

SQLDA variables are *not* defined in the Declare Section.

The select SQLDA contains the following information about a query select list:

- maximum number of columns that can be DESCRIBEd
- actual number of columns found by DESCRIBE
- addresses of buffers to store column values
- lengths of column values
- datatypes of column values
- addresses of indicator-variable values
- addresses of buffers to store column names
- sizes of buffers to store column names
- current lengths of column names

The bind SQLDA contains the following information about the input host variables in a SQL statement:

- maximum number of placeholders that can be DESCRIBEd
- actual number of placeholders found by DESCRIBE
- addresses of input host variables

- lengths of input host variables
- datatypes of input host variables
- addresses of indicator variables
- addresses of buffers to store placeholder names
- sizes of buffers to store placeholder names
- current lengths of placeholder names
- addresses of buffers to store indicator-variable names
- sizes of buffers to store indicator-variable names
- current lengths of indicator-variable names

The SQLDA structure and variable names are defined in Chapter 14, "Using Dynamic SQL: Advanced Concepts"

Implementing Method 4

With Method 4, you generally use the following sequence of embedded SQL statements:

```
EXEC SQL PREPARE statement_name
     FROM { :host_string | string_literal };
EXEC SQL DECLARE cursor_name CURSOR FOR statement_name;
EXEC SQL DESCRIBE BIND VARIABLES FOR statement_name
     INTO bind_descriptor_name;
EXEC SQL OPEN cursor_name
     [USING DESCRIPTOR bind_descriptor_name];
EXEC SQL DESCRIBE [SELECT LIST FOR] statement_name
     INTO select_descriptor_name;
EXEC SQL FETCH cursor_name
     USING DESCRIPTOR select_descriptor_name;
EXEC SQL CLOSE cursor_name;
```

However, select and bind descriptors need not work in tandem. So, if the number of columns in a query select list is known, but the number of placeholders for input host variables is unknown, you can use the Method 4 OPEN statement with the following Method 3 FETCH statement:

```
EXEC SQL FETCH emp_cursor INTO host_variable_list;
```

Conversely, if the number of placeholders for input host variables is known, but the number of columns in the select list is unknown, you can use the Method 3 OPEN statement

```
EXEC SQL OPEN cursor_name [USING host_variable_list];
```

with the Method 4 FETCH statement.

Note that EXECUTE can be used for nonqueries with Method 4.

Restriction

In dynamic SQL Method 4, you cannot bind a host array to a PL/SQL procedure with a parameter of type "table."

Using the DECLARE STATEMENT Statement

With Methods 2, 3, and 4, you might need to use the statement

```
EXEC SQL [AT db_name] DECLARE statement_name STATEMENT;
```

where *db_name* and *statement_name* are identifiers used by the precompiler, *not* host or program variables.

DECLARE STATEMENT declares the name of a dynamic SQL statement so that the statement can be referenced by PREPARE, EXECUTE, DECLARE CURSOR, and DESCRIBE. It is required if you want to execute the dynamic SQL statement at a non-default database. An example using Method 2 follows:

```
EXEC SQL AT remote_db DECLARE sql_stmt STATEMENT;
EXEC SQL PREPARE sql_stmt FROM :dyn_string;
EXEC SQL EXECUTE sql_stmt;
```

In the example, *remote_db* tells Oracle where to EXECUTE the SQL statement.

With Methods 3 and 4, DECLARE STATEMENT is also required if the DECLARE CURSOR statement precedes the PREPARE statement, as shown in the following example:

```
EXEC SQL DECLARE sql_stmt STATEMENT;
EXEC SQL DECLARE emp_cursor CURSOR FOR sql_stmt;
EXEC SQL PREPARE sql_stmt FROM :dyn_string;
```

The usual sequence of statements is

```
EXEC SQL PREPARE sql_stmt FROM :dyn_string;
EXEC SQL DECLARE emp_cursor CURSOR FOR sql_stmt;
```

Using Host Arrays

The use of host arrays in static SQL and dynamic SQL is similar. For example, to use input host arrays with dynamic SQL Method 2, simply use the syntax

```
EXEC SQL EXECUTE statement_name USING host_array_list;
```

where *host_array_list* contains one or more host arrays.

Similarly, to use input host arrays with Method 3, use the following syntax:

```
OPEN cursor_name USING host_array_list;
```

To use output host arrays with Method 3, use the following syntax:

```
FETCH cursor_name INTO host_array_list;
```

With Method 4, you must use the optional FOR clause to tell Oracle the size of your input or output host array. This is described in Chapter 14, "Using Dynamic SQL: Advanced Concepts".

Using PL/SQL

The Pro*C/C++ Precompiler treats a PL/SQL block like a single SQL statement. So, like a SQL statement, a PL/SQL block can be stored in a string host variable or literal. When you store the PL/SQL block in the string, omit the keywords EXEC SQL EXECUTE, the keyword END-EXEC, and the ';' statement terminator.

However, there are two differences in the way the precompiler handles SQL and PL/SQL:

- The precompiler treats all PL/SQL host variables as *input* host variables whether they serve as input or output host variables (or both) inside the PL/SQL block.
- You cannot FETCH from a PL/SQL block because it might contain any number of SQL statements.

With Method 1

If the PL/SQL block contains no host variables, you can use Method 1 to EXECUTE the PL/SQL string in the usual way.

With Method 2

If the PL/SQL block contains a known number of input and output host variables, you can use Method 2 to PREPARE and EXECUTE the PL/SQL string in the usual way.

You must put *all* host variables in the USING clause. When the PL/SQL string is EXECUTEd, host variables in the USING clause replace corresponding placeholders in the PREPAREd string. Though the precompiler treats all PL/SQL host variables as input host variables, values are assigned correctly. Input (program) values are assigned to input host variables, and output (column) values are assigned to output host variables.

Every placeholder in the PREPAREd PL/SQL string must correspond to a host variable in the USING clause. So, if the same placeholder appears two or more times in the PREPAREd string, each appearance must correspond to a host variable in the USING clause.

With Method 3

Methods 2 and 3 are the same except that Method 3 allows FETCHing. Since you cannot FETCH from a PL/SQL block, just use Method 2 instead.

With Method 4

If the PL/SQL block contains an unknown number of input or output host variables, you must use Method 4.

To use Method 4, you set up one bind descriptor for all the input and output host variables. Executing DESCRIBE BIND VARIABLES stores information about input *and* output host variables in the bind descriptor. Because the precompiler treats all PL/SQL host variables as input host variables, executing DESCRIBE SELECT LIST has no effect.

> **Warning:** In dynamic SQL Method 4, you cannot bind a host array to a PL/SQL procedure with a parameter of type “table.”

The use of bind descriptors with Method 4 is detailed in Chapter 14, “Using Dynamic SQL: Advanced Concepts”.

Caution

Do not use ANSI-style Comments (- -) in a PL/SQL block that will be processed dynamically because end-of-line characters are ignored. As a result, ANSI-style

Comments extend to the end of the block, not just to the end of a line. Instead, use C-style Comments (/* ... */).

14

Using Dynamic SQL: Advanced Concepts

This chapter shows you how to implement dynamic SQL Method 4, which lets your program accept or build dynamic SQL statements that contain a varying number of host variables. Subjects discussed include the following:

- Meeting the Special Requirements of Method 4
- Understanding the SQLDA
- Using the SQLDA Variables
- Some Preliminaries
- The Basic Steps
- A Closer Look at Each Step
- Sample Program: Dynamic SQL Method 4

Note: For a discussion of dynamic SQL Methods 1, 2, and 3, and an overview of Method 4, see Chapter 13, “Using Dynamic SQL”.

Meeting the Special Requirements of Method 4

Before looking into the requirements of Method 4, you should feel comfortable with the terms *select-list item* and *placeholder*. Select-list items are the columns or expressions following the keyword SELECT in a query. For example, the following dynamic query contains three select-list items:

```
SELECT ename, job, sal + comm FROM emp WHERE deptno = 20
```

Placeholders are dummy bind variables that hold places in a SQL statement for actual bind variables. You do not declare placeholders, and can name them anything you like.

Placeholders for bind variables are most often used in the SET, VALUES, and WHERE clauses. For example, the following dynamic SQL statements each contain two placeholders:

```
INSERT INTO emp (empno, deptno) VALUES (:e, :d)
DELETE FROM dept WHERE deptno = :num OR loc = :loc
```

What Makes Method 4 Special?

Unlike Methods 1, 2, and 3, dynamic SQL Method 4 lets your program

- accept or build dynamic SQL statements that contain an unknown number of select-list items or placeholders, and
- take explicit control over datatype conversion between Oracle and C types

To add this flexibility to your program, you must give the Oracle runtime library additional information.

What Information Does Oracle Need?

The Pro*C/C++ Precompiler generates calls to Oracle for all executable dynamic SQL statements. If a dynamic SQL statement contains no select-list items or placeholders, Oracle needs no additional information to execute the statement. The following DELETE statement falls into this category:

```
DELETE FROM emp WHERE deptno = 30
```

However, most dynamic SQL statements contain select-list items or placeholders for bind variables, as does the following

UPDATE statement:

```
UPDATE emp SET comm = :c WHERE empno = :e
```

To execute a dynamic SQL statement that contains placeholders for bind variables or select-list items, Oracle needs information about the program variables that hold the input (bind) values, and that will hold the FETCHed values when a query is executed. The information needed by Oracle is:

- the number of bind variables and select-list items
- the length of each bind variable and select-list item
- the datatype of each bind variable and select-list item
- the address of each bind variable, and of the output variable that will receive each select-list item

Where Is the Information Stored?

All the information Oracle needs about select-list items or placeholders for bind variables, except their values, is stored in a program data structure called the SQL Descriptor Area (SQLDA). The SQLDA struct is defined in the *sqlda.h* header file.

Descriptions of select-list items are stored in a *select descriptor*, and descriptions of placeholders for bind variables are stored in a *bind descriptor*.

The values of select-list items are stored in output variables; the values of bind variables are stored in input variables. You store the addresses of these variables in the select or bind SQLDA so that Oracle knows where to write output values and read input values.

How do values get stored in these data variables? Output values are FETCHed using a cursor, and input values are typically filled in by the program, usually from information entered interactively by the user.

How is the SQLDA Referenced?

The bind and select descriptors are usually referenced by pointer. A dynamic SQL program should declare a pointer to at least one bind descriptor, and a pointer to at least one select descriptor, in the following way:

```
#include <sqlda.h>
...
SQLDA *bind_dp;
SQLDA *select_dp;
```

You can then use the *SQLSQLDAAlloc()* function to allocate the descriptor, as follows:

```
bind_dp = SQLSQLDAAlloc(runtime_context, size, name_length, ind_name_length);
```

SQLSQLDAAlloc() was known as sqlaldt() before Oracle8.

The constant SQL_SINGLE_RCTX is defined as (dvoid*)0. Use it for *runtime_context* when your application is single-threaded.

See Table 4–2 for information on this and other SQLLIB functions. See the section "Allocating a SQLDA" on page 14-5 for detailed information about *SQLSQLDAAlloc()* and its parameters.

How is the Information Obtained?

You use the DESCRIBE statement to help obtain the information Oracle needs.

The DESCRIBE SELECT LIST statement examines each select-list item to determine its name and name length. It then stores this information in the select SQLDA for your use. For example, you might use select-list names as column headings in a printout. The total number of select-list items is also stored in the SQLDA by DESCRIBE.

The DESCRIBE BIND VARIABLES statement examines each placeholder to determine its name and length, then stores this information in an input buffer and bind SQLDA for your use. For example, you might use placeholder names to prompt the user for the values of bind variables.

Understanding the SQLDA

This section describes the SQLDA data structure in detail. You learn how to declare it, what variables it contains, how to initialize them, and how to use them in your program.

Purpose of the SQLDA

Method 4 is required for dynamic SQL statements that contain an unknown number of select-list items or placeholders for bind variables. To process this kind of dynamic SQL statement, your program must explicitly declare SQLDAs, also called *descriptors*. Each descriptor is a **struct** which you must copy or hardcode into your program.

A *select descriptor* holds descriptions of select-list items, and the addresses of output buffers where the names and values of select-list items are stored.

> **Note:** The “name" of a select-list item can be a column name, a column alias, or the text of an expression such as *sal + comm*.

A *bind descriptor* holds descriptions of bind variables and indicator variables, and the addresses of input buffers where the names and values of bind variables and indicator variables are stored.

Multiple SQLDAs

If your program has more than one active dynamic SQL statement, each statement must have its own SQLDA(s). You can declare any number of SQLDAs with different names. For example, you might declare three select SQLDAs named *sel_desc1*, *sel_desc2*, and *sel_desc3*, so that you can FETCH from three concurrently OPEN cursors. However, non-concurrent cursors can reuse SQLDAs.

Declaring a SQLDA

To declare a SQLDA, include the *sqlda.h* header file. The contents of the SQLDA are

```
struct SQLDA
{
    long    N;          /* Descriptor size in number of entries */
    char  **V;        Ptr to Arr of addresses of main variables */
    long   *L;              /* Ptr to Arr of lengths of buffers */
    short  *T;                /* Ptr to Arr of types of buffers */
    short **I;      * Ptr to Arr of addresses of indicator vars */
    long    F;         /* Number of variables found by DESCRIBE */
    char  **S;          /* Ptr to Arr of variable name pointers */
    short  *M;       /* Ptr to Arr of max lengths of var. names */
    short  *C;    * Ptr to Arr of current lengths of var. names */
    char  **X;         /* Ptr to Arr of ind. var. name pointers */
    short  *Y;  /* Ptr to Arr of max lengths of ind. var. names */
    short  *Z;  /* Ptr to Arr of cur lengths of ind. var. names */
};
```

Allocating a SQLDA

After declaring a SQLDA, you allocate storage space for it with the *SQLSQLDAAlloc()* library function (known as *sqlaldt()* before Oracle8), using the syntax

```
descriptor_name = SQLSQLDAAlloc (runtime_context, max_vars, max_name,
max_ind_name);
```

where:

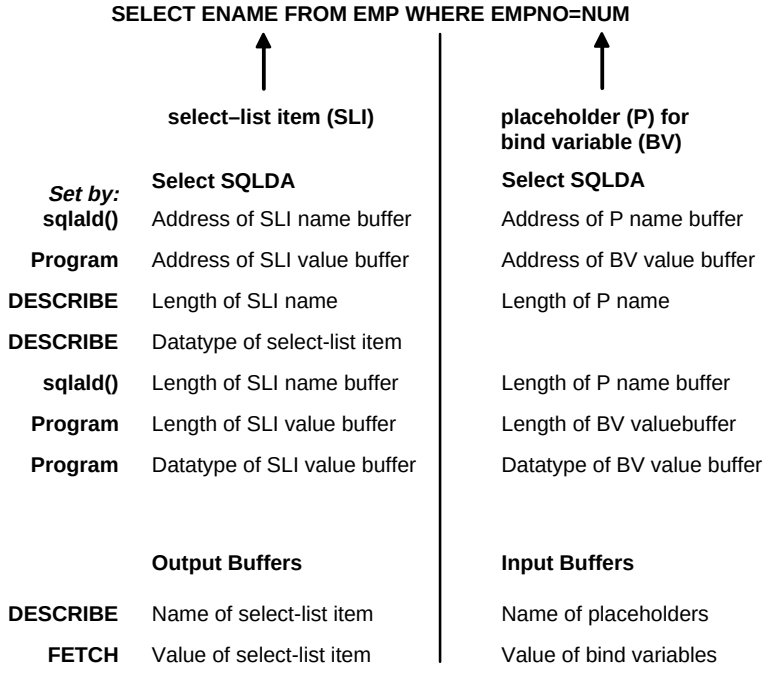
runtime_context	pointer to runtime context
max_vars	Is the maximum number of select-list items or placeholders that the descriptor can describe.
max_name	Is the maximum length of select-list or placeholder names.
max_ind_name	Is the maximum length of indicator variable names, which are optionally appended to placeholder names. This parameter applies to bind descriptors only, so set it to zero when allocating a select descriptor.

Besides the descriptor, SQLSQLDAAlloc*()* allocates data buffers to which descriptor variables point.

For more information about *SQLSQLDAAlloc()*, see "Using the SQLDA Variables" on page 14-7 and "Allocate Storage Space for the Descriptors" on page 14-21.

Figure 14–1 shows whether variables are set by *SQLSQLDAAlloc()* calls, DESCRIBE commands, FETCH commands, or program assignments.

Figure 14–1 How Variables Are Set



Using the SQLDA Variables

This section explains the purpose and use of each variable in the SQLDA.

The *N* Variable

N specifies the maximum number of select-list items or placeholders that can be DESCRIBEd. Thus, *N* determines the number of elements in the descriptor arrays.

Before issuing the optional DESCRIBE command, you must set *N* to the dimension of the descriptor arrays using the *SQLSQLDAAlloc()* library function. After the DESCRIBE, you must reset *N* to the actual number of variables DESCRIBEd, which is stored in the *F* variable.

The *V* Variable

V is a pointer to an array of addresses of data buffers that store select-list or bind-variable values.

When you allocate the descriptor, *SQLSQLDAAlloc()* zeros the elements *V[0]* through *V[N - 1]* in the array of addresses.

For select descriptors, you must allocate data buffers and set this array before issuing the FETCH command. The statement

```
EXEC SQL FETCH ... USING DESCRIPTOR ...
```

directs Oracle to store FETCHed select-list values in the data buffers to which *V[0]* through *V[N - 1]* point. Oracle stores the *i*th select-list value in the data buffer to which *V[i]* points.

For bind descriptors, you must set this array before issuing the OPEN command. The statement

```
EXEC SQL OPEN ... USING DESCRIPTOR ...
```

directs Oracle to execute the dynamic SQL statement using the bind-variable values to which *V[0]* through *V[N - 1]* point. Oracle finds the *i*th bind-variable value in the data buffer to which *V[i]* points.

The *L* Variable

L is a pointer to an array of lengths of select-list or bind-variable values stored in data buffers.

For select descriptors, DESCRIBE SELECT LIST sets the array of lengths to the maximum expected for each select-list item. However, you might want to reset some lengths before issuing a FETCH command. FETCH returns at most *n* characters, where *n* is the value of *L[i]* before the FETCH.

The format of the length differs among Oracle datatypes. For CHAR or VARCHAR2 select-list items, DESCRIBE SELECT LIST sets *L[i]* to the maximum length of the select-list item. For NUMBER select-list items, scale and precision are returned respectively in the low and next-higher bytes of the variable. You can use the library function *SQLNumberPrecV6()* to extract precision and scale values from *L[i]*. See the section "Extracting Precision and Scale" on page 14-16.

You must reset *L[i]* to the required length of the data buffer before the FETCH. For example, when coercing a NUMBER to a C **char** string, set *L[i]* to the precision of the number plus two for the sign and decimal point. When coercing a NUMBER to

a C **float**, set *L[i]* to the length of **float**s on your system. For more information about the lengths of coerced datatypes, see the section "Converting Data" on page 14-12.

For bind descriptors, you must set the array of lengths before issuing the OPEN command. For example, you can use *strlen()* to get the lengths of bind-variable character strings entered by the user, then set the appropriate array elements.

Because Oracle accesses a data buffer indirectly, using the address stored in *V[i]*, it does not know the length of the value in that buffer. If you want to change the length Oracle uses for the *i*th select-list or bind-variable value, reset *L[i]* to the length you need. Each input or output buffer can have a different length.

The *T* Variable

T is a pointer to an array of datatype codes of select-list or bind-variable values. These codes determine how Oracle data is converted when stored in the data buffers addressed by elements of the *V* array. This topic is covered in the section "Converting Data" on page 14-12.

For select descriptors, DESCRIBE SELECT LIST sets the array of datatype codes to the *internal* datatype (CHAR, NUMBER, or DATE, for example) of the items in the select list.

Before FETCHing, you might want to reset some datatypes because the internal format of Oracle datatypes can be difficult to handle. For display purposes, it is usually a good idea to coerce the datatype of select-list values to VARCHAR2 or STRING. For calculations, you might want to coerce numbers from Oracle to C format. See the section "Coercing Datatypes" on page 14-15.

The high bit of *T[i]* is set to indicate the null/not null status of the *i*th select-list item. You must always clear this bit before issuing an OPEN or FETCH command. You use the library function *SQLColumnNullCheck()* to retrieve the datatype code and clear the null/not null bit. See the section "Handling Null/Not Null Datatypes" on page 14-17.

You should change the Oracle NUMBER internal datatype to an external datatype compatible with that of the C data buffer to which *V[i]* points.

For bind descriptors, DESCRIBE BIND VARIABLES sets the array of datatype codes to zeros. You must set the datatype code stored in each element before issuing the OPEN command. The code represents the external (C) datatype of the data buffer to which *V[i]* points. Often, bind-variable values are stored in character strings, so the datatype array elements are set to 1 (the VARCHAR2 datatype code). You can also use datatype code 5 (STRING).

To change the datatype of the *i*th select-list or bind-variable value, reset *T[i]* to the datatype you want.

The *I* Variable

I is a pointer to an array of addresses of data buffers that store indicator-variable values.

You must set the elements *I[0]* through *I[N - 1]* in the array of addresses.

For select descriptors, you must set the array of addresses before issuing the FETCH command. When Oracle executes the statement

```
EXEC SQL FETCH ... USING DESCRIPTOR ...
```

if the *i*th returned select-list value is null, the indicator-variable value to which *I[i]* points is set to -1. Otherwise, it is set to zero (the value is not null) or a positive integer (the value was truncated).

For bind descriptors, you must set the array of addresses and associated indicator variables before issuing the OPEN command. When Oracle executes the statement

```
EXEC SQL OPEN ... USING DESCRIPTOR ...
```

the data buffer to which *I[i]* points determines whether the *i*th bind variable has a null value. If the value of an indicator variable is -1, the value of its associated bind variable is null.

The *F* Variable

F is the actual number of select-list items or placeholders found by DESCRIBE.

F is set by DESCRIBE. If *F* is less than zero, DESCRIBE has found too many select-list items or placeholders for the allocated size of the descriptor. For example, if you set *N* to 10 but DESCRIBE finds 11 select-list items or placeholders, *F* is set to -11. This feature lets you dynamically reallocate a larger storage area for select-list items or placeholders if necessary.

The *S* Variable

S is a pointer to an array of addresses of data buffers that store select-list or placeholder names as they appear in dynamic SQL statements.

You use *SQLSQLDAAlloc()* to allocate the data buffers and store their addresses in the *S* array.

DESCRIBE directs Oracle to store the name of the *i*th select-list item or placeholder in the data buffer to which *S[i]* points.

The *M* Variable

M is a pointer to an array of maximum lengths of data buffers that store select-list or placeholder names. The buffers are addressed by elements of the *S* array.

When you allocate the descriptor, *SQLSQLDAAlloc()* sets the elements *M[0]* through *M[N - 1]* in the array of maximum lengths. When stored in the data buffer to which *S[i]* points, the *i*th name is truncated to the length in *M[i]* if necessary.

The *C* Variable

C is a pointer to an array of current lengths of select-list or placeholder names.

DESCRIBE sets the elements *C[0]* through *C[N - 1]* in the array of current lengths. After a DESCRIBE, the array contains the number of characters in each select-list or placeholder name.

The *X* Variable

X is a pointer to an array of addresses of data buffers that store indicator-variable names. You can associate indicator-variable *values* with select-list items and bind variables. However, you can associate indicator-variable *names* only with bind variables. So, *X* applies only to bind descriptors.

Use *SQLSQLDAAlloc()* to allocate the data buffers and store their addresses in the *X* array.

DESCRIBE BIND VARIABLES directs Oracle to store the name of the *i*th indicator variable in the data buffer to which *X[i]* points.

The *Y* Variable

Y is a pointer to an array of maximum lengths of data buffers that store indicator-variable names. Like *X*, *Y* applies only to bind descriptors.

You use *SQLSQLDAAlloc()* to set the elements *Y[0]* through *Y[N - 1]* in the array of maximum lengths. When stored in the data buffer to which *X[i]* points, the *i*th name is truncated to the length in *Y[i]* if necessary.

The *Z* Variable

Z is a pointer to an array of current lengths of indicator-variable names. Like *X* and *Y*, *Z* applies only to bind descriptors.

DESCRIBE BIND VARIABLES sets the elements *Z[0]* through *Z[N - 1]* in the array of current lengths. After a DESCRIBE, the array contains the number of characters in each indicator-variable name.

Some Preliminaries

You need a working knowledge of the following subjects to implement dynamic SQL Method 4:

- Converting Data
- Coercing Datatypes
- Handling Null/Not Null Datatypes

Converting Data

This section provides more detail about the *T* (datatype) descriptor array. In host programs that use neither datatype equivalencing nor dynamic SQL Method 4, the conversion between Oracle internal and external datatypes is determined at precompile time. By default, the precompiler assigns a specific external datatype to each host variable in the Declare Section. For example, the precompiler assigns the INTEGER external datatype to host variables of type *int*.

However, Method 4 lets you control data conversion and formatting. You specify conversions by setting datatype codes in the *T* descriptor array.

Internal Datatypes

Internal datatypes specify the formats used by Oracle to store column values in database tables, as well as the formats used to represent pseudocolumn values.

When you issue a DESCRIBE SELECT LIST command, Oracle returns the internal datatype code for each select-list item to the *T* descriptor array. For example, the datatype code for the *i*th select-list item is returned to *T[i]*.

Table 14–1 shows the Oracle internal datatypes and their codes:

Table 14–1 Oracle Internal Datatypes

Oracle Internal Datatype	Code
VARCHAR2	1
NUMBER	2
LONG	8
ROWID	11
DATE	12
RAW	23
LONG RAW	24
CHARACTER (or CHAR)	96
MLSLABEL	106

External Datatypes

External datatypes specify the formats used to store values in input and output host variables.

The DESCRIBE BIND VARIABLES command sets the *T* array of datatype codes to zeros. So, you must reset the codes *before* issuing the OPEN command. The codes tell Oracle which external datatypes to expect for the various bind variables. For the *i*th bind variable, reset *T[i]* to the external datatype you want.

Table 14–2 shows the Oracle external datatypes and their codes, as well as the C datatype normally used with each external datatype.

Table 14–2 Oracle External Datatypes and Datatype Codes

External Datatype	Code	C Datatype
VARCHAR2	1	char[n]
NUMBER	2	char[n] (n 22)
INTEGER	3	int
FLOAT	4	float
STRING	5	char[n+1]
VARNUM	6	char[n] (n 22)
DECIMAL	7	float
LONG	8	char[n]
VARCHAR	9	char[n+2]
ROWID	11	char[n]
DATE	12	char[n]
VARRAW	15	char[n]
RAW	23	unsigned char[n]
LONG RAW	24	unsigned char[n]
UNSIGNED	68	unsigned int
DISPLAY	91	char[n]
LONG VARCHAR	94	char[n+4]
LONG VARRAW	95	unsigned char[n+4]
CHAR	96	char[n]
CHARF	96	char[n]
CHARZ	97	char[n+1]
MLSLABEL	106	char[n]

For more information about the Oracle datatypes and their formats, see Chapter 3, “Developing a Pro*C/C++ Application” in this guide, and *Oracle8 SQL Reference*.

Coercing Datatypes

For a select descriptor, DESCRIBE SELECT LIST can return any of the Oracle internal datatypes. Often, as in the case of character data, the internal datatype corresponds exactly to the external datatype you want to use. However, a few internal datatypes map to external datatypes that can be difficult to handle. So, you might want to reset some elements in the *T* descriptor array. For example, you might want to reset NUMBER values to FLOAT values, which correspond to **float** values in C. Oracle does any necessary conversion between internal and external datatypes at FETCH time. So, be sure to reset the datatypes *after* the DESCRIBE SELECT LIST but *before* the FETCH.

For a bind descriptor, DESCRIBE BIND VARIABLES does *not* return the datatypes of bind variables, only their number and names. Therefore, you must explicitly set the *T* array of datatype codes to tell Oracle the external datatype of each bind variable. Oracle does any necessary conversion between external and internal datatypes at OPEN time.

When you reset datatype codes in the *T* descriptor array, you are "coercing datatypes." For example, to coerce the *i*th select-list value to STRING, you use the following statement:

```
/* Coerce select-list value to STRING. */
select_des->T[i] = 5;
```

When coercing a NUMBER select-list value to STRING for display purposes, you must also extract the precision and scale bytes of the value and use them to compute a maximum display length. Then, before the FETCH, you must reset the appropriate element of the *L* (length) descriptor array to tell Oracle the buffer length to use. See the section "Extracting Precision and Scale" on page 14-16

For example, if DESCRIBE SELECT LIST finds that the *i*th select-list item is of type NUMBER, and you want to store the returned value in a C variable declared as **float**, simply set *T[i]* to 4 and *L[i]* to the length of **float**s on your system.

Caution

In some cases, the internal datatypes that DESCRIBE SELECT LIST returns might not suit your purposes. Two examples of this are DATE and NUMBER. When you DESCRIBE a DATE select-list item, Oracle returns the datatype code 12 to the *T* descriptor array. Unless you reset the code before the FETCH, the date value is returned in its 7-byte internal format. To get the date in character format (DD-MON-YY), you can change the datatype code from 12 to 1 (VARCHAR2) or 5 (STRING), and increase the *L* value from 7 to 9 or 10.

Similarly, when you DESCRIBE a NUMBER select-list item, Oracle returns the datatype code 2 to the *T* array. Unless you reset the code before the FETCH, the numeric value is returned in its internal format, which is probably not what you want. So, change the code from 2 to 1 (VARCHAR2), 3 (INTEGER), 4 (FLOAT), 5 (STRING) or some other appropriate datatype.

Extracting Precision and Scale

The library function *SQLNumberPrecV6()* (previously know as *SQLNumberPrecV6())* extracts precision and scale. Normally, it is used after the DESCRIBE SELECT LIST, and its first argument is *L[i]*. You call*SQLNumberPrecV6()* using the following syntax:

```
SQLNumberPrecV6(dvoid *runtime_context, long *length, int *precision, int
*scale);
```

> **Note:** See your platform-specific *SQLNumberPrecV6.h* file for the correct prototype for your platform.

where:

runtime_context	pointer tom the runtime context
length	Is a pointer to a long integer variable that stores the length of an Oracle NUMBER value; the length is stored in L[i]. The scale and precision of the value are stored respectively in the low and next-higher bytes.
precision	Is a pointer to an integer variable that returns the precision of the NUMBER value. Precision is the number of significant digits. It is set to zero if the select-list item refers to a NUMBER of unspecified size. In this case, because the size is unspecified, you might want to assume the maximum precision (38).
scale	Is a pointer to an integer variable that returns the scale of the NUMBER value. Scale specifies where rounding will occur. For example, a scale of 2 means the value is rounded to the nearest hundredth (3.456 becomes 3.46); a scale of -3 means the number is rounded to the nearest thousand (3456 becomes 3000).

When the scale is negative, add its absolute value to the length. For example, a precision of 3 and scale of -2 allow for numbers as large as 99900.

The following example shows how SQLNumberPrecV6*()* is used to compute maximum display lengths for NUMBER values that will be coerced to STRING:

```
/* Declare variables for the function call. */
sqlda         *select_des;  /* pointer to select descriptor */
int            prec;        /* precision                    */
int            scal;        /* scale                        */
extern void SQLNumberPrecV6();  /* Declare library function. */
/* Extract precision and scale. */
SQLNumberPrecV6( &(select_des->L[i]), &prec, &scal);
/* Allow for maximum size of NUMBER. */
if (prec == 0)
    prec = 38;
/* Allow for possible decimal point and sign. */
select_des->L[i] = prec + 2;
/* Allow for negative scale. */
if (scal < 0)
    select_des->L[i] += -scal;
```

Notice that the first argument in this function call points to the *i*th element in the array of lengths, and that all three parameters are addresses.

The *SQLNumberPrecV6()* function returns zero as the precision and scale values for certain SQL datatypes. The *SQLNumberPrecV7()* function is similar, having the same argument list, and returning the same values, except in the cases of these SQL datatypes:

Table 14–3 Precision and Scale Values for SQL Datatypes

SQL Datatype	Binary Precision	Scale
FLOAT	126	-127
FLOAT(N)	N (range is 1 to 126)	-127
REAL	63	-127
DOUBLE PRECISION	126	-127

Handling Null/Not Null Datatypes

For every select-list column (not expression), DESCRIBE SELECT LIST returns a null/not null indication in the datatype array *T* of the select descriptor. If the *i*th select-list column is constrained to be not null, the high-order bit of *T[i]* is clear; otherwise, it is set.

Before using the datatype in an OPEN or FETCH statement, if the null/not null bit is set, you must clear it. (Never set the bit.)

You can use the library function *SQLColumnNullCheck() (*previously was *sqlnul())* to find out if a column allows nulls, and to clear the datatype's null/not null bit. You call *SQLColumnNullCheck()* using the syntax

```
SQLColumnNullCheck(dvoid *context, unsigned short *value_type,
      unsigned short *type_code, int *null_status);
```

where:

context	pointer to the runtime context
value_type	Is a pointer to an unsigned short integer variable that stores the datatype code of a select-list column; the datatype is stored in T[i].
type_code	Is a pointer to an unsigned short integer variable that returns the datatype code of the select-list column with the high-order bit cleared.
null_status	Is a pointer to an integer variable that returns the null status of the select-list column. 1 means the column allows nulls; 0 means it does not.

The following example shows how to use *SQLColumnNullCheck()*:

```
/* Declare variables for the function call. */
sqlda  *select_des;      /* pointer to select descriptor */
unsigned short   dtype;  /* datatype without null bit    */
int   nullok;            /* 1 = null, 0 = not null       */
extern void SQLColumnNullCheck();    /* Declare library function.    */
/* Find out whether column is not null. */
SQLColumnNUllCheck(SQL_SINGLE_RCTX, &select_des->T[i], &dtype, &nullok);
if (nullok)
{
     /* Nulls are allowed. */
     ...
     /* Clear the null/not null bit. */
SQLColumnNullCheck(SQL_SINGLE_RCTX, &(select_des->T[i]), &(select_des->T[i]),
&nullok);
}
```

Notice that the first and second arguments in the second call to the *SQLColumnNullCheck()* function point to the *i*th element in the array of datatypes, and that all three parameters are addresses.

The Basic Steps

Method 4 can be used to process *any* dynamic SQL statement. In the coming example, a query is processed so you can see how both input and output host variables are handled.

To process the dynamic query, our example program takes the following steps:

1. Declare a host string in the Declare Section to hold the query text.
2. Declare select and bind SQLDAs.
3. Allocate storage space for the select and bind descriptors.
4. Set the maximum number of select-list items and placeholders that can be DESCRIBEd.
5. Put the query text in the host string.
6. PREPARE the query from the host string.
7. DECLARE a cursor FOR the query.
8. DESCRIBE the bind variables INTO the bind descriptor.
9. Reset the number of placeholders to the number actually found by DESCRIBE.
10. Get values and allocate storage for the bind variables found by DESCRIBE.
11. OPEN the cursor USING the bind descriptor.
12. DESCRIBE the select list INTO the select descriptor.
13. Reset the number of select-list items to the number actually found by DESCRIBE.
14. Reset the length and datatype of each select-list item for display purposes.
15. FETCH a row from the database INTO the allocated data buffers pointed to by the select descriptor.
16. Process the select-list values returned by FETCH.
17. Deallocate storage space used for the select-list items, placeholders, indicator variables, and descriptors.
18. CLOSE the cursor.

    Note: Some of these steps are unnecessary if the dynamic SQL statement contains a known number of select-list items or placeholders.

A Closer Look at Each Step

This section discusses each step in detail. Also, at the end of this chapter is a Commented, full-length program illustrating Method 4.

With Method 4, you use the following sequence of embedded SQL statements:

```
EXEC SQL PREPARE statement_name
     FROM { :host_string | string_literal };
EXEC SQL DECLARE cursor_name CURSOR FOR statement_name;
EXEC SQL DESCRIBE BIND VARIABLES FOR statement_name
     INTO bind_descriptor_name;
EXEC SQL OPEN cursor_name
     [USING DESCRIPTOR bind_descriptor_name];
EXEC SQL DESCRIBE [SELECT LIST FOR] statement_name
     INTO select_descriptor_name;
EXEC SQL FETCH cursor_name
     USING DESCRIPTOR select_descriptor_name;
EXEC SQL CLOSE cursor_name;
```

If the number of select-list items in a dynamic query is known, you can omit DESCRIBE SELECT LIST and use the following Method 3 FETCH statement:

```
EXEC SQL FETCH cursor_name INTO host_variable_list;
```

Or, if the number of placeholders for bind variables in a dynamic SQL statement is known, you can omit DESCRIBE BIND VARIABLES and use the following Method 3 OPEN statement:

```
EXEC SQL OPEN cursor_name [USING host_variable_list];
```

Next, you see how these statements allow your host program to accept and process a dynamic SQL statement using descriptors.

Note: Several figures accompany the following discussion. To avoid cluttering the figures, it was necessary to do the following:

- confine descriptor arrays to 3 elements
- limit the maximum length of names to 5 characters
- limit the maximum length of values to 10 characters

Declare a Host String

Your program needs a host variable to store the text of the dynamic SQL statement. The host variable (*select_stmt* in our example) must be declared as a character string.

```
...
int      emp_number;
VARCHAR  emp_name[10];
VARCHAR  select_stmt[120];
float    bonus;
```

Declare the SQLDAs

In our example, instead of hardcoding the SQLDA data structure, you use INCLUDE to copy it into your program, as follows:

```
#include <sqlda.h>
```

Then, because the query might contain an unknown number of select-list items or placeholders for bind variables, you declare pointers to select and bind descriptors, as follows:

```
sqlda  *select_des;
sqlda  *bind_des;
```

Allocate Storage Space for the Descriptors

Recall that you allocate storage space for a descriptor with the *SQLSQLDAAlloc()* library function. The syntax, using ANSI C notation, is:

```
SQLDA *SQLSQLDAAlloc(dvoid *context, unsigned int max_vars, unsigned int
max_name, unsigned int max_ind_name);
```

The *SQLSQLDAAlloc()* function allocates the descriptor structure and the arrays addressed by the pointer variables *V*, *L*, *T*, and *I*.

If *max_name* is non-zero, arrays addressed by the pointer variables *S*, *M*, and *C* are allocated. If *max_ind_name* is non-zero, arrays addressed by the pointer variables *X*, *Y*, and *Z* are allocated. No space is allocated if *max_name* and *max_ind_name* are zero.

If *SQLSQLDAAlloc()* succeeds, it returns a pointer to the structure. If *SQLSQLDAAlloc()* fails, it returns a zero.

In our example, you allocate select and bind descriptors, as follows:

```
select_des = SQLSQLDAAlloc(SQL_SINGLE_RCTX, 3, (size_t) 5, (size_t) 0);
bind_des = SQLSQLDAAlloc(SQL_SINGLE_RCTX, 3, (size_t) 5, (size_t) 4);
```

For select descriptors, always set *max_ind_name* to zero so that no space is allocated for the array addressed by *X*.

Set the Maximum Number to DESCRIBE

Next, you set the maximum number of select-list items or placeholders that can be DESCRIBEd, as follows:

```
select_des->N = 3;
bind_des->N = 3;
```

Figure 14–2 and Figure 14–3 represent the resulting descriptors. **Note:** In the select descriptor (Figure 14–2), the section for indicator-variable names is crossed out to show that it is not used.

Figure 14–2 Initialized Select Descriptor

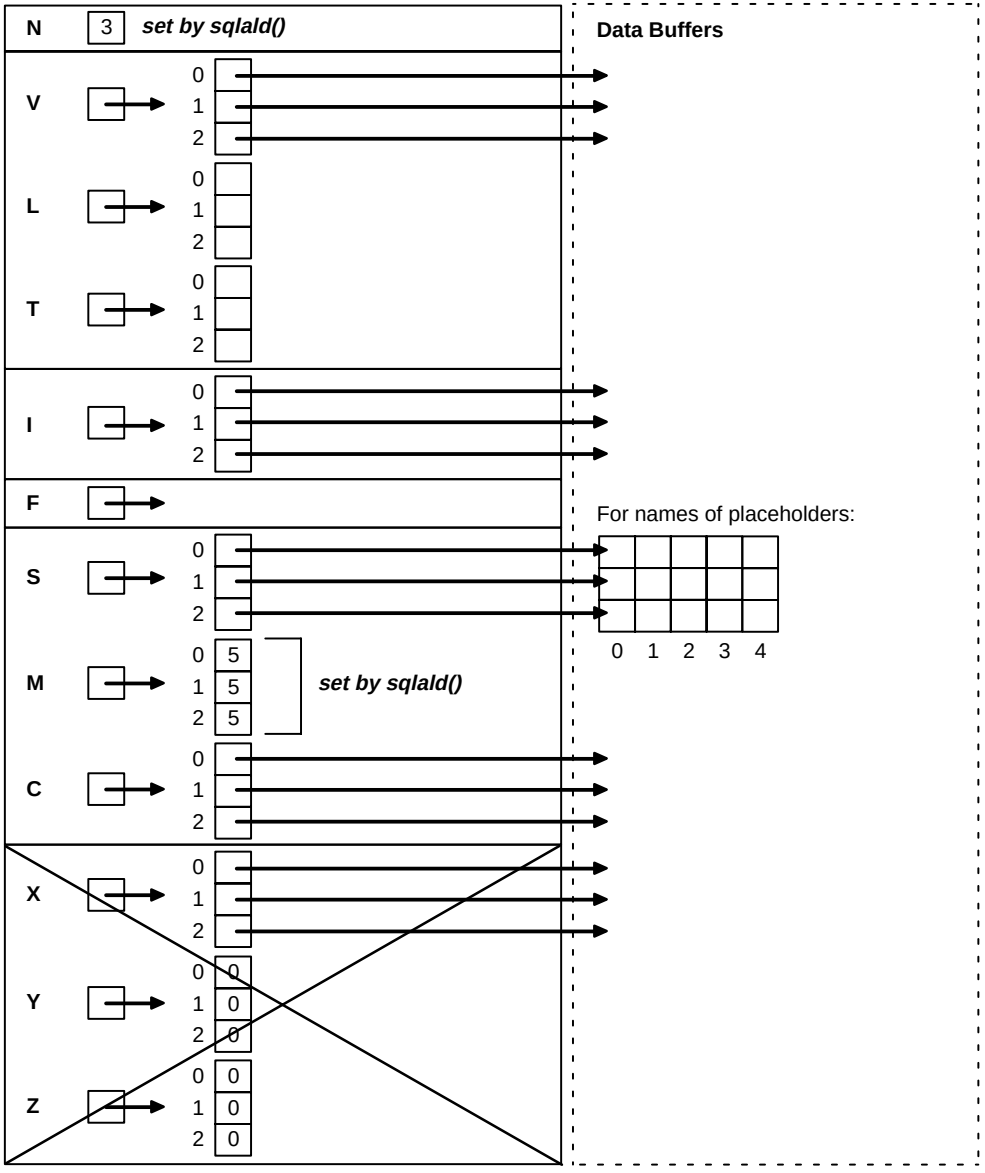
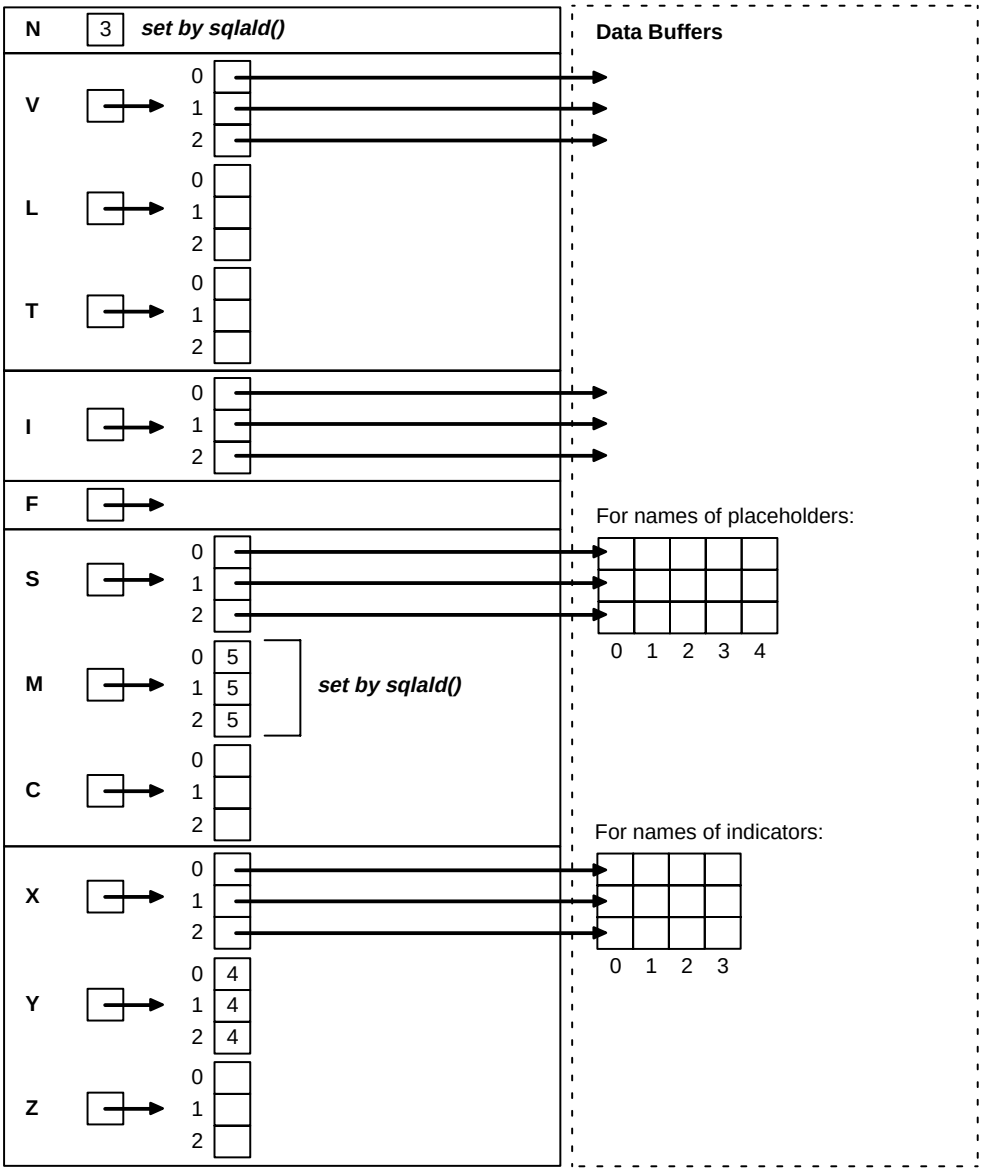


Figure 14–3 Initialized Bind Descriptor



Put the Query Text in the Host String

Continuing our example, you prompt the user for a SQL statement, then store the input string in *select_stmt*, as follows:

```
printf("\n\nEnter SQL statement: ");
gets(select_stmt.arr);
select_stmt.len = strlen(select_stmt.arr);
```

We assume the user entered the following string:

```
"SELECT ename, empno, comm FROM emp WHERE comm < :bonus"
```

PREPARE the Query from the Host String

PREPARE parses the SQL statement and gives it a name. In our example, PREPARE parses the host string *select_stmt* and gives it the name *sql_stmt*, as follows:

```
EXEC SQL PREPARE sql_stmt FROM :select_stmt;
```

DECLARE a Cursor

DECLARE CURSOR defines a cursor by giving it a name and associating it with a specific SELECT statement.

To declare a cursor for *static* queries, you use the following syntax:

```
EXEC SQL DECLARE cursor_name CURSOR FOR SELECT ...
```

To declare a cursor for *dynamic* queries, the statement name given to the dynamic query by PREPARE is substituted for the static query. In our example, DECLARE CURSOR defines a cursor named *emp_cursor* and associates it with *sql_stmt*, as follows:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR sql_stmt;
```

> **Note:** You can declare a cursor for all dynamic SQL statements, not just queries. With non-queries, OPENing the cursor executes the dynamic SQL statement.

DESCRIBE the Bind Variables

DESCRIBE BIND VARIABLES puts descriptions of placeholders into a bind descriptor. In our example, DESCRIBE readies *bind_des*, as follows:

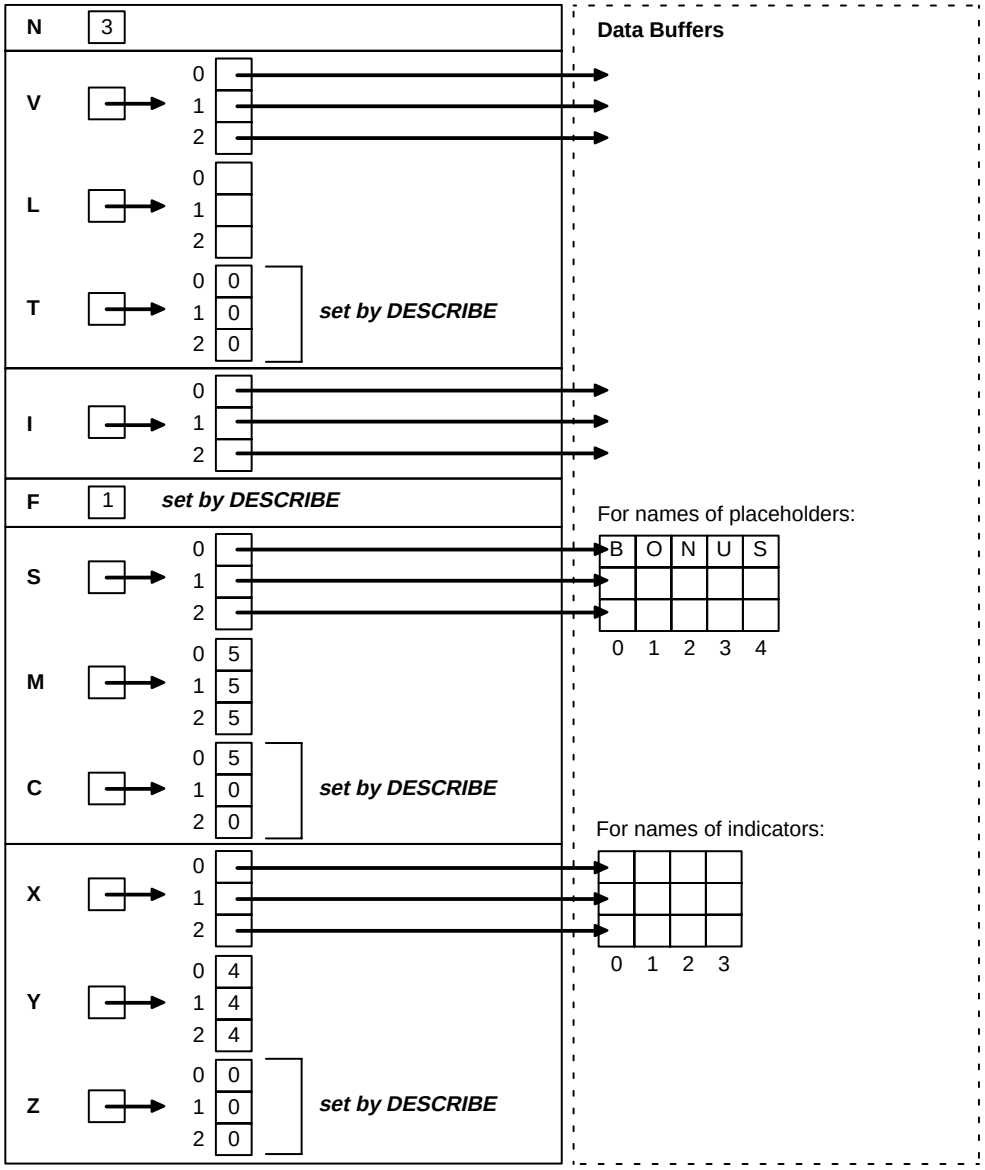
```
EXEC SQL DESCRIBE BIND VARIABLES FOR sql_stmt INTO bind_des;
```

Note that *bind_des* must *not* be prefixed with a colon.

The DESCRIBE BIND VARIABLES statement must follow the PREPARE statement but precede the OPEN statement.

Figure 14–4 shows the bind descriptor in our example after the DESCRIBE. Notice that DESCRIBE has set *F* to the actual number of placeholders found in the processed SQL statement.

Figure 14–4 Bind Descriptor after the DESCRIBE



Reset Number of Placeholders

Next, you must reset the maximum number of placeholders to the number actually found by DESCRIBE, as follows:

```
bind_des->N = bind_des->F;
```

Get Values and Allocate Storage for Bind Variables

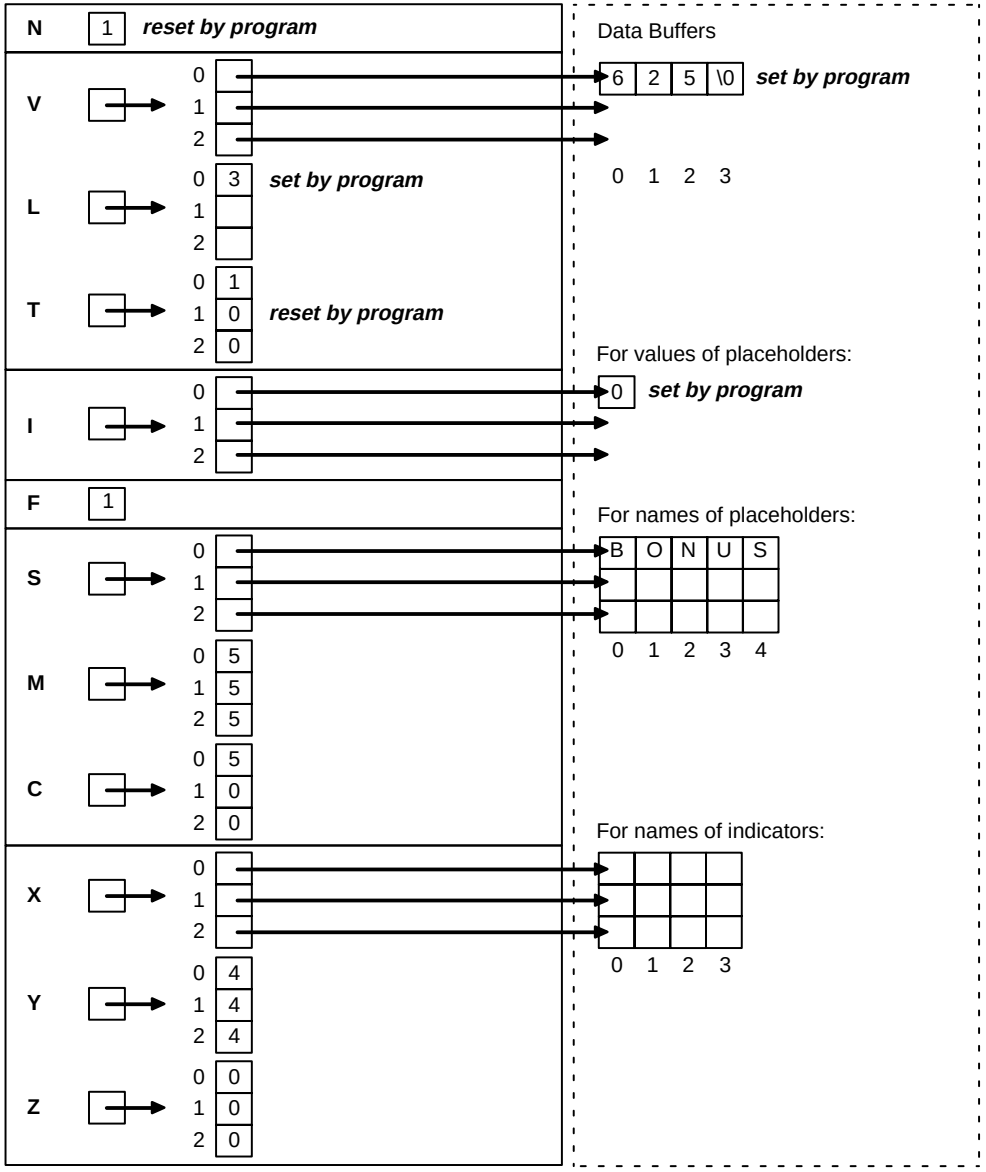
Your program must get values for the bind variables found in the SQL statement, and allocate memory for them. How the program gets the values is up to you. For example, they can be hardcoded, read from a file, or entered interactively.

In our example, a value must be assigned to the bind variable that replaces the placeholder *bonus* in the query WHERE clause. So, you choose to prompt the user for the value, then process it as follows:

```
for (i = 0; i < bind_des->F; i++)
{
     printf("\nEnter value of bind variable %.*s:\n? ",
         (int) bind_des->C[i], bind_des->S[i]);
     gets(hostval);
     /* Set length of value. */
     bind_des->L[i] = strlen(hostval);
     /* Allocate storage for value and null terminator. */
     bind_des->V[i] = malloc(bind_des->L[i] + 1);
     /* Allocate storage for indicator value. */
     bind_des->I[i] = (unsigned short *) malloc(sizeof(short));
     /* Store value in bind descriptor. */
     strcpy(bind_des->V[i], hostval);
     /* Set value of indicator variable. */
     *(bind_des->I[i]) = 0;  /* or -1 if "null" is the value */
     /* Set datatype to STRING. */
     bind_des->T[i] = 5;
}
```

Assuming that the user supplied a value of 625 for *bonus*, Figure 14–5 shows the resulting bind descriptor. Notice that the value is null-terminated.

Figure 14–5 Bind Descriptor after Assigning Values



OPEN the Cursor

The OPEN statement used for dynamic queries is like that used for static queries except that the cursor is associated with a bind descriptor. Values determined at run time and stored in buffers addressed by elements of the bind descriptor arrays are used to evaluate the SQL statement. With queries, the values are also used to identify the active set.

In our example, OPEN associates *emp_cursor* with *bind_des*, as follows:

```
EXEC SQL OPEN emp_cursor USING DESCRIPTOR bind_des;
```

Remember, *bind_des* must *not* be prefixed with a colon.

Then, OPEN executes the SQL statement. With queries, OPEN also identifies the active set and positions the cursor at the first row.

DESCRIBE the Select List

If the dynamic SQL statement is a query, the DESCRIBE SELECT LIST statement must follow the OPEN statement but precede the FETCH statement.

DESCRIBE SELECT LIST puts descriptions of select-list items in a select descriptor. In our example, DESCRIBE readies *select_des*, as follows:

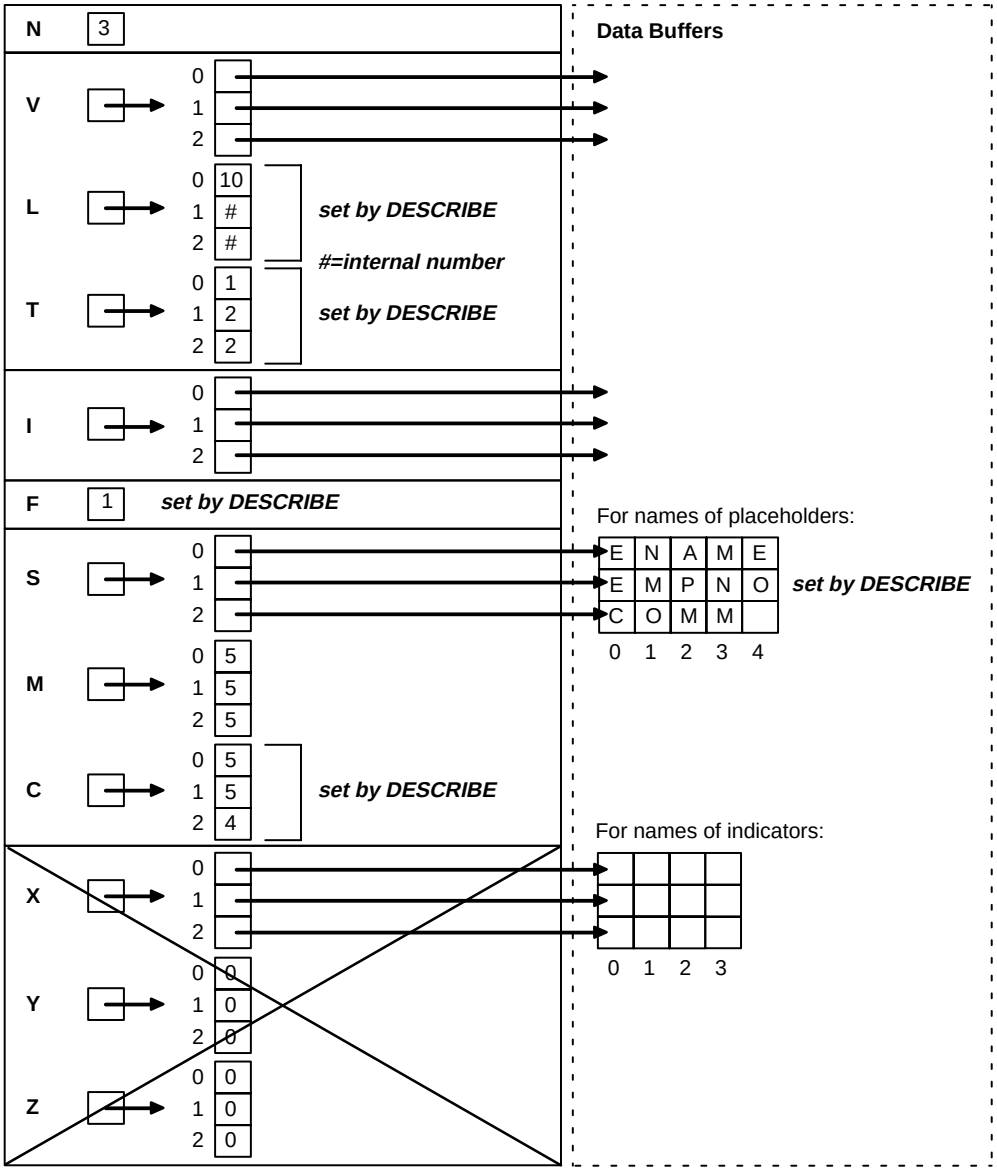
```
EXEC SQL DESCRIBE SELECT LIST FOR sql_stmt INTO select_des;
```

Accessing the Oracle data dictionary, DESCRIBE sets the length and datatype of each select-list value.

Figure 14–6 shows the select descriptor in our example after the DESCRIBE. Notice that DESCRIBE has set *F* to the actual number of items found in the query select list. If the SQL statement is not a query, *F* is set to zero.

Also notice that the NUMBER lengths are not usable yet. For columns defined as NUMBER, you must use the library function `SQLNumberPrecV6()` to extract precision and scale. See "Coercing Datatypes" on page 14-15.

Figure 14–6 Select Descriptor after the DESCRIBE



Reset Number of Select-List Items

Next, you must reset the maximum number of select-list items to the number actually found by DESCRIBE, as follows:

```
select_des->N = select_des->F;
```

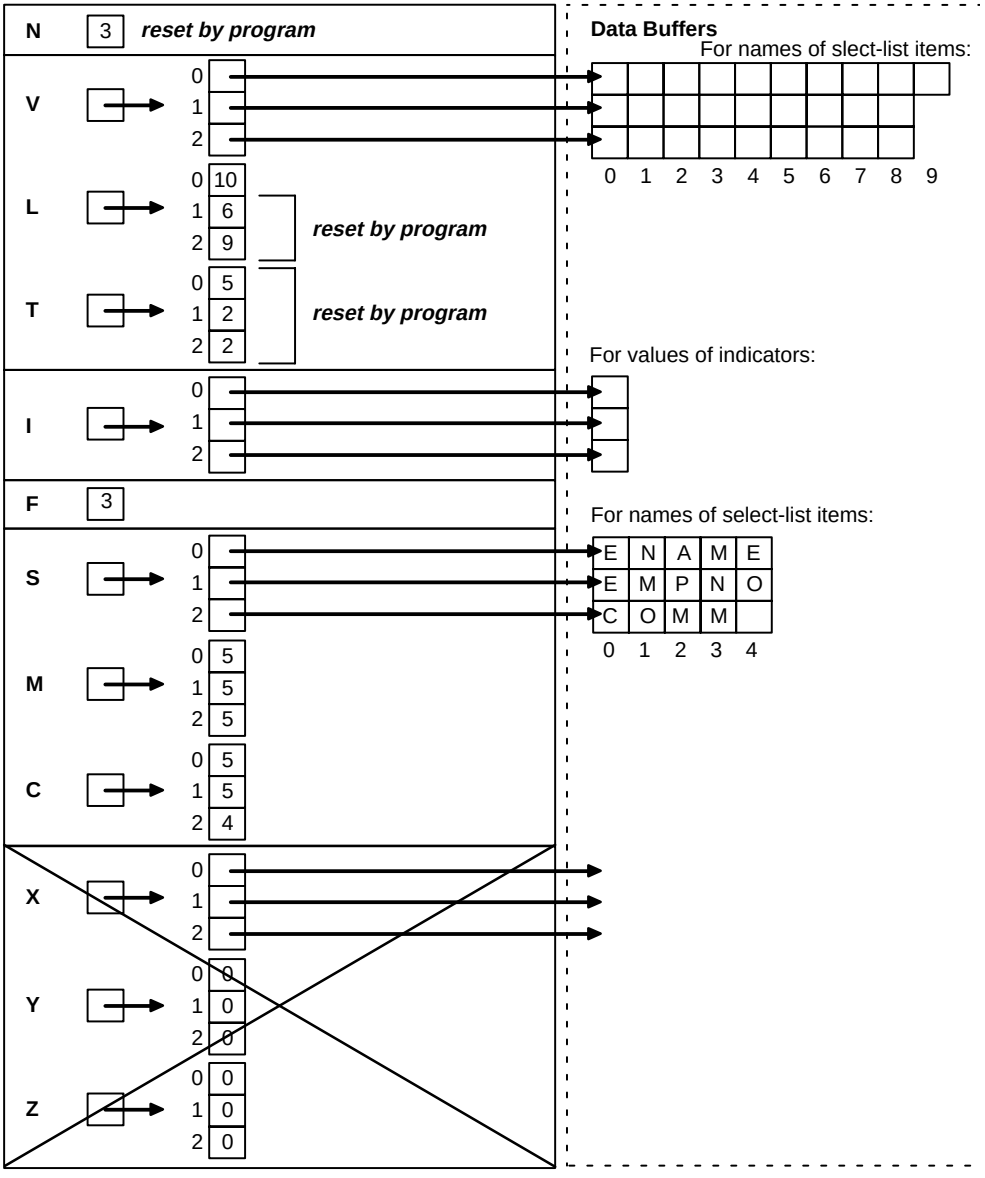
Reset Length/Datatype of Each Select-list Item

In our example, before FETCHing the select-list values, you allocate storage space for them using the library function *malloc()*. You also reset some elements in the length and datatype arrays for display purposes.

```
for (i=0; i<select_des->F; i++)
{
     /* Clear null bit. */
     SQLColumnNullCheck(SQL_SINGLE_RCTX, &(select_des->T[i], &(select_des-
>T[i], &nullok)));
     /* Reset length if necessary. */
     switch(select_des->T[i])
     {
         case  1: break;
         case  2: SQLNumberPrecV6(SQL_SINGLE_RCTX, &select_des->L[i], &prec,
&scal);
                  if (prec == 0) prec = 40;
                  select_des->L[i] = prec + 2;
                  if (scal < 0) select_des->L[i] += -scal;
                  break;
         case  8: select_des->L[i] = 240;
                  break;
         case 11: select_des->L[i] = 18;
                  break;
         case 12: select_des->L[i] = 9;
                  break;
         case 23: break;
         case 24: select_des->L[i] = 240;
                  break;
     }
     /* Allocate storage for select-list value. */
     select_des->V[i] = malloc(select_des->L[i+1]);
     /* Allocate storage for indicator value. */
     select_des->I[i] = (short *)malloc(sizeof(short *));
     /* Coerce all datatypes except LONG RAW to STRING. */
     if (select_des->T[i] != 24) select_des->T[i] = 5;
}
```

Figure 14–7 shows the resulting select descriptor. Notice that the NUMBER lengths are now usable and that all the datatypes are STRING. The lengths in *L[1]* and *L[2]* are 6 and 9 because we increased the DESCRIBEd lengths of 4 and 7 by 2 to allow for a possible sign and decimal point.

Figure 14–7 Select Descriptor before the FETCH



FETCH Rows from the Active Set

FETCH returns a row from the active set, stores select-list values in the data buffers, and advances the cursor to the next row in the active set. If there are no more rows, FETCH sets *sqlca.sqlcode* to the "no data found" Oracle error code. In our example, FETCH returns the values of columns ENAME, EMPNO, and COMM to *select_des*, as follows:

```
EXEC SQL FETCH emp_cursor USING DESCRIPTOR select_des;
```

Figure 14–8 shows the select descriptor in our example after the FETCH. Notice that Oracle has stored the select-list and indicator values in the data buffers addressed by the elements of *V* and *I*.

For output buffers of datatype 1, Oracle, using the lengths stored in the *L* array, left-justifies CHAR or VARCHAR2 data and right-justifies NUMBER data. For output buffer of type 5 (STRING), Oracle left-justifies and null terminates CHAR, VARCHAR2, and NUMBER data.

The value 'MARTIN' was retrieved from a VARCHAR2(10) column in the EMP table. Using the length in *L[0]*, Oracle left-justifies the value in a 10-byte field, filling the buffer.

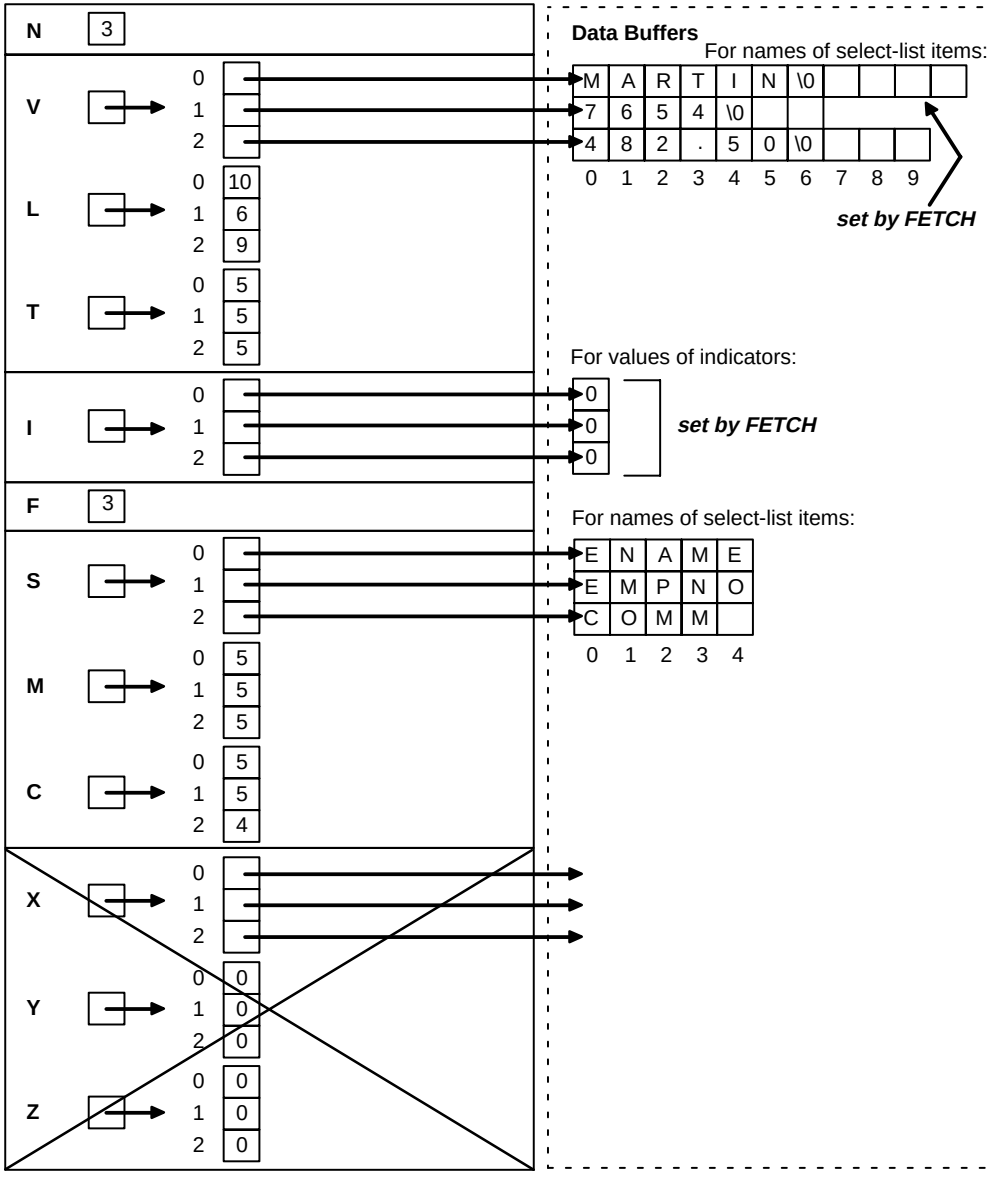
The value 7654 was retrieved from a NUMBER(4) column and coerced to '7654'. However, the length in *L[1]* was increased by 2 to allow for a possible sign and decimal point. So, Oracle left-justifies and null terminates the value in a 6-byte field.

The value 482.50 was retrieved from a NUMBER(7,2) column and coerced to '482.50'. Again, the length in *L[2]* was increased by 2. So, Oracle left-justifies and null terminates the value in a 9-byte field.

Get and Process Select-List Values

After the FETCH, your program can process the returned values. In our example, values for columns ENAME, EMPNO, and COMM are processed.

Figure 14–8 Selected Descriptor after the FETCH



Deallocate Storage

You use the *free()* library function to deallocate the storage space allocated by *malloc()*. The syntax is as follows:

```
free(char *pointer);
```

In our example, you deallocate storage space for the values of the select-list items, bind variables, and indicator variables, as follows:

```
for (i = 0; i < select_des->F; i++)   /* for select descriptor */
{
     free(select_des->V[i]);
     free(select_des->I[i]);
}
for (i = 0; i < bind_des->F; i++)   /* for bind descriptor */
{
     free(bind_des->V[i]);
     free(bind_des->I[i]);
}
```

You deallocate storage space for the descriptors themselves with the *SQLSQLDAFree()* library function, using the following syntax:

```
SQLSQLDAFree(descriptor_name);
```

The descriptor must have been allocated using *SQLSQLDAAlloc()*. Otherwise, the results are unpredictable.

In our example, you deallocate storage space for the select and bind descriptors as follows:

```
SQLSQLDAFree(SQL_SINGLE_RCTX, select_des);
SQLSQLDAFree(SQL_SINGLE_RCTX, bind_des);
```

CLOSE the Cursor

CLOSE disables the cursor. In our example, CLOSE disables *emp_cursor* as follows:

```
EXEC SQL CLOSE emp_cursor;
```

Using Host Arrays

To use input or output host arrays with Method 4, you must use the optional FOR clause to tell Oracle the size of your host array. For more information about the FOR clause, see Chapter 12, “Using Host Arrays”.

You must set descriptor entries for the *i*th select-list item or bind variable using the syntax

```
V[i] = array_address;
L[i] = element_size;
```

where *array_address* is the address of the host array, and *element_size* is the size of one array element.

Then, you must use a FOR clause in the EXECUTE or FETCH statement (whichever is appropriate) to tell Oracle the number of array elements you want to process. This procedure is necessary because Oracle has no other way of knowing the size of your host array.

In the complete program example below, three input host arrays are used to INSERT rows into the EMP table. Note that EXECUTE can be used for Data Manipulation Language statements other than queries with Method 4.

```
#include <stdio.h>
#include <sqlca.h>
#include <sqlda.h>

#define NAME_SIZE    10
#define ARRAY_SIZE    5

/* connect string */
char *username = "scott/tiger";

char *sql_stmt =
"INSERT INTO emp (empno, ename, deptno) VALUES (:e, :n, :d)";
int  array_size = ARRAY_SIZE;  /* must have a host variable too */

SQLDA   *binda;

char    names[ARRAY_SIZE][NAME_SIZE];
int     numbers[ARRAY_SIZE], depts[ARRAY_SIZE];

extern  SQLDA  *SQLSQLDAAlloc();
main()
{
    EXEC SQL WHENEVER SQLERROR GOTO sql_error;

/* Connect */
    EXEC SQL CONNECT :username;
    printf("Connected.\n");
```

```
/* Allocate the descriptors and set the N component.
   This must be done before the DESCRIBE. */
    binda = SQLSQLDAAlloc(3, ARRAY_SIZE, 0);
    binda->N = 3;

/* Prepare and describe the SQL statement. */
    EXEC SQL PREPARE stmt FROM :sql_stmt;
    EXEC SQL DESCRIBE BIND VARIABLES FOR stmt INTO binda;

/* Initialize the descriptors. */
    binda->V[0] = (char *) numbers;
    binda->L[0] = (long) sizeof (int);
    binda->T[0] = 3;
    binda->I[0] = 0;

    binda->V[1] = (char *) names;
    binda->L[1] = (long) NAME_SIZE;
    binda->T[1] = 1;
    binda->I[1] = 0;

    binda->V[2] = (char *) depts;
    binda->L[2] = (long) sizeof (int);
    binda->T[2] = 3;
    binda->I[2] = 0;

/* Initialize the data buffers. */
    strcpy(&names[0] [0], "ALLISON");
    numbers[0] = 1014;
    depts[0] = 30;

    strcpy(&names[1] [0], "TRUSDALE");
    numbers[1] = 1015;
    depts[1] = 30;

    strcpy(&names[2] [0], "FRAZIER");
    numbers[2] = 1016;
    depts[2] = 30;

    strcpy(&names[3] [0], "CARUSO");
    numbers[3] = 1017;
    depts[3] = 30;

    strcpy(&names[4] [0], "WESTON");
    numbers[4] = 1018;
    depts[4] = 30;
```

```
/* Do the INSERT. */
    printf("Adding to the Sales force...\n");

    EXEC SQL FOR :array_size
    EXECUTE stmt USING DESCRIPTOR binda;

/*  Print rows-processed count. */
    printf("%d rows inserted.\n\n", sqlca.sqlerrd[2]);
    EXEC SQL COMMIT RELEASE;
    exit(0);

sql_error:
/* Print Oracle error message. */
    printf("\n%.70s", sqlca.sqlerrm.sqlerrmc);
    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL ROLLBACK RELEASE;
    exit(1);
}
```

Sample Program: Dynamic SQL Method 4

This program shows the basic steps required to use dynamic SQL with Method 4. After connecting to Oracle, the program allocates memory for the descriptors using *SQLSQLDAAlloc(),* prompts the user for a SQL statement, PREPAREs the statement, DECLAREs a cursor, checks for any bind variables using DESCRIBE BIND, OPENs the cursor, and DESCRIBEs any select-list items. If the input SQL statement is a query, the program FETCHes each row of data, then CLOSEs the cursor. This program is available on-line in the *demo* directory, in the file *sample10.pc*.

```
/*************************************************************
Sample Program 10:  Dynamic SQL Method 4

This program connects you to ORACLE using your username and
password, then prompts you for a SQL statement. You can enter
any legal SQL statement.

Use regular SQL syntax, not embedded SQL. Your statement will
be processed. If it is a query, the rows fetched are
displayed. You can enter multi-line statements. The limit is
1023 bytes.

This sample program only processes up to MAX_ITEMS bind
```

```
variables and MAX_ITEMS select-list items. MAX_ITEMS is
#defined to be 40.

************************************************************/

#include <stdio.h>
#include <string.h>
#include <setjmp.h>

/* Maximum number of select-list items or bind variables. */
#define MAX_ITEMS         40

/* Maximum lengths of the _names_ of the
   select-list items or indicator variables. */
#define MAX_VNAME_LEN     30
#define MAX_INAME_LEN     30


#ifndef NULL
#define NULL  0
#endif

char *dml_commands[] = {"SELECT", "select", "INSERT", "insert",
                        "UPDATE", "update", "DELETE", "delete"};

EXEC SQL BEGIN DECLARE SECTION;
    char    dyn_statement[1024];
    EXEC SQL VAR dyn_statement IS STRING(1024);
EXEC SQL END DECLARE SECTION;

EXEC SQL INCLUDE sqlca;
EXEC SQL INCLUDE sqlda;

SQLDA *bind_dp;
SQLDA *select_dp;

extern SQLDA *SQLSQLDAAlloc();
extern void sqlnul();

/* Define a buffer to hold longjmp state info. */
jmp_buf jmp_continue;

/* A global flag for the error routine. */
int parse_flag = 0;
```

```
main()
{
    int oracle_connect();
    int alloc_descriptors();
    int get_dyn_statement();
    int set_bind_variables();
    int process_select_list();
    int i;

    /* Connect to the database. */
    if (oracle_connect() != 0)
        exit(1);

    /* Allocate memory for the select and bind descriptors. */
    if (alloc_descriptors(MAX_ITEMS,
                          MAX_VNAME_LEN, MAX_INAME_LEN) != 0)
        exit(1);




    /* Process SQL statements. */
    for (;;)
    {
        i = setjmp(jmp_continue);

        /* Get the statement.  Break on "exit". */
        if (get_dyn_statement() != 0)
            break;

        /* Prepare the statement and declare a cursor. */
        EXEC SQL WHENEVER SQLERROR DO sql_error();

        parse_flag = 1;     /* Set a flag for sql_error(). */
        EXEC SQL PREPARE S FROM :dyn_statement;
        parse_flag = 0;     /* Unset the flag. */

        EXEC SQL DECLARE C CURSOR FOR S;

        /* Set the bind variables for any placeholders in the
           SQL statement. */
        set_bind_variables();

        /* Open the cursor and execute the statement.
```

```
     * If the statement is not a query (SELECT), the
     * statement processing is completed after the
     * OPEN.
     */

    EXEC SQL OPEN C USING DESCRIPTOR bind_dp;

    /* Call the function that processes the select-list.
     * If the statement is not a query, this function
     * just returns, doing nothing.
     */
    process_select_list();

    /* Tell user how many rows processed. */
    for (i = 0; i < 8; i++)
    {
       if (strncmp(dyn_statement, dml_commands[i], 6) == 0)
       {
           printf("\n\n%d row%c processed.\n",
                  sqlca.sqlerrd[2],
                  sqlca.sqlerrd[2] == 1 ? '\0' : 's');
           break;
       }
    }
}       /* end of for(;;) statement-processing loop */

/* When done, free the memory allocated for
   pointers in the bind and select descriptors. */
for (i = 0; i < MAX_ITEMS; i++)
{
    if (bind_dp->V[i] != (char *) 0)
        free(bind_dp->V[i]);
    free(bind_dp->I[i]);   /* MAX_ITEMS were allocated. */
    if (select_dp->V[i] != (char *) 0)
        free(select_dp->V[i]);
    free(select_dp->I[i]); /* MAX_ITEMS were allocated. */
}

/* Free space used by the descriptors themselves. */
SQLSQLDAFree(SQL_SINGLE_RCTX, bind_dp);
SQLSQLDAFree(SQL_SINGLE_RCTX, select_dp);

EXEC SQL WHENEVER SQLERROR CONTINUE;
/* Close the cursor. */
EXEC SQL CLOSE C;
```

```
    EXEC SQL COMMIT WORK RELEASE;
    puts("\nHave a good day!\n");

    EXEC SQL WHENEVER SQLERROR DO sql_error();
    return;
}


oracle_connect()
{
    EXEC SQL BEGIN DECLARE SECTION;
        VARCHAR  username[128];
        VARCHAR  password[32];
    EXEC SQL END DECLARE SECTION;

    printf("\nusername: ");
    fgets((char *) username.arr, sizeof username.arr, stdin);
    fflush(stdin);
    username.arr[strlen((char *) username.arr)-1] = '\0';
    username.len = strlen((char *) username.arr);

    printf("password: ");
    fgets((char *) password.arr, sizeof password.arr, stdin);
    fflush(stdin);
    password.arr[strlen((char *) password.arr) - 1] = '\0';
    password.len = strlen((char *) password.arr);


    EXEC SQL WHENEVER SQLERROR GOTO connect_error;

    EXEC SQL CONNECT :username IDENTIFIED BY :password;

    printf("\nConnected to ORACLE as user %s.\n", username.arr);

    return 0;

connect_error:
    fprintf(stderr,
            "Cannot connect to ORACLE as user %s\n",
            username.arr);
    return -1;
}
```

```
/*
 *  Allocate the BIND and SELECT descriptors using SQLSQLDAAlloc().
 *  Also allocate the pointers to indicator variables
 *  in each descriptor.  The pointers to the actual bind
 *  variables and the select-list items are realloc'ed in
 *  the set_bind_variables() or process_select_list()
 *  routines.  This routine allocates 1 byte for select_dp->V[i]
 *  and bind_dp->V[i], so the realloc will work correctly.
 */

alloc_descriptors(size, max_vname_len, max_iname_len)
int size;
int max_vname_len;
int max_iname_len;
{
    int i;

    /*
     * The first SQLSQLDAAlloc parameter determines the maximum number
     * of array elements in each variable in the descriptor. In
     * other words, it determines the maximum number of bind
     * variables or select-list items in the SQL statement.
     *
     * The second parameter determines the maximum length of
     * strings used to hold the names of select-list items
     * or placeholders.  The maximum length of column
     * names in ORACLE is 30, but you can allocate more or less
     * as needed.
     *
     * The third parameter determines the maximum length of
     * strings used to hold the names of any indicator
     * variables.  To follow ORACLE standards, the maximum
     * length of these should be 30.  But, you can allocate
     * more or less as needed.
     */

    if ((bind_dp =
            SQLSQLDAAlloc(SQL_SINGLE_RCTX, size,
                   max_vname_len, max_iname_len)) == (SQLDA *) 0)
    {
        fprintf(stderr,
            "Cannot allocate memory for bind descriptor.");
        return -1;  /* Have to exit in this case. */
    }
```

```
    if ((select_dp =
        SQLSQLDAAlloc (SQL_SINGLE_RCTX, size,
                max_vname_len, max_iname_len)) == (SQLDA *) 0)
    {
        fprintf(stderr,
            "Cannot allocate memory for select descriptor.");
        return -1;
    }
    select_dp->N = MAX_ITEMS;

    /* Allocate the pointers to the indicator variables, and the
       actual data. */
    for (i = 0; i < MAX_ITEMS; i++) {
        bind_dp->I[i] = (short *) malloc(sizeof (short));
        select_dp->I[i] = (short *) malloc(sizeof(short));
        bind_dp->V[i] = (char *) malloc(1);
        select_dp->V[i] = (char *) malloc(1);
    }

    return 0;
}


get_dyn_statement()
{
    char *cp, linebuf[256];
    int iter, plsql;
    int help();


    for (plsql = 0, iter = 1; ;)
    {
        if (iter == 1)
        {
            printf("\nSQL> ");
            dyn_statement[0] = '\0';
        }

        fgets(linebuf, sizeof linebuf, stdin);
        fflush(stdin);

        cp = strrchr(linebuf, '\n');
        if (cp && cp != linebuf)
            *cp = ' ';
        else if (cp == linebuf)
```

```
            continue;

        if ((strncmp(linebuf, "EXIT", 4) == 0) ||
            (strncmp(linebuf, "exit", 4) == 0))
        {
            return -1;
        }

        else if (linebuf[0] == '?' ||
            (strncmp(linebuf, "HELP", 4) == 0) ||
            (strncmp(linebuf, "help", 4) == 0))
        {
            help();
            iter = 1;
            continue;
        }

        if (strstr(linebuf, "BEGIN") ||
            (strstr(linebuf, "begin")))
        {
            plsql = 1;
        }

        strcat(dyn_statement, linebuf);

        if ((plsql && (cp = strrchr(dyn_statement, '/'))) ||
            (!plsql && (cp = strrchr(dyn_statement, ';'))))
        {
            *cp = '\0';
            break;
        }
        else
        {
            iter++;
            printf("%3d  ", iter);
        }
    }
    return 0;
}



set_bind_variables()
{
    int i, n;
```

```
char bind_var[64];

/* Describe any bind variables (input host variables) */
EXEC SQL WHENEVER SQLERROR DO sql_error();

bind_dp->N = MAX_ITEMS;  /* Init. count of array elements. */
EXEC SQL DESCRIBE BIND VARIABLES FOR S INTO bind_dp;

/* If F is negative, there were more bind variables
   than originally allocated by SQLSQLDAAlloc(). */
if (bind_dp->F < 0)
{
    printf
        ("\nToo many bind variables (%d), maximum is %d.\n",
                -bind_dp->F, MAX_ITEMS);
    return;
}

/* Set the maximum number of array elements in the
   descriptor to the number found. */
bind_dp->N = bind_dp->F;

/* Get the value of each bind variable as a
 * character string.
 *
 * C[i] contains the length of the bind variable
 *      name used in the SQL statement.
 * S[i] contains the actual name of the bind variable
 *      used in the SQL statement.
 *
 * L[i] will contain the length of the data value
 *      entered.
 *
 * V[i] will contain the address of the data value
 *      entered.
 *
 * T[i] is always set to 1 because in this sample program
 *      data values for all bind variables are entered
 *      as character strings.
 *      ORACLE converts to the table value from CHAR.
 *
 * I[i] will point to the indicator value, which is
 *      set to -1 when the bind variable value is "null".
 */
```

```
    for (i = 0; i < bind_dp->F; i++)
    {
        printf ("\nEnter value for bind variable %.*s:  ",
               (int)bind_dp->C[i], bind_dp->S[i]);
        fgets(bind_var, sizeof bind_var, stdin);

        /* Get length and remove the new line character. */
        n = strlen(bind_var) - 1;

        /* Set it in the descriptor. */
        bind_dp->L[i] = n;

        /* (re-)allocate the buffer for the value.
           SQLSQLDAAlloc() reserves a pointer location for
           V[i] but does not allocate the full space for
           the pointer. */

         bind_dp->V[i] = (char *) realloc(bind_dp->V[i],
                         (bind_dp->L[i] + 1));

        /* And copy it in. */
        strncpy(bind_dp->V[i], bind_var, n);

        /* Set the indicator variable's value. */
        if ((strncmp(bind_dp->V[i], "NULL", 4) == 0) ||
                (strncmp(bind_dp->V[i], "null", 4) == 0))
            *bind_dp->I[i] = -1;
        else
            *bind_dp->I[i] = 0;

        /* Set the bind datatype to 1 for CHAR. */
        bind_dp->T[i] = 1;
    }
}



process_select_list()
{
    int i, null_ok, precision, scale;

    if ((strncmp(dyn_statement, "SELECT", 6) != 0) &&
        (strncmp(dyn_statement, "select", 6) != 0))
    {
```

```
    select_dp->F = 0;
    return;
}


/* If the SQL statement is a SELECT, describe the
    select-list items.  The DESCRIBE function returns
    their names, datatypes, lengths (including precision
    and scale), and NULL/NOT NULL statuses. */

select_dp->N = MAX_ITEMS;

EXEC SQL DESCRIBE SELECT LIST FOR S INTO select_dp;

/* If F is negative, there were more select-list
   items than originally allocated by SQLSQLDAAlloc(). */
if (select_dp->F < 0)
{
    printf
       ("\nToo many select-list items (%d), maximum is %d\n",
            -(select_dp->F), MAX_ITEMS);
    return;
}

/* Set the maximum number of array elements in the
   descriptor to the number found. */
select_dp->N = select_dp->F;

/* Allocate storage for each select-list item.

   SQLNumberPrecV6() is used to extract precision and scale
   from the length (select_dp->L[i]).

   SQLColumnNullCheck() is used to reset the high-order bit of
   the datatype and to check whether the column
   is NOT NULL.

   CHAR    datatypes have length, but zero precision and
           scale.  The length is defined at CREATE time.

   NUMBER  datatypes have precision and scale only if
           defined at CREATE time.  If the column
           definition was just NUMBER, the precision
           and scale are zero, and you must allocate
           the required maximum length.
```

```
           DATE    datatypes return a length of 7 if the default
                   format is used.  This should be increased to
                   9 to store the actual date character string.
                   If you use the TO_CHAR function, the maximum
                   length could be 75, but will probably be less
                   (you can see the effects of this in SQL*Plus).

           ROWID   datatype always returns a fixed length of 18 if
                   coerced to CHAR.

           LONG and
           LONG RAW datatypes return a length of 0 (zero),
                   so you need to set a maximum.  In this example,
                   it is 240 characters.

           */

        printf ("\n");
        for (i = 0; i < select_dp->F; i++)
        {
            /* Turn off high-order bit of datatype (in this example,
               it does not matter if the column is NOT NULL). */
            SQLColumnNullCheck (&(select_dp->T[i]),
                   &(select_dp->T[i]), &null_ok);

            switch (select_dp->T[i])
            {
                case  1 : /* CHAR datatype: no change in length
                             needed, except possibly for TO_CHAR
                             conversions (not handled here). */
                    break;
                case  2 : /* NUMBER datatype: use SQLNumberPrecV6() to
                             extract precision and scale. */
                SQLNumberPrecV6 (SQL_SINGLE_RCTX, &(select_dp->L[i]), &precision,
&scale);
                             /* Allow for maximum size of NUMBER. */
                    if (precision == 0) precision = 40;
                          /* Also allow for decimal point and
                             possible sign. */
                    /* convert NUMBER datatype to FLOAT if scale > 0,
                       INT otherwise. */
                    if (scale > 0)
                        select_dp->L[i] = sizeof(float);
                    else
```

```
            select_dp->L[i] = sizeof(int);
        break;

    case  8 : /* LONG datatype */
        select_dp->L[i] = 240;
        break;

    case 11 : /* ROWID datatype */
        select_dp->L[i] = 18;
        break;

    case 12 : /* DATE datatype */
        select_dp->L[i] = 9;
        break;

    case 23 : /* RAW datatype */
        break;

    case 24 : /* LONG RAW datatype */
        select_dp->L[i] = 240;
        break;
}
/* Allocate space for the select-list data values.
   SQLSQLDAAlloc() reserves a pointer location for
   V[i] but does not allocate the full space for
   the pointer.  */

 if (select_dp->T[i] != 2)
   select_dp->V[i] = (char *) realloc(select_dp->V[i],
                              select_dp->L[i] + 1);
 else
   select_dp->V[i] = (char *) realloc(select_dp->V[i],
                              select_dp->L[i]);

/* Print column headings, right-justifying number
    column headings. */
if (select_dp->T[i] == 2)
   if (scale > 0)
     printf ("%.*s ",select_dp->L[i]+3, select_dp->S[i]);
   else
     printf ("%.*s ", select_dp->L[i], select_dp->S[i]);
else
    printf ("%-.*s ", select_dp->L[i], select_dp->S[i]);

/* Coerce ALL datatypes except for LONG RAW and NUMBER to
```

```
       character. */
    if (select_dp->T[i] != 24 && select_dp->T[i] != 2)
        select_dp->T[i] = 1;

    /* Coerce the datatypes of NUMBERs to float
       or int depending on the scale. */
    if (select_dp->T[i] == 2)
      if (scale > 0)
         select_dp->T[i] = 4;  /* float */
      else
         select_dp->T[i] = 3;  /* int */
}
printf ("\n\n");

/* FETCH each row selected and print the column values. */
EXEC SQL WHENEVER NOT FOUND GOTO end_select_loop;


for (;;)
{
    EXEC SQL FETCH C USING DESCRIPTOR select_dp;

    /* Since each variable returned has been coerced to a
       character string, int, or float very little processing
       is required here.  This routine just prints out the
       values on the terminal. */
    for (i = 0; i < select_dp->F; i++)
    {
        if (*select_dp->I[i] < 0)
            if (select_dp->T[i] == 4)
              printf ("%-*c ",(int)select_dp->L[i]+3, ' ');
            else
              printf ("%-*c ",(int)select_dp->L[i], ' ');
        else
            if (select_dp->T[i] == 3)     /* int datatype */
              printf ("%*d ", (int)select_dp->L[i],
                              *(int *)select_dp->V[i]);
            else if (select_dp->T[i] == 4)/* float datatype*/
              printf ("%*.2f ", (int)select_dp->L[i],
                              *(float *)select_dp->V[i]);
            else                          /* character string */
              printf ("%-*s ",
                      (int)select_dp->L[i], select_dp->V[i]);
    }
    printf ("\n");
```

```
    }
end_select_loop:
    return;
}



help()
{
    puts("\n\nEnter a SQL statement or a PL/SQL block");
    puts("at the SQL> prompt.");
    puts("Statements can be continued over several");
    puts("lines, except within string literals.");
    puts("Terminate a SQL statement with a semicolon.");
    puts("Terminate a PL/SQL block");
    puts("(which can contain embedded semicolons)");
    puts("with a slash (/).");
    puts("Typing \"exit\" (no semicolon needed)");
    puts("exits the program.");
    puts("You typed \"?\" or \"help\"");
    puts(" to get this message.\n\n");
}
sql_error()
{
    int i;

    /* ORACLE error handler */
    printf ("\n\n%.70s\n",sqlca.sqlerrm.sqlerrmc);
    if (parse_flag)
        printf("Parse error at character offset %d.\n",
           sqlca.sqlerrd[4]);

    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL ROLLBACK WORK;
    longjmp(jmp_continue, 1);
}
```

15

Writing User Exits

This chapter focuses on writing user exits for your Oracle Tools applications. You learn how C subroutines can do certain jobs more quickly and easily than SQL*Forms and Oracle Forms. The following topics are covered:

- What Is a User Exit?
- Why Write a User Exit?
- Developing a User Exit
- Writing a User Exit
- Calling a User Exit
- Passing Parameters to a User Exit
- Returning Values to a Form
- An Example
- Precompiling and Compiling a User Exit
- Sample Program: A User Exit
- Using the GENXTB Utility
- Linking a User Exit into SQL*Forms
- Guidelines
- EXEC TOOLS Statements

This chapter is supplemental. For more information about user exits, refer to the *SQL*Forms Designer's Reference*, the *Oracle Forms Reference Manual, Vol. 2*, and your system-specific Oracle documentation.

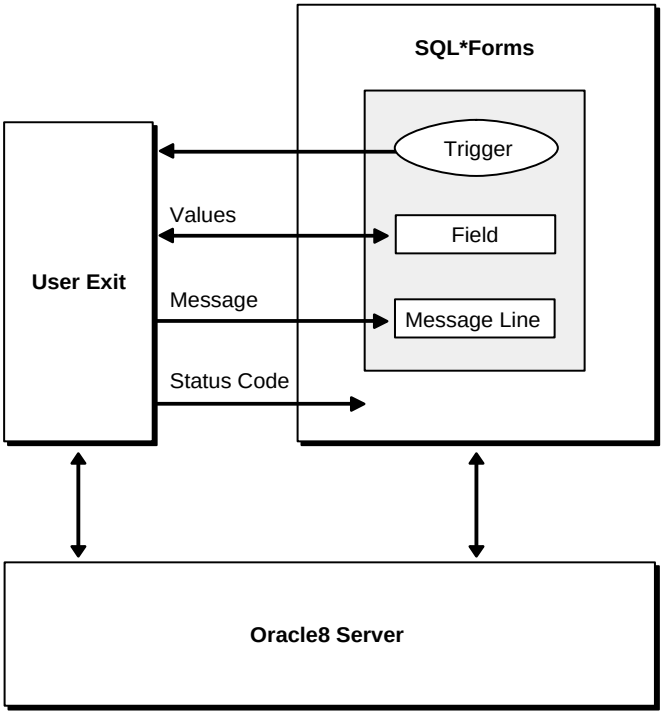
What Is a User Exit?

A *user exit* is a C subroutine written by you and called by Oracle Forms to do special-purpose processing. You can embed SQL statements and PL/SQL blocks in your user exit, then precompile it as you would a host program.

When called by an Oracle Forms V3 trigger, the user exit runs, then returns a status code to Oracle Forms. Your exit can display messages on the Oracle Forms status line, get and set field values, do high-speed computations and table lookups, and manipulate Oracle data.

Figure 15–1 shows how an Oracle Forms application interacts with a user exit.

Figure 15–1 Oracle Forms and a User Exit



Why Write a User Exit?

SQL*Forms Version 3 allows you to use PL/SQL blocks in triggers. So, in most cases, instead of calling a user exit, you can use the procedural power of PL/SQL. If the need arises, you can call user exits from a PL/SQL block with the USER_EXIT function. User exits are harder to write and implement than SQL, PL/SQL, or SQL*Forms commands. So, you will probably use them only to do processing that is beyond the scope of SQL, PL/SQL, and SQL*Forms. Some common uses follow:

- operations more quickly or easily done in a third generation languages like C (numerical integration, for instance)
- controlling real time devices or processes (issuing a sequence of instructions to a printer or graphics device, for example)
- data manipulations that need extended procedural capabilities (recursive sorting, for example)
- special file I/O operations

Developing a User Exit

This section outlines the way to develop a SQL*Forms 3.0 user exit; later sections go into more detail. For information about the EXEC TOOLS options available with SQL*Forms 4, see the section "EXEC TOOLS Statements" on page 15-14. To incorporate a user exit into a form, you take the following steps:

1. Write the user exit in Pro*C.
2. Precompile the source code.
3. Compile the. c file from step 2.
4. Use the GENXTB utility to create a database table, IAPXTB.
5. Use the GENXTB form in SQL*Forms to insert your user exit information into the table.
6. Use the GENXTB utility to read the information from the table and create an IAPXIT source code module. Then compile the source code module.
7. Create a new SQL*Forms executable by linking the standard SQL*Forms modules, your user exit object, and the IAPXIT object created in step 6.
8. In the form, define a trigger to call the user exit.

9. Instruct operators to use the new IAP when running the form. This is unnecessary if the new IAP replaces the standard one. For details, see the Oracle installation or user's guide for your system.

Writing a User Exit

You can use the following kinds of statements to write your SQL*Forms user exit:

- C code
- EXEC SQL
- EXEC ORACLE
- EXEC TOOLS

This section focuses on the EXEC TOOLS statements, which let you pass values between SQL*Forms and a user exit.

Requirements for Variables

The variables used in EXEC TOOLS statements must correspond to field names used in the form definition. If a field reference is ambiguous because you did not specify a block name, EXEC IAF defaults to the *context block*—the block that calls the user exit. An invalid or ambiguous reference to a form field generates an error. Host variables must be prefixed with a colon (:) in EXEC IAF statements.

> **Note:** Indicator variables are *not* allowed in EXEC IAF GET and PUT statements.

The IAF GET Statement

This statement allows your user exit to "get" values from fields on a form and assign them to host variables. The user exit can then use the values in calculations, data manipulations, updates, and so on. The syntax of the GET statement follows:

```
EXEC IAF GET field_name1, field_name2, ...
     INTO :host_variable1, :host_variable2, ...;
```

where *field_name* can be any of the following SQL*Forms variables:

- field
- block.field
- system variable
- global variable

- host variable (prefixed with a colon) containing the value of a field, block.field, system variable, or global variable

If a *field_name* is not qualified, the field must be in the context block.

Using IAF GET

The following example shows how a user exit GETs a field value and assigns it to a host variable:

```
EXEC IAF GET employee.job INTO :new_job;
```

All field values are character strings. If it can, GET converts a field value to the datatype of the corresponding host variable. If an illegal or unsupported datatype conversion is attempted, an error is generated.

In the last example, a constant is used to specify *block.field*. You can also use a host string to specify block and field names, as follows:

```
char blkfld[20] = "employee.job";
EXEC IAF GET :blkfld INTO :new_job;
```

Unless the field is in the context block, the host string must contain the full *block.field* reference with intervening period. For example, the following usage is *invalid*:

```
char blk[20] = "employee";
strcpy(fld, "job");
EXEC IAF GET :blk.:fld INTO :new_job;
```

You can mix explicit and stored field names in a GET statement field list, but not in a single field reference. For example, the following usage is *invalid*:

```
strcpy(fld, "job");
EXEC IAF GET employee.:fld INTO :new_job;
```

The IAF PUT Statement

This statement allows your user exit to "put" the values of constants and host variables into fields on a form. Thus, the user exit can display on the SQL*Forms screen any value or message you like. The syntax of the PUT statement follows:

```
EXEC IAF PUT field_name1, field_name2, ...
    VALUES (:host_variable1, :host_variable2, ...);
```

where *field_name* can be any of the following SQL*Forms variables:

- field
- block.field
- system variable
- global variable
- host variable (prefixed with a colon) containing the value of a field, block.field, system variable, or global variable

Using IAF PUT

The following example shows how a user exit PUTs the values of a numeric constant, string constant, and host variable into fields on a form:

```
EXEC IAF PUT employee.number, employee.name, employee.job
     VALUES (7934, 'MILLER', :new_job);
```

Like GET, PUT lets you use a host string to specify block and field names, as follows:

```
char blkfld[20] = "employee.job";
...
EXEC IAF PUT :blkfld VALUES (:new_job);
```

On character-mode terminals, a value PUT into a field is displayed when the user exit returns, rather than when the assignment is made, provided the field is on the current display page. On block-mode terminals, the value is displayed the next time a field is read from the device.

If a user exit changes the value of a field several times, only the last change takes effect.

Calling a User Exit

You call a user exit from a SQL*Forms trigger using a packaged procedure named USER_EXIT (supplied with SQL*Forms). The syntax you use is

```
USER_EXIT(user_exit_string [, error_string]);
```

where *user_exit_string* contains the name of the user exit plus optional parameters and *error_string* contains an error message issued by SQL*Forms if the user exit fails. For example, the following trigger command calls a user exit named LOOKUP:

```
USER_EXIT('LOOKUP');
```

Notice that the user exit string is enclosed by single (not double) quotes.

Passing Parameters to a User Exit

When you call a user exit, SQL*Forms passes it the following parameters automatically:

Command Line	Is the user exit string.
Command Line Length	Is the length (in characters) of the user exit string.
Error Message	Is the error string (failure message) if one is defined.
Error Message Length	Is the length of the error string.
In-Query	Is a Boolean value indicating whether the exit was called in normal or query mode.

However, the user exit string allows you to pass additional parameters to the user exit. For example, the following trigger command passes two parameters and an error message to the user exit LOOKUP:

Notice that the user exit string is enclosed by single (not double) quotes.

```
USER_EXIT('LOOKUP 2025 A', 'Lookup failed');
```

You can use this feature to pass field names to the user exit, as the following example shows:

```
USER_EXIT('CONCAT firstname, lastname, address');
```

However, it is up to the user exit, not SQL*Forms, to parse the user exit string.

Returning Values to a Form

When a user exit returns control to SQL*Forms, it must also return a code indicating whether it succeeded, failed, or suffered a fatal error. The return code is an integer constant defined by SQL*Forms (see the next section). The three results have the following meanings:

success	The user exit encountered no errors. SQL*Forms proceeds to the *success* label or the next step, unless the Reverse Return Code switch is set by the calling trigger step.
failure	The user exit detected an error, such as an invalid value in a field. An optional message passed by the exit appears on the message line at the bottom of the SQL*Forms screen and on the Display Error screen. SQL*Forms responds as it does to a SQL statement that affects no rows.
fatal error	The user exit detected a condition that makes further processing impossible, such as an execution error in a SQL statement. An optional error message passed by the exit appears on the SQL*Forms Display Error screen. SQL*Forms responds as it does to a fatal SQL error. If a user exit changes the value of a field, then returns a *failure* or *fatal error* code, SQL*Forms does *not* discard the change. Nor does SQL*Forms discard changes when the Reverse Return Code switch is set and a *success* code is returned.

The IAP Constants

SQL*Forms defines three symbolic constants for use as return codes. Depending on the host language, they are prefixed with IAP or SQL. For example, they might be IAPSUCC, IAPFAIL, and IAPFTL.

Using the SQLIEM Function

By calling the function SQLIEM, your user exit can specify an error message that SQL*Forms will display on the message line if the trigger step fails or on the Display Error screen if the step causes a fatal error. The specified message replaces any message defined for the step. The syntax of the SQLIEM function call is

```
sqliem (char *error_message, int message_length);
```

where *error_message* and *message_length* are character and integer variables, respectively. The Pro*C/C++ Precompiler generates the appropriate external function declaration for you. *You pass both parameters by reference; that is, you pass their addresses, not their values.* SQLIEM is a SQL*Forms function; it cannot be called from other Oracle tools such as SQL*ReportWriter.

Using WHENEVER

You can use the WHENEVER statement in an exit to detect invalid datatype conversions (SQLERROR), truncated values PUT into form fields (SQLWARNING), and queries that return no rows (NOT FOUND).

An Example

The following example shows how a user exit that uses the EXEC IAF GET and PUT routines, as well as the *sqliem* function, is coded.

```
int
myexit()
{
    char field1[20], field2[20], value1[20], value2[20];
    char result_value[20];
    char errmsg[80];
    int errlen;

    #include sqlca.h
    EXEC SQL WHENEVER SQLERROR GOTO sql_error;
    /* get field values into form */
    EXEC IAF GET :field1, :field2 INTO :value1, :value2;
    /* manipulate the values to obtain result_val */
    ...
    /* put result_val into form field result */
    EXEC IAF PUT result VALUES (:result_val);
    return IAPSUCC;   /* trigger step succeeded */

sql_error:
    strcpy(errmsg, CONCAT("MYEXIT", sqlca.sqlerrm.sqlerrmc);
    errlen = strlen(errmsg);
    sqliem(errmsg, &errlen); /* send error msg to Forms */
    return IAPFAIL;
```

Precompiling and Compiling a User Exit

User exits are precompiled like stand-alone host programs. Refer to Chapter 9, “Running the Pro*C/C++ Precompiler”. For instructions on compiling a user exit, see the Oracle installation or user’s guide for your system.

Sample Program: A User Exit

The example below shows a user exit.

```
/************************************************************
Sample Program 5:  SQL*Forms User Exit

This user exit concatenates form fields.  To call the user
exit from a SQL*Forms trigger, use the syntax

   user_exit('CONCAT field1, field2, ..., result_field');

where user_exit is a packaged procedure supplied with SQL*Forms
and CONCAT is the name of the user exit.  A sample form named
CONCAT invokes the user exit.
************************************************************/

#define min(a, b) ((a < b) ? a : b)
#include <stdio.h>
#include <string.h>

/* Include the SQL Communications Area, a structure through which
   Oracle makes runtime status information such as error
   codes, warning flags, and diagnostic text available to the
   program. */

EXEC SQL INCLUDE sqlca;

/* All host variables used in embedded SQL must appear in the
   Declare Section. */

VARCHAR   field[81];
VARCHAR   value[81];
VARCHAR   result[241];

int concat(cmd, cmdlen, msg, msglen, query)

char *cmd;     /* command line in trigger step ("CONCAT...") */
int  *cmdlen;  /* length of command line */
char *msg;     /* trigger step failure message from form */
int  *msglen;  /* length of failure message */
int  *query;   /* TRUE if invoked by post-query trigger,
                  FALSE otherwise */
{
    char *cp = cmd + 7;    /* pointer to field list in
```

```
                                cmd string; 7 characters
                                are needed for "CONCAT " */
    char *fp = (char*)&field.arr[0]; /* pointer to a field name in
                                        cmd string */
    char  errmsg[81];      /* message returned to SQL*Forms
                              on error */
    int   errlen;          /* length of message returned
                              to SQL*Forms */

    /* Branch to label sqlerror if an Oracle error occurs. */
    EXEC SQL WHENEVER SQLERROR GOTO sqlerror;

    result.arr[0] = '\0';
    /* Parse field names from cmd string. */
    for (; *cp != '\0'; cp++)
    {
       if (*cp != ',' && *cp != ' ')
           /* Copy a field name into field.arr from cmd. */
       {
           *fp = *cp;
           fp++;
       }
       else
           if (*cp == ' ')
           {   /* Have whole field name now. */
               *fp = '\0';
               field.len = strlen((char *) field.arr);
               /* Get field value from form. */
               EXEC IAF GET :field INTO :value;
               value.arr[value.len] = '\0';
               strcat((char *) result.arr, (char *) value.arr);
              /* Reset field pointer. *
               fp = (char *)&field.arr[0];/
           }
    }

    /* Have last field name now. */
    *fp = '\0';
    field.len = strlen((char *) field.arr);
    result.len = strlen((char *) result.arr);
    /* Put result into form. */
    EXEC IAF PUT :field VALUES (:result);
    return(IAPSUCC);  /* Trigger step succeeded. */

sqlerror:
```

```
    strcpy(errmsg, "CONCAT: ");
    strncat(errmsg, sqlca.sqlerrm.sqlerrmc, min(72,
        sqlca.sqlerrm.sqlerrml));
    errlen = strlen(errmsg);
    /* Pass error message to SQL*Forms status line. */
    sqliem(errmsg, &errlen);
    return(IAPFAIL);  /* Trigger step failed. */
}
```

Using the GENXTB Utility

The IAP program table IAPXTB in module IAPXIT contains an entry for each user exit linked into IAP. IAPXTB tells IAP the name, location, and host language of each user exit. When you add a new user exit to IAP, you must add a corresponding entry to IAPXTB. IAPXTB is derived from a database table, also named IAPXTB. You can modify the database table by running the GENXTB form on the operating system command line, as follows:

```
RUNFORM GENXTB username/password
```

A form is displayed that allows you to enter the following information for each user exit you define:

- exit name (see the section "Guidelines" on page 15-13)
- C-language code
- date created
- date last modified
- Comments

After modifying the IAPXTB database table, use the GENXTB utility to read the table and create an Assembler or C source program that defines the module IAPXIT and the IAPXTB program table it contains. The source language used depends on your operating system. The syntax you use to run the GENXTB utility is

```
GENXTB username/password outfile
```

where *outfile* is the name you give the Assembler or C source program that GENXTB creates.

Linking a User Exit into SQL*Forms

Before running a form that calls a user exit, you must link the user exit into IAP, the SQL*Forms component that runs a form. The user exit can be linked into your standard version of IAP or into a special version for those forms that call the exit.

To produce a new executable copy of IAP, link your user exit object module, the standard IAP modules, the IAPXIT module, and any modules needed from the Oracle and C link libraries.

The details of linking are system-dependent. Check the Oracle installation or user's guide for your system.

Guidelines

The guidelines in this section will help you avoid some

common pitfalls.

Naming the Exit

The name of your user exit cannot be an Oracle reserved word. Also avoid using names that conflict with the names of SQL*Forms commands, function codes, and externally defined names used by SQL*Forms. The name of the user exit entry point in the source code becomes the name of the user exit itself. The exit name must be a valid C function name, and a valid filename for your operating system.

SQL*Forms converts the name of a user exit to upper case before searching for the exit. Therefore, the exit name must be in upper case in your source code.

Connecting to Oracle

User exits communicate with Oracle via the connection made by SQL*Forms. However, a user exit can establish additional connections to any database via SQL*Net. For more information, see the section "Concurrent Connections" on page 4-23.

Issuing I/O Calls

File I/O is supported but screen I/O is not.

Using Host Variables

Restrictions on the use of host variables in a stand-alone program also apply to user exits. Host variables must be prefixed with a colon in EXEC SQL and EXEC IAF statements. The use of host arrays is not allowed in EXEC IAF statements.

Updating Tables

Generally, a user exit should not UPDATE database tables associated with a form. For example, suppose an operator updates a record in the SQL*Forms work space, then a user exit UPDATEs the corresponding row in the associated database table. When the transaction is COMMITted, the record in the SQL*Forms work space is applied to the table, overwriting the user exit UPDATE.

Issuing Commands

Avoid issuing a COMMIT or ROLLBACK command from your user exit because Oracle will commit or roll back work begun by the SQL*Forms operator, not just work done by the user exit. Instead, issue the COMMIT or ROLLBACK from the SQL*Forms trigger. This also applies to data definition commands (such as ALTER, CREATE, and GRANT) because they issue an implicit COMMIT before and after executing.

EXEC TOOLS Statements

EXEC TOOLS statements support the basic Oracle Toolset (Oracle Forms V4, Oracle Report V2, and Oracle Graphics V2) by providing a generic way to handle get, set, and exception callbacks from user exits. The following discussion focuses on Oracle Forms but the same concepts apply to Oracle Report and Oracle Graphics.

Writing a Toolset User Exit

Besides EXEC SQL, EXEC ORACLE, and host language statements, you can use the following EXEC TOOLS statements to write an Oracle Forms user exit:

- SET
- GET
- SET CONTEXT
- GET CONTEXT
- MESSAGE

The EXEC TOOLS GET and SET statements replace the EXEC IAF GET and PUT statements used with earlier versions of Oracle Forms. Unlike IAF GET and PUT, however, TOOLS GET and SET accept indicator variables. The EXEC TOOLS MESSAGE statement replaces the message-handling function *sqliem*. Now, let us take a brief look at all the EXEC TOOLS statements. For more information, see the *Oracle Forms Reference Manual, Vol 2*.

EXEC TOOLS SET

The EXEC TOOLS SET statement passes values from a user exit to Oracle Forms. Specifically, it assigns the values of host variables and constants to Oracle Forms variables and items. Values passed to form items display after the user exit returns control to the form. To code the EXEC TOOLS SET statement, you use the syntax

```
EXEC TOOLS SET form_variable[, ...]
     VALUES ({:host_variable :indicator | constant}[, ...]);
```

where *form_variable* is an Oracle Forms field, block.field, system variable, or global variable, or a host variable (prefixed with a colon) containing the value of one of the foregoing items. In the following example, a user exit passes an employee name to Oracle Forms:

```
char ename[20];
short ename_ind;

...

    strcpy(ename, "MILLER");
    ename_ind = 0;
    EXEC TOOLS SET emp.ename VALUES (:ename :ename_ind);
```

In this example, *emp.ename* is an Oracle Forms block.field.

EXEC TOOLS GET

The EXEC TOOLS GET statement passes values from Oracle Forms to a user exit. Specifically, it assigns the values of Oracle Forms variables and items to host variables. As soon as the values are passed, the user exit can use them for any purpose. To code the EXEC TOOLS GET statement, you use the syntax

```
EXEC TOOLS GET form_variable[, ...]
    INTO :host_variable:indicator[, ...];
```

where *form_variable* is an Oracle Forms field, block.field, system variable, or global variable, or a host variable (prefixed with a colon) containing the value of one of the foregoing items. In the following example, Oracle Forms passes an item name from a block to your user exit:

```
...
char     name_buff[20];
VARCHAR  name_fld[20];

strcpy(name_fld.arr, "EMP.NAME");
name_fld.len = strlen(name_fld.arr);
EXEC TOOLS GET :name_fld INTO :name_buff;
```

EXEC TOOLS SET CONTEXT

The EXEC TOOLS SET CONTEXT statement saves context information from a user exit for later use in another user exit. A pointer variable points to a block of memory in which the context information is stored. With SET CONTEXT, you need not declare a global variable to hold the information. To code the EXEC TOOLS SET CONTEXT statement, you use the syntax

```
EXEC TOOLS SET CONTEXT :host_pointer_variable
    IDENTIFIED BY context_name;
```

where *context_name* is an undeclared identifier or a character host variable (prefixed with a colon) that names the context area.

```
...
char  *context_ptr;
char  context[20];

strcpy(context, "context1")
EXEC TOOLS SET CONTEXT :context IDENTIFIED BY application1;
```

EXEC TOOLS GET CONTEXT

The EXEC TOOLS GET CONTEXT statement retrieves context information (saved earlier by SET CONTEXT) into a user exit. A host-language pointer variable points to a block of memory in which the context information is stored. To code the EXEC TOOLS GET CONTEXT statement, you use the syntax

```
EXEC TOOLS GET CONTEXT context_name
    INTO :host_pointer_variable;
```

where *context_name* is an undeclared identifier or a character host variable (prefixed with a colon) that names the context area. In the following example, your user exit retrieves context information 1saved earlier:

```
...
char  *context_ptr;

EXEC TOOLS GET CONTEXT application1 INTO :context_ptr;
```

EXEC TOOLS MESSAGE

The EXEC TOOLS MESSAGE statement passes a message from a user exit to Oracle Forms. The message is displayed on the Oracle Forms message line after the user exit returns control to the form. To code the EXEC TOOLS MESSAGE statement, you use the syntax

```
EXEC TOOLS MESSAGE message_text [severity_code];
```

where *message_text* is a quoted string or a character host variable (prefixed with a colon), and the optional *severity_code* is an integer constant or an integer host variable (prefixed with a colon). The MESSAGE statement does *not* accept indicator variables. In the following example, your user exit passes an error message to Oracle Forms:

```
EXEC TOOLS MESSAGE 'Bad field name! Please reenter.';
```

16

Using the Object Type Translator

This chapter discusses the Object Type Translator (OTT), which maps database object types and named collection types to C structs for use in OCI and Pro*C/C++ applications.

Support for Objects and for the Object Type Translator are available only if you have purchased the Oracle8 Enterprise Edition with the Objects Option.

The chapter includes the following sections:

- OTT Overview
- What Is the Object Type Translator
- Using OTT with OCI Applications
- Using OTT with Pro*C/C++ Applications
- OTT Reference

OTT Overview

OTT (The Object Type Translator) assists in the development of C or Java language applications that make use of user-defined types in an Oracle8 Server.

Through the use of SQL CREATE TYPE statements, you can create object types. The definitions of these types are stored in the database, and can be used in the creation of database tables. Once these tables are populated, an OCI, Pro*C/C++, or Java programmer can access objects stored in the tables.

An application that accesses object data must be able to represent the data in a host language format. This is accomplished by representing object types as C structs. It would be possible for a programmer to code struct declarations by hand to represent database object types, but this can be very time-consuming and error-prone if many types are involved. OTT simplifies this step by automatically generating appropriate struct declarations. For Pro*C/C++, the application only needs to include the header file generated by OTT. In OCI, the application also needs to call an initialization function generated by OTT.

In addition to creating structs that represent stored datatypes, OTT also generates parallel indicator structs which indicate whether an object type or its fields are null.

> **See Also:** For detailed information about object types and collections, refer to Chapter 8, "Object Support in Pro*C/C++".

What Is the Object Type Translator

The Object Type Translator (OTT) converts database definitions of object types and named collection types into C struct declarations which can be included in an OCI or Pro*C/C++ application.

Both OCI programmers and Pro*C/C++ programmers must explicitly invoke OTT to translate database types to C representations. OCI programmers must also initialize a data structure called the *Type Version Table* with information about the user-defined types required by the program. Code to perform this initialization is generated by OTT. In Pro*C/C++, the type version information is recorded in the OUTTYPE file which is passed as a parameter to Pro*C/C++.

On most operating systems, OTT is invoked on the command line. It takes as input an *intype file*, and it generates an *outtype file* and one or more C *header files* and an optional *implementation file* (for OCI programmers). The following is an example of a command that invokes OTT:

```
ott userid=scott/tiger intype=demoin.typ outtype=demoout.typ code=c hfile=demo.h
```

This command causes OTT to connect to the database with username *scott* and password *tiger*, and translate database types to C structs, based on instructions in the `intype` file, *demoin.typ*. The resulting structs are output to the `header` file, *demo.h*, for the host language (C) specified by the `code` parameter. The `outtype` file, *demoout.typ*, receives information about the translation.

Each of these parameters is described in more detail in later sections of this chapter.

Sample `demoin.typ` file:

```
CASE=LOWER
TYPE employee
```

Sample `demoout.typ` file:

```
CASE = LOWER
TYPE EMPLOYEE AS employee
  VERSION = "$8.0"
  HFILE = demo.h
```

In this example, the `demoin.typ` file contains the type to be translated, preceded by TYPE (e.g., TYPE employee). The structure of the `outtype` file is similar to the `intype` file, with the addition of information obtained by OTT.

Once OTT has completed the translation, the header file contains a C struct representation of each type specified in the intype file, and a null indicator struct corresponding to each type. For example, if the employee type listed in the intype file was defined as

```
CREATE TYPE employee AS OBJECT
(
    name       VARCHAR2(30),
    empno      NUMBER,
    deptno     NUMBER,
    hiredate   DATE,
    salary     NUMBER
);
```

the header file generated by OTT (`demo.h`) includes, among other items, the following declarations:

```
struct employee
{
    OCIString * name;
    OCINumber empno;
    OCINumber deptno;
```

```
    OCIDate   hiredate;
    OCINumber salary;
};
typedef struct emp_type emp_type;

struct employee_ind
{
    OCIInd _atomic;
    OCIInd name;
    OCIInd empno;
    OCIInd deptno;
    OCIInd hiredate;
    OCIInd salary;
};
typedef struct employee_ind employee_ind;
```

> **Note:** Parameters in the intype file control the way generated structs are named. In this example, the struct name `employee` matches the database type name `employee`. The struct name is in lower case because of the line CASE=lower in the intype file.
>
> The datatypes that appear in the struct declarations (for example, **OCIString** and **OCIInd**) are special datatypes which are new to Oracle8. For more information about these types, see "OTT Datatype Mappings" on page 16-9.

The following sections describe these aspects of using OTT:

- Creating Types in the Database
- Invoking OTT
- The OTT Command Line
- The Intype File
- OTT Datatype Mappings
- Null Indicator Structs
- The Outtype File

The remaining sections of the chapter discuss the use of OTT with OCI and Pro*C/C++, followed by a reference section that describes command line syntax, parameters, intype file structure, nested `#include` file generation, schema names usage, default name mapping, and restrictions.

Creating Types in the Database

The first step in using OTT is to create object types or named collection types and store them in the database. This is accomplished through the use of the SQL CREATE TYPE statement.

> **See Also:** For information about creating object types and collections, refer to Chapter 8, “Object Support in Pro*C/C++”.

Invoking OTT

The next step is to invoke OTT.

You can specify OTT parameters on the command line, or in a file called a configuration file. Certain parameters can also be specified in the INTYPE file.

If you specify a parameter in more than one place, its value on the command line will take precedence over its value in the INTYPE file, which takes precedence over its value in a user-defined configuration file, which takes precedence over its value in the default configuration file.

Command Line

Parameters (also called options) set on the command line override any set elsewhere. See "The OTT Command Line" on page -6 for more information.

Configuration File

A configuration file is a text file that contains OTT parameters. Each non-blank line in the file contains one parameter, with its associated value or values. If more than one parameter is put on a line, only the first one will be used. No whitespace may occur on any non-blank line of a configuration file.

A configuration file can be named on the command line. In addition, a default configuration file is always read. This default configuration file must always exist, but can be empty. The name of the default configuration file is *ottcfg.cfg*, and the location of the file is system-specific. See your platform-specific documentation for further information.

INTYPE File

The INTYPE file gives a list of types for OTT to translate.

The parameters CASE, HFILE, INITFUNC, and INITFILE can appear in the INTYPE file. See “The Intype File” on page 16-8 for more information.

The OTT Command Line

On most platforms, OTT is invoked on the command line. You can specify the input and output files and the database connection information, among other things. Consult your platform-specific documentation to see how to invoke OTT on your platform.

The following is an example (example 1) of an OTT invocation from the command line:

```
ott userid=scott/tiger intype=demoin.typ outtype=demoout.typ code=c hfile=demo.h
```

Note: No spaces are permitted around the equals sign (=).

The following sections describe the elements of the command line used in this example.

For a detailed discussion of the various OTT command line options, see "OTT Reference" on page 16-25.

OTT

Causes OTT to be invoked. It must be the first item on the command line.

Userid

Specifies the database connection information which OTT will use. In example one, OTT will attempt to connect with username *scott* and password *tiger*.

Intype

Specifies the name of the intype file which will be used. In example 1, the name of the intype file is specified as `demoin.typ`.

Outtype

Specifies the name of the outtype file. When OTT generates the C header file, it also writes information about the translated types into the outtype file. This file contains an entry for each of the types that is translated, including its version string, and the header file to which its C representation was written.

In example one, the name of the outtype file is specified as *demoout.typ*.

Note: If the file specified by the *outtype* keyword already exists, it will be overwritten when OTT runs, with one exception: if the contents of the file as generated by OTT are identical to the previous contents of the file, OTT will not actually write to the file. This preserves the modification time of the file so that

UNIX *make* and similar facilities on other platforms do not perform unnecessary recompilations.

Code

Specifies the target language for the translation. The following options are available:

- C (equivalent to ANSI_C)
- ANSI_C (for ANSI C)
- KR_C (for Kernighan & Ritchie C)

There is currently no default value, so this parameter is required.

Struct declarations are identical in both C dialects. The style in which the initialization function defined in the INITFILE file is defined depends on whether KR_C is used. If the INITFILE option is not used, all three options are equivalent.

Hfile

Specifies the name of the C header file to which the generated structs should be written. In example 1, the generated structs will be stored in a file called `demo.h`.

Note: If the file specified by the `hfile` keyword already exists, it will be overwritten when OTT runs, with one exception: if the contents of the file as generated by OTT are identical to the previous contents of the file, OTT will not actually write to the file. This preserves the modification time of the file so that UNIX *make* and similar facilities on other platforms do not perform unnecessary recompilations.

Initfile

Specifies the use of the C source file into which the type initialization function is to be written.

The initialization function is only needed in OCI programs. In Pro*C/C++ programs, the Pro*C/C++ runtime library initializes types for the user.

Note: If the file specified by the `initfile` keyword already exists, it will be overwritten when OTT runs, with one exception: if the contents of the file as generated by OTT are identical to the previous contents of the file, OTT will not actually write to the file. This preserves the modification time of the file so that UNIX *make* and similar facilities on other platforms do not perform unnecessary recompilations.

Initfunc

Specifies the name of the initialization function to be defined in the initfile.

If this parameter is not used and an initialization function is generated, the name of the initialization function will be the same as the base name of the *initfile*.

This function is only needed in OCI programs.

The Intype File

When you run OTT, the INTYPE file tells OTT which database types should be translated. It can also control the naming of the generated structs. You can create the intype file, or use the outtype file of a previous invocation of OTT. If the INTYPE parameter is not used, all types in the schema to which OTT connects are translated.

The following is a simple example of a user-created intype file:

```
CASE=LOWER
TYPE employee
  TRANSLATE SALARY$ AS salary
            DEPTNO AS department
TYPE ADDRESS
TYPE item
TYPE "Person"
TYPE PURCHASE_ORDER AS p_o
```

The first line, with the CASE keyword, indicates that generated C identifiers should be in lower case. However, this CASE option is only applied to those identifiers that are not explicitly mentioned in the intype file. Thus, *employee* and *ADDRESS* would always result in C structures `employee` and `ADDRESS`, respectively. The members of these structures would be named in lower case.

See “CASE” on page 16-30 for further information regarding the CASE option.

The lines that begin with the TYPE keyword specify which types in the database should be translated. In this case, the *EMPLOYEE, ADDRESS, ITEM, PERSON,* and *PURCHASE_ORDER* types.

The TRANSLATE...AS keywords specify that the name of an object attribute should be changed when the type is translated into a C struct. In this case, the SALARY$ attribute of the `employee` type is translated to `salary`.

The AS keyword in the final line specifies that the name of an object type should be changed when it is translated into a struct. In this case, the *purchase_order* database type is translated into a struct called *p_o*.

If you do not use AS to translate a type or attribute name, the database name of the type or attribute will be used as the C identifier name, except that the CASE option will be observed, and any characters that cannot be mapped to a legal C identifier character will be replaced by an underscore. Reasons for translating a type or attribute name include:

- the name contains characters other than letters, digits, and underscores
- the name conflicts with a C keyword
- the type name conflicts with another identifier in the same scope. This can happen, for example, if the program uses two types with the same name from different schemas.
- the programmer prefers a different name

OTT may need to translate additional types that are not listed in the intype file. This is because OTT analyzes the types in the intype file for type dependencies before performing the translation, and translates other types as necessary. For example, if the *ADDRESS* type were not listed in the intype file, but the *Person* type had an attribute of type *ADDRESS*, OTT would still translate *ADDRESS* because it is required to define the *Person* type.

A normal case-insensitive SQL identifier can be spelled in any combination of upper and lower case in the INTYPE file, and is not quoted.

Use quotation marks, such as TYPE "*Person*" to reference SQL identifiers that have been created in a case-sensitive manner, e.g., CREATE TYPE "*Person*". A SQL identifier is case-sensitive if it was quoted when it was declared. Quotation marks can also be used to refer to a SQL identifier that is an OTT-reserved word, e.g., TYPE "CASE". When a name is quoted for this reason, the quoted name must be in upper case if the SQL identifier was created in a case-insensitive manner, e.g., CREATE TYPE Case. If an OTT-reserved word is used to refer to the name of a SQL identifier but is not quoted, OTT will report a syntax error in the INTYPE file.

> **See Also:** For a more detailed specification of the structure of the intype file and the available options, see “Structure of the Intype File” on page 16-32.

OTT Datatype Mappings

When OTT generates a C struct from a database type, the struct contains one element corresponding to each attribute of the object type. The datatypes of the attributes are mapped to types that are used in Oracle8’s object data types. The datatypes found in Oracle8 include a set of predefined, primitive types, and provide for the creation of user-defined types, like object types and collections.

The set of predefined types in Oracle8 includes standard types that are familiar to most programmers, including number and character types. It also includes new datatypes being introduced with Oracle8 (for example, BLOB or CLOB).

Oracle8 also includes a set of predefined types that are used to represent object type attributes in C structs. As an example, consider the following object type definition, and its corresponding OTT-generated struct declarations:

```
CREATE TYPE employee AS OBJECT
(   name       VARCHAR2(30),
    empno      NUMBER,
    deptno     NUMBER,
    hiredate   DATE,
    salary$    NUMBER);
```

The OTT output, assuming CASE=LOWER and no explicit mappings of type or attribute names, is:

```
struct employee
{   OCIString * name;
    OCINumber empno;
    OCINumber department;
    OCIDate   hiredate;
    OCINumber salary_;
};
typedef struct emp_type emp_type;
struct employee_ind
{
    OCIInd _atomic;
    OCIInd name;
    OCIInd empno;
    OCIInd department;
    OCIInd hiredate;
    OCIInd salary_;
}
typedef struct employee_ind employee_ind;
```

The indicator struct (`struct employee_ind`) is explained in "Null Indicator Structs" on page 16-15.

The datatypes in the struct declarations—*OCIString, OCINumber, OCIDate, OCIInd*—are C mappings of object types introduced in Oracle8. They are used here to map the datatypes of the object type attributes. The *number* datatype of the `empno` attribute, maps to the new *OCINumber* datatype, for example. These new datatypes can also be used as the types of bind and define variables.

See Also: For further information about the use of datatypes, including object datatypes, in OCI applications, refer to Chapter 5 of the *Programmer's Guide to the Oracle Call Interface.*

Mapping Object Datatypes to C

This section describes the mappings of Oracle8 object attribute types to C types generated by OTT. "OTT Type Mapping Example" on page 16-12 includes examples of many of these different mappings. Table 16–1 lists the mappings from types that can be used as attributes of object datatypes that are generated by OTT.

Table 16–1 Object Datatype Mappings for Object Type Attributes

Object Attribute Types	C Mapping
VARCHAR2(N)	OCIString *
VARCHAR(N)	OCIString *
CHAR(N), CHARACTER(N)	OCIString *
NUMBER, NUMBER(N), NUMBER(N,N)	OCINumber
NUMERIC, NUMERIC(N), NUMERIC(N,N)	OCINumber
REAL	OCINumber
INT, INTEGER, SMALLINT	OCINumber
FLOAT, FLOAT(N), DOUBLE PRECISION	OCINumber
DEC, DEC(N), DEC(N,N)	OCINumber
DECIMAL, DECIMAL(N), DECIMAL(N,N)	OCINumber
DATE	OCIDate
BLOB	OCIBlobLocator *
CLOB	OCIClobLocator *
BFILE	OCIBFileLocator *
Nested Object Type	C name of the nested object type
REF	declared using typedef; equivalent to OCIRef * See the following example.

Table 16–1 Object Datatype Mappings for Object Type Attributes

Object Attribute Types	C Mapping
RAW(N)	OCIRaw *

Table 16–2 shows the mappings of named collection types to Oracle8 object datatypes generated by OTT:

Table 16–2 Object Datatype Mappings for Collection Types

Named Collection Type	C Mapping
VARRAY	declared using typedef; equivalent to OCIArray * See the following example.
NESTED TABLE	declared using typedef; equivalent to OCITable * See the following example.

Note: For REF, VARRAY, and NESTED TABLE types, OTT generates a typedef. The type declared in the typedef is then used as the type of the data member in the struct declaration. For examples, see "OTT Type Mapping Example" on page 16-12.

If an object type includes an attribute of a REF or collection type, a typedef for the REF or collection type is first generated. Then the struct declaration corresponding to the object type is generated. The struct includes an element whose type is a pointer to the REF or collection type.

If an object type includes an attribute whose type is another object type, OTT first generates the nested type. It then maps the object type attribute to a nested struct of the type of the nested object type.

The Oracle8 C datatypes to which OTT maps non-object database attribute types are structures, which, except for OCIDate, are opaque.

OTT Type Mapping Example

The following example demonstrates the various type mappings created by OTT.

Given the following database types:

```
CREATE TYPE my_varray AS VARRAY(5) of integer;

CREATE TYPE object_type AS OBJECT
(object_name    VARCHAR2(20));
```

```
CREATE TYPE my_table AS TABLE OF object_type;

CREATE TYPE many_types AS OBJECT
( the_varchar    VARCHAR2(30),
  the_char       CHAR(3),
  the_blob       BLOB,
  the_clob       CLOB,
  the_object     object_type,
  another_ref    REF other_type,
  the_ref        REF many_types,
  the_varray     my_varray,
  the_table      my_table,
  the_date       DATE,
  the_num        NUMBER,
  the_raw        RAW(255));
```

and an intype file that includes:

```
CASE = LOWER
TYPE many_types
```

OTT would generate the following C structs:

Note: Comments are provided here to help explain the structs. These comments are not part of actual OTT output.

```
#ifndef MYFILENAME_ORACLE
#define MYFILENAME_ORACLE

#ifndef OCI_ORACLE
#include <oci.h>
#endif

typedef OCIRef many_types_ref;
typedef OCIRef object_type_ref;
typedef OCIArray my_varray;             /* part of many_types */
typedef OCITable my_table;              /* part of many_types*/
typedef OCIRef other_type_ref;
struct object_type                      /* part of many_types */
{
   OCIString * object_name;
};
typedef struct object_type object_type;

struct object_type_ind                  /*indicator struct for*/
```

```
{                                        /*object_types*/
   OCIInd _atomic;
   OCIInd object_name;
};
typedef struct object_type_ind object_type_ind;

struct many_types
{
   OCIString *        the_varchar;
   OCIString *        the_char;
   OCIBlobLocator *   the_blob;
   OCIClobLocator *   the_clob;
   struct object_type the_object;
   other_type_ref *   another_ref;
   many_types_ref *   the_ref;
   my_varray *        the_varray;
   my_table *         the_table;
   OCIDate            the_date;
   OCINumber          the_num;
   OCIRaw *           the_raw;
};
typedef struct many_types many_types;

struct many_types_ind                    /*indicator struct for*/
{                                        /*many_types*/
   OCIInd _atomic;
   OCIInd the_varchar;
   OCIInd the_char;
   OCIInd the_blob;
   OCIInd the_clob;
   struct object_type_ind the_object;   /*nested*/
   OCIInd another_ref;
   OCIInd the_ref;
   OCIInd the_varray;
   OCIInd the_table;
   OCIInd the_date;
   OCIInd the_num;
   OCIInd the_raw;
};
typedef struct many_types_ind many_types_ind;

#endif
```

Note that even though only one item was listed for translation in the intype file, two object types and two named collection types were translated. As described in

"The OTT Command Line" on page 16-6, OTT automatically translates any types that are used as attributes of a type being translated, in order to complete the translation of the listed type.

This is not the case for types that are only accessed by a pointer or REF in an object type attribute. For example, although the *many_types* type contains the attribute *another_ref REF other_type*, a declaration of `struct other_type` was not generated.

This example also illustrates how typedefs are used to declare VARRAY, NESTED TABLE, and REF types.

The typedefs occur near the beginning:

```
typedef OCIRef many_types_ref;
typedef OCIRef object_type_ref;
typedef OCIArray my_varray;
typedef OCITable my_table;
typedef OCIRef other_type_ref;
```

In the struct `many_types`, the VARRAY, NESTED TABLE, and REF attributes are declared:

```
struct many_types
{
   ...
   other_type_ref *   another_ref;
   many_types_ref *   the_ref;
   my_varray *        the_varray;
   my_table *         the_table;
   ...
}
```

Null Indicator Structs

Each time OTT generates a C struct to represent a database object type, it also generates a corresponding null indicator struct. When an object type is selected into a C struct, null indicator information can be selected into a parallel struct.

For example, the following null indicator struct was generated in the example in the previous section:

```
struct many_types_ind
{
OCIInd _atomic;
OCIInd the_varchar;
```

```
OCIInd the_char;
OCIInd the_blob;
OCIInd the_clob;
struct object_type_ind the_object;
OCIInd another_ref;
OCIInd the_ref;
OCIInd the_varray;
OCIInd the_table;
OCIInd the_date;
OCIInd the_num;
OCIInd the_raw;
};
typedef struct many_types_ind many_types_ind;
```

The layout of the null struct is important. The first element in the struct (`_atomic`) is the *atomic null indicator*. This value indicates the null status for the object type as a whole. The atomic null indicator is followed by an indicator element corresponding to each element in the OTT-generated struct representing the object type.

Notice that when an object type contains another object type as part of its definition (in the above example, it is the *object_type* attribute), the indicator entry for that attribute is the null indicator struct (`object_type_ind`) corresponding to the nested object type.

VARRAYs and NESTED TABLEs contain the null information for their elements. The datatype for all other elements of a null indicator struct is *OCIInd*.

> **See Also:** For more information about atomic nullness, refer to the discussion of object types in Chapter 1 of *Programmer's Guide to the Oracle Call Interface*.

The Outtype File

The outtype file is named on the OTT command line. When OTT generates the C header file, it also writes the results of the translation into the outtype file. This file contains an entry for each of the types that is translated, including its version string, and the header file to which its C representation was written.

The outtype file from one OTT run can be used as the intype file for a subsequent OTT invocation.

For example, given the simple intype file used earlier in this chapter

```
CASE=LOWER
TYPE employee
  TRANSLATE SALARY$ AS salary
            DEPTNO AS department
```

```
TYPE ADDRESS
TYPE item
TYPE person
TYPE PURCHASE_ORDER AS p_o
```

the user has chosen to specify the case for OTT-generated C identifiers, and has provided a list of types that should be translated. In two of these types, naming conventions are specified.

The following example shows what the outtype file looks like after running OTT:

```
CASE = LOWER
TYPE EMPLOYEE AS employee
  VERSION = "$8.0"
  HFILE = demo.h
  TRANSLATE SALARY$ AS salary
            DEPTNO AS department
TYPE ADDRESS AS ADDRESS
  VERSION = "$8.0"
  HFILE = demo.h
TYPE ITEM AS item
  VERSION = "$8.0"
  HFILE = demo.h
TYPE "Person" AS Person
  VERSION = "$8.0"
  HFILE = demo.h
TYPE PURCHASE_ORDER AS p_o
  VERSION = "$8.0"
  HFILE = demo.h
```

When examining the contents of the outtype file, you might discover types listed that were not included in the intype specification. For example, if the intype file only specified that the *person* type was to be translated:

```
CASE = LOWER
TYPE PERSON
```

and the definition of the person type includes an attribute of type *address*, then the outtype file will include entries for both `PERSON` and `ADDRESS`. The `person` type cannot be translated completely without first translating *address*.

As described in "The OTT Command Line" on page 16-6, OTT analyzes the types in the intype file for type dependencies before performing the translation, and translates other types as necessary.

Using OTT with OCI Applications

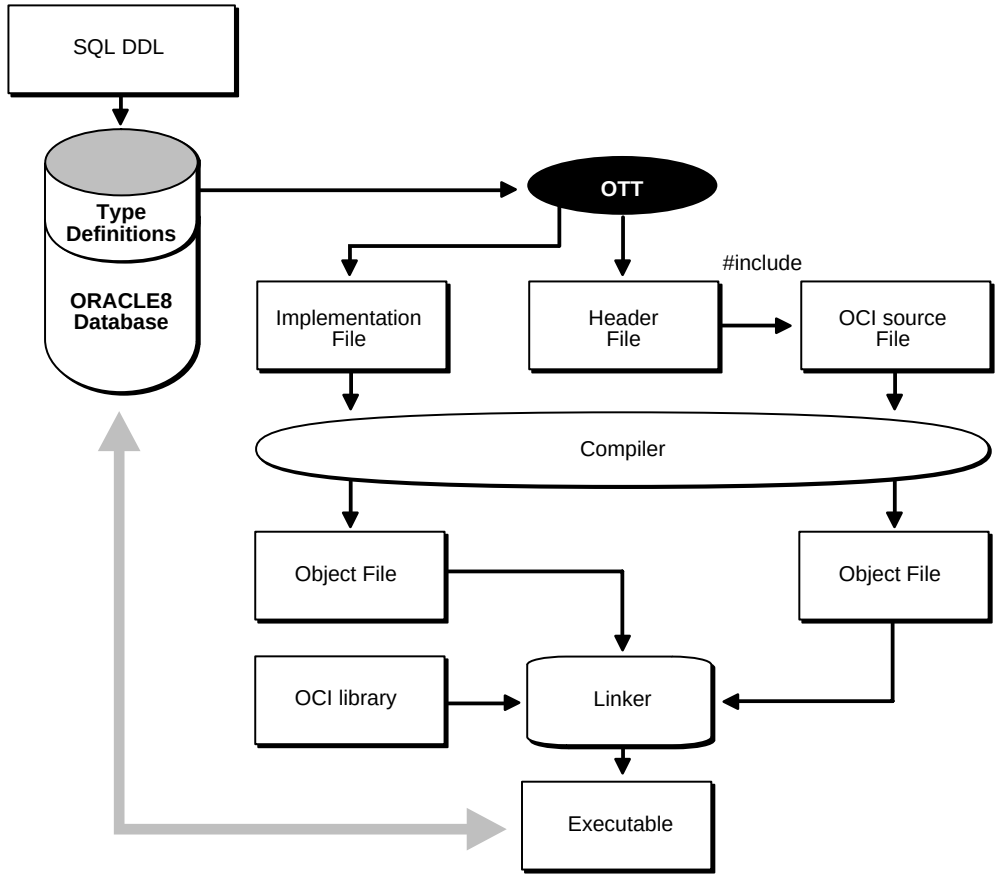
C header and implementation files that have been generated by OTT can be used by an OCI application that accesses objects in an Oracle8 Server. Incorporate the header file into the OCI code with an `#include` statement.

Once the header file has been included, the OCI application can access and manipulate object data in the host language format.

Figure 16–2 shows the steps involved in using OTT with OCI.

1. SQL is used to create type definitions in the database.
2. OTT generates a header file containing C representations of object types and named collection types. It also generates an implementation file, as named with the INITFILE option.
3. The application is written. User-written code in the OCI application declares and calls the INITFUNC function.
4. The header file is included in an OCI source code file.
5. The OCI application, including the implementation file generated by OTT, is compiled and linked with the OCI libraries.
6. The OCI executable is run against the Oracle8 Server.

Figure 16–1 Using OTT with OCI



Accessing and Manipulating Objects with OCI

Within the application, the OCI program can perform bind and define operations using program variables declared to be of types that appear in the OTT-generated header file.

For example, an application might fetch a REF to an object using a SQL SELECT statement and then pin that object using the appropriate OCI function. Once the

object has been pinned, its attribute data can be accessed and manipulated with other OCI functions.

OCI includes a set of datatype mapping and manipulation functions specifically designed to work on attributes of object types and named collection types.

Some of the available functions follow:

- *OCIStringSize()* gets the size of an *OCIString* string.
- *OCINumberAdd()* adds two *OCINumber* numbers together.
- *OCILobIsEqual()* compares two LOB locators for equality.
- *OCIRawPtr()* gets a pointer to an *OCIRaw* raw datatype.
- *OCICollAppend()* appends an element to a collection type (*OCIArray* or *OCITable*).
- *OCITableFirst()* returns the index for the first existing element of a nested table (*OCITable*).
- *OCIRefIsNull()* tests if a REF (*OCIRef)* is null

These functions are described in detail in the following chapters of the *Programmer's Guide to the Oracle Call Interface:*

- Chapter 2, which covers OCI concepts, including binding and defining
- Chapter 6, which covers object access and navigation
- Chapter 7, which covers datatype mapping and manipulation
- Chapter 12, which lists datatype mapping and manipulation functions

Calling the Initialization Function

OTT generates a C initialization function if requested. The initialization function tells the environment, for each object type used in the program, which version of the type is used. You can specify a name for the initialization function when invoking OTT with the INITFUNC option, or may allow OTT to select a default name based on the name of the implementation file (INITFILE) containing the function.

The initialization function takes two arguments, an environment handle pointer and an error handle pointer. There is typically a single initialization function, but this is not required. If a program has several separately compiled pieces requiring different types, you may want to execute OTT separately for each piece requiring, for each piece, one initialization file, containing an initialization function.

After you create an environment handle by an explicit OCI object call, for example, by calling *OCIEnvInit()*, you must also call the initialization functions explicitly for each environment handle. This gives each handle access to all the Oracle8 datatypes used in the entire program.

If an environment handle is implicitly created via embedded SQL statements, such as EXEC SQL CONTEXT USE and EXEC SQL CONNECT, the handle is initialized implicitly, and the initialization functions need not be called. This is relevant for Pro*C/C++ applications, or when Pro*C/C++ is being combined with OCI applications.

The following example shows and initialization function.

Given an intype file, ex2c.typ, containing

```
TYPE SCOTT.PERSON
TYPE SCOTT.ADDRESS
```

and the command line

```
ott userid=scott/tiger intype=ex2c outtype=ex2co hfile=ex2ch.h initfile=ex2cv.c
```

OTT generates the following to the file ex2cv.c:

```
#ifndef OCI_ORACLE
#include <oci.h>
#endif

sword ex2cv(OCIEnv *env, OCIError *err)
{
   sword status = OCITypeVTInit(env, err);
   if (status == OCI_SUCCESS)
      status = OCITypeVTInsert(env, err,
          "SCOTT", 5,
          "PERSON", 6,
          "$8.0", 4);
    if (status == OCI_SUCCESS)
        status = OCITypeVTInsert(env, err,
           "SCOTT", 5,
           "ADDRESS", 7,
           "$8.0", 4);
    return status;
}
```

The function *ex2cv* creates the type version table and inserts the types SCOTT.PERSON and SCOTT.ADDRESS.

If a program explicitly creates an environment handle, all the initialization functions must be generated, compiled, and linked, because they must be called for each explicitly created handle. If a program does not explicitly create any environment handles, initialization functions are not required.

A program that uses an OTT-generated header file must also use the initialization function generated at the same time. More precisely, if a header file generated by OTT is included in a compilation that generates code that is linked into program P, and an environment handle is explicitly created somewhere in program P, the implementation file generated by the same invocation of OTT must also be compiled and linked into program P. Doing this correctly is your responsibility.

Tasks of the Initialization Function

The C initialization function supplies version information about the types processed by OTT. It adds to the type-version table the name and version identifier of every OTT-processed object datatype.

The type-version table is used by the Open Type Manager (OTM) to determine which version of a type a particular program uses. Different initialization functions generated by OTT at different times may add some of the same types to the type version table. When a type is added more than once, OTM ensures that the same version of the type is registered each time.

It is the OCI programmer's responsibility to declare a function prototype for the initialization function, and to call the function.

> **Note:** In the current release of Oracle8, each type has only one version. Initialization of the type version table is required only for compatibility with future releases of Oracle8.

Using OTT with Pro*C/C++ Applications

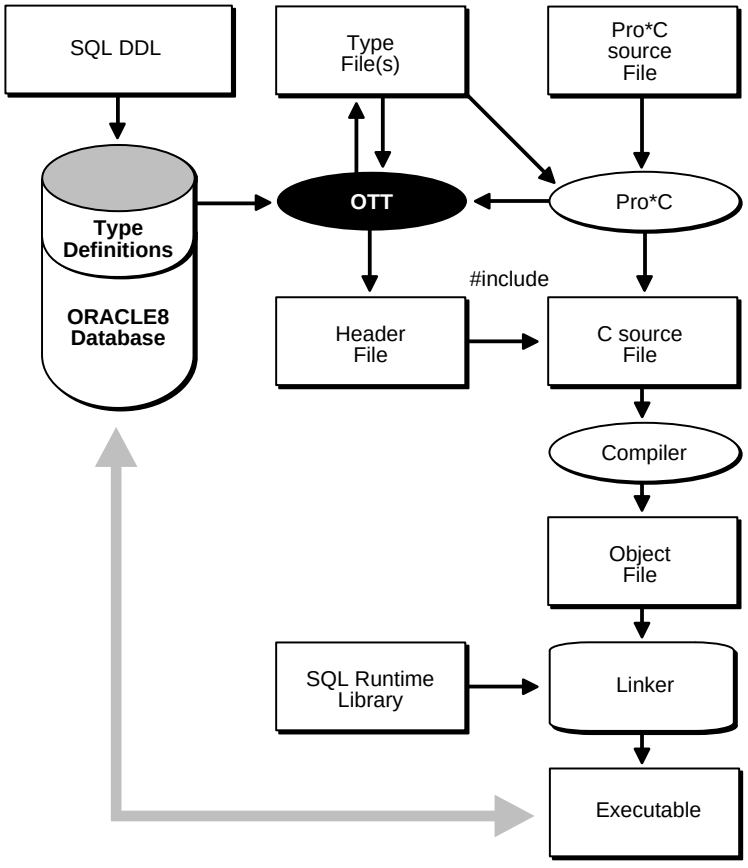
When building Pro*C/C++ applications, the type-translation process can be simpler than when building OCI-based applications. This is because precompiler-generated code will automatically initialize the type version table.

A C header file generated by OTT can be used by a Pro*C/C++ application to access objects in an Oracle8 Server. The header file is incorporated into the code with an `#include` statement. Once the header file has been included, the Pro*C/C++ application can access and manipulate object data in the host language format.

The following figure shows the steps involved in using OTT with Pro*C/C++.

1. SQL is used to create type definitions in the database.
2. OTT generates a header file containing C representations of object types, REF types, and named collection types. It also generates an OUTTYPE file that is passed as the INTYPE parameter to Pro*C/C++.
3. The header file is included in a Pro*C/C++ source code file.
4. The Pro*C/C++ application is compiled and linked with the Pro*C/C++ run-time library SQLLIB.
5. The Pro*C/C++ executable is run against the Oracle8 Server.

Figure 16–2 Building an Object-oriented Pro*C/C++ Application



As noted in step 2, above, the OUTTYPE file generated by OTT serves a special purpose for Pro*C/C++ programmers. Pass the OUTTYPE file to the new INTYPE command line parameter when invoking Pro*C/C++. The contents of this file are used by the precompiler to determine which database types correspond to which OTT-generated structs. OCI programmers must make this association explicitly through the use of special bind, define, and type information access functions.

Also, the precompiler generates code to initialize the type version table with the types named in the OTT OUTTYPE (Pro*C/C++ INTYPE) file.

> **Note:** Oracle recommends that the OUTTYPE file from OTT always serve as the INTYPE file to Pro*C/C++. It would be possible you to write an INTYPE

file for Pro*C/C++, but this is not recommended, due to the possibility of errors being introduced.

One way to manipulate the attributes of objects retrieved from the server is to call the OCI datatype mapping and manipulation functions. Before doing this, the application must first call *SQLEnvGet()* to obtain an OCI environment handle to pass to the OCI functions, and *SQLSvcCtxGet()* to obtain an OCI service context to pass to the OCI functions. There are also Pro*C facilities that can be used to manipulate object attributes. See Chapter 8, "Object Support in Pro*C/C++" for more information.

The process of calling OCI functions from Pro*C/C++ is described briefly in "Accessing and Manipulating Objects with OCI" on page 16-19, and in more detail in Chapter 8 of *Programmer's Guide to the Oracle Call Interface*.

OTT Reference

Behavior of OTT is controlled by parameters which can appear on the OTT command line or in a CONFIG file. Certain parameters may also appear in the INTYPE file. This section provides detailed information about the following topics:

- OTT Command Line Syntax
- OTT Parameters
- Where OTT Parameters Can Appear
- Structure of the Intype File
- Nested #include File Generation
- SCHEMA_NAMES Usage
- Default Name Mapping
- Restrictions

The following conventions are used in this chapter to describe OTT syntax:

- Angle brackets (<...>) enclose strings to be supplied by the user.
- Strings in UPPERCASE are entered as shown, except that case is not significant.
- Square brackets [...] enclose optional items.
- An ellipsis (...) immediately following an item (or items enclosed in brackets) means that the item can be repeated any number of times.

- Punctuation symbols other than those described above are entered as shown. These include '.', '@', etc.

OTT Command Line Syntax

The OTT command-line interface is used when explicitly invoking OTT to translate database types into C structs. This is always required when developing OCI applications or Pro*C / C++ applications that use objects.

An OTT command-line statement consists of the keyword *OTT*, followed by a list of OTT parameters.

The parameters that can appear on an OTT command-line statement are as follows:

[USERID=<*username*> / <*password*>[@<*db_name*>]]

[INTYPE=<*in_filename*>]

OUTTYPE=<*out_filename*>

CODE=<C | ANSI_C | KR_C>

[HFILE=<*filename*>]

[ERRTYPE=<*filename*>]

[CONFIG=<*filename*>]

[INITFILE=<*filename*>]

[INITFUNC=<*filename*>]

[CASE=<SAME | LOWER | UPPER | OPPOSITE>]

[SCHEMA_NAMES=<ALWAYS | IF_NEEDED | FROM_INTYPE>]

Note: Generally, the order of the parameters following the OTT command does not matter, and only the OUTTYPE and CODE parameters are always required.

The HFILE parameter is almost always used. If omitted, HFILE must be specified individually for each type in the INTYPE file. If OTT determines that a type not listed in the INTYPE file must be translated, an error will be reported. Therefore, it is safe to omit the HFILE parameter only if the INTYPE file was previously generated as an OTT OUTTYPE file.

If the INTYPE file is omitted, the entire schema will be translated. See the parameter descriptions in the following section for more information.

The following is an example of an OTT command line statement (enter it as one line):

```
OTT userid=scott/tiger intype=in.typ outtype=out.typ code=c hfile=demo.h
errtype=demo.tls case=lower
```

Each of the OTT command line parameters is described in the following sections.

OTT Parameters

Enter parameters on the OTT command line using the following format:

parameter=value

where *parameter* is the literal parameter string and *value* is a valid parameter setting. The literal parameter string is not case sensitive.

Separate command-line parameters using either spaces or tabs.

Parameters can also appear within a configuration file, but, in that case, no whitespace is permitted within a line, and each parameter must appear on a separate line. Additionally, the parameters CASE, HFILE, INITFUNC, and INITFILE can appear in the INTYPE file.

USERID

The USERID parameter specifies the Oracle username, password, and optional database name (Net8 database specification string). If the database name is omitted, the default database is assumed. The syntax of this parameter is:

USERID=<*username*/*password*[*@db_name*]>

If this is the first parameter, "USERID=" may be omitted as shown here:

OTT *username*/*password* ...

The USERID parameter is optional. If you omit it, OTT automatically attempts to connect to the default database as user OPS$*username*, where *username* is the user's operating system user name.

INTYPE

The INTYPE parameter specifies the name of the file from which to read the list of object type specifications. OTT translates each type in the list. The syntax for this parameter is

INTYPE=<*filename*>

"INTYPE=" may be omitted if USERID and INTYPE are the first two parameters, in that order, and "USERID=" is omitted. If INTYPE is not specified, all types in the user's schema will be translated.

OTT *username*/*password filename* ...

The INTYPE file can be thought of as a makefile for type declarations. It lists the types for which C struct declarations are needed. The format of the INTYPE file is described in “Structure of the Intype File”page 16-32.

If the file name on the command line or in the INTYPE file does not include an extension, a platform-specific extension such as "TYP" or "typ" will be added.

OUTTYPE

The name of a file into which OTT will write type information for all the object datatypes it processes. This includes all types explicitly named in the INTYPE file, and may include additional types that are translated because they are used in the declarations of other types that need to be translated. This file may be used as an INTYPE file in a future invocation of OTT.

OUTTYPE=<*filename*>

If the INTYPE and OUTTYPE parameters refer to the same file, the new INTYPE information replaces the old information in the INTYPE file. This provides a convenient way for the same INTYPE file to be used repeatedly in the cycle of altering types, generating type declarations, editing source code, precompiling, compiling, and debugging.

OUTTYPE must be specified.

If the file name on the command line or in the INTYPE file does not include an extension, a platform-specific extension such as "TYP" or "typ" will be added.

CODE

CODE= C | KR_C | ANSI_C

This is the desired host language for OTT output, that may be specified as CODE=C, CODE=KR_C, or CODE=ANSI_C. "CODE=C" is equivalent to "CODE=ANSI_C".

There is no default value for this parameter; it must be supplied.

INITFILE

The INITFILE parameter specifies the name of the file where the OTT-generated initialization file is to be written. OTT does not generate the initialization function if you omit this parameter.

For Pro*C/C++ programs, the INITFILE is not necessary, because the SQLLIB run-time library performs the necessary initializations. An OCI program user must compile and link the INITFILE file(s), and must call the initialization function(s) when an environment handle is created.

If the file name of an INITFILE on the command line or in the INTYPE file does not include an extension, a platform-specific extension such as "C" or ".c" will be added.

INITFILE=<*filename*>

INITFUNC

The INITFUNC parameter is used only in OCI programs. It specifies the name of the initialization function generated by OTT. If this parameter is omitted, the name of the initialization function is derived from the name of the INITFILE.

INITFUNC=<*filename*>

HFILE

The name of the include (.h) file to be generated by OTT for the declarations of types that are mentioned in the INTYPE file but whose include files are not specified there. This parameter is required unless the include file for each type is specified individually in the INTYPE file. This parameter is also required if a type not mentioned in the INTYPE file must be generated because other types require it, and these other types are declared in two or more different files.

If the file name of an HFILE on the command line or in the INTYPE file does not include an extension, a platform-specific extension such as "H" or ".h" will be added.

HFILE=<*filename*>

CONFIG

The CONFIG parameter specifies the name of the OTT configuration file, that lists commonly used parameter specifications. Parameter specifications are also read from a system configuration file in a platform-dependent location. All remaining parameter specifications must appear on the command line, or in the INTYPE file.

CONFIG=<*filename*>

Note: A CONFIG parameter is not allowed in the CONFIG file.

ERRTYPE

If you supply this parameter, a listing of the INTYPE file is written to the ERRTYPE file, along with all informational and error messages. Informational and error messages are sent to the standard output whether or not ERRTYPE is specified.

Essentially, the ERRTYPE file is a copy of the INTYPE file with error messages added. In most cases, an error message will include a pointer to the text that caused the error.

If the file name of an ERRTYPE on the command line or in the INTYPE file does not include an extension, a platform-specific extension such as "TLS" or "tls" will be added.

ERRTYPE=<*filename*>

CASE

This parameter affects the case of certain C identifiers generated by OTT. The possible values of CASE are SAME, LOWER, UPPER, and OPPOSITE. If CASE = SAME, the case of letters is not changed when converting database type and attribute names to C identifiers. If CASE=LOWER, all uppercase letters are converted to lowercase. If CASE=UPPER, all lowercase letters are converted to uppercase. If CASE=OPPOSITE, all uppercase letters are converted to lower-case, and vice-versa.

CASE=[SAME | LOWER | UPPER | OPPOSITE]

This parameter affects only those identifiers (attributes or types not explicitly listed) not mentioned in the INTYPE file. Case conversion takes place after a legal identifier has been generated.

Note: The case of the C struct identifier for a type specifically mentioned in the INTYPE is the same as its case in the INTYPE file. For example, if the INTYPE file includes the following line

```
TYPE Worker
```

then OTT will generate

```
struct Worker {...};
```

On the other hand, if the INTYPE file were written as

```
TYPE wOrKeR
```

OTT would generate

```
struct wOrKeR {...};
```

following the case of the INTYPE file.

Case-insensitive SQL identifiers not mentioned in the INTYPE file will appear in upper case if CASE=SAME, and in lower case if CASE=OPPOSITE. A SQL identifier is case-insensitive if it was not quoted when it was declared.

SCHEMA_NAMES

This parameter offers control in qualifying the database name of a type from the default schema with a schema name in the OUTTYPE file. The OUTTYPE file generated by OTT contains information about the types processed by OTT, including the type names.

See "SCHEMA_NAMES Usage" on page 16-36 for further information.

Where OTT Parameters Can Appear

Supply OTT parameters on the command line, in a CONFIG file named on the command line, or both. Some parameters are also allowed in the INTYPE file.

OTT is invoked as follows:

OTT *username/password* <parameters>

If one of the parameters on the command line is

CONFIG=<filename>

additional parameters are read from the configuration file <filename>.

In addition, parameters are also read from a default configuration file in a platform-dependent location. This file must exist, but can be empty. You must enter parameters in a configuration file one per line, with no whitespace on the line.

If OTT is executed without any arguments, an on-line parameter reference is displayed.

The types for OTT to translate are named in the file specified by the INTYPE parameter. The parameters CASE, INITFILE, INITFUNC, and HFILE may also appear in the INTYPE file. OUTTYPE files generated by OTT include the CASE parameter, and include the INITFILE, and INITFUNC parameters if an initialization file was generated. The OUTTYPE file specifies the HFILE individually for each type.

The case of the OTT command is platform-dependent.

Structure of the Intype File

The intype and outtype files list the types translated by OTT and provide all the information needed to determine how a type or attribute name is translated to a legal C identifier. These files contain one or more type specifications. These files also may contain specifications of the following options:

- CASE
- HFILE
- INITFILE
- INITFUNC

If the CASE, INITFILE, or INITFUNC options are present, they must precede any type specifications. If these options appear both on the command line and in the intype file, the value on the command line is used.

For an example of a simple user-defined intype file, and of the full outtype file that OTT generates from it, see "The Outtype File" on page 16-16.

Intype File Type Specifications

A type specification in the INTYPE names an object datatype that is to be translated. A type specification in the OUTTYPE file names an object datatype that has been translated,

```
TYPE PERSON AS PERSON
  VERSION = "$8.0"
  HFILE = demo.h
```

The structure of a type specification is as follows:

```
TYPE <type_name> [AS <type_identifier>]
[VERSION [=] <version_string>]
[HFILE [=] <hfile_name>]
[TRANSLATE{<member_name> [AS <identifier>]}...]
```

The syntax of *type_name* is:

```
[<schema_name>.]<type_name>
```

where *schema_name* is the name of the schema that owns the given object datatype, and *type_name* is the name of the type. The default schema is that of the user running OTT. The default database is the local database.

The components of a type specification are:

- <type name> is the name of an Oracle8 object datatype.
- <type identifier> is the C identifier used to represent the type. If omitted, the default name mapping algorithm will be used. For further information, see "Default Name Mapping" on page 16-38.
- <version string> is the version string of the type that was used when the code was generated by a previous invocation of OTT. The version string is generated by OTT and written to the OUTTYPE file, that may later be used as the INTYPE file when OTT is later executed. The version string does not affect the OTT's operation, but will eventually be used to select which version of the object datatype should be used in the running program.
- <member name> is the name of an attribute (data member) which is to be translated to the following <identifier>.
- <identifier> is the C identifier used to represent the attribute in the user program. You can specify identifiers in this way for any number of attributes. The default name mapping algorithm will be used for the attributes that are not mentioned.
- <hfile name> is the name of the header file in which the declarations of the corresponding struct or class appears or will appear. If <hfile name> is omitted, the file named by the command-line HFILE parameter will be used if a declaration is generated.

An object datatype may need to be translated for one of two reasons:

- It appears in the INTYPE file.
- It is required to declare another type that must be translated.

If a type that is not mentioned explicitly is required by types declared in exactly one file, the translation of the required type is written to the same file(s) as the explicitly declared types that require it.

If a type that is not mentioned explicitly is required by types declared in two or more different files, the translation of the required type is written to the global HFILE file.

Nested `#include` File Generation

Every HFILE generated by OTT `#includes` other necessary files, and `#defines` a symbol constructed from the name of the file, that may be used to determine if the HFILE has already been included. Consider, for example, a database with the following types:

```
create type px1 AS OBJECT (col1 number, col2 integer);
create type px2 AS OBJECT (col1 px1);
create type px3 AS OBJECT (col1 px1);
```

where the intype file contains:

```
CASE=lower
type pxl
  hfile tott95a.h
type px3
  hfile tott95b.h
```

If we invoke OTT with

```
ott scott/tiger tott95i.typ outtype=tott95o.typ code=c
```

then it will generate the two following header files.

File tott95b.h is:

```
#ifndef TOTT95B_ORACLE
#define TOTT95B_ORACLE
#ifndef OCI_ORACLE
#include <oci.h>
#endif
#ifndef TOTT95A_ORACLE
#include "tott95a.h"
#endif
typedef OCIRef px3_ref;
struct px3
{
   struct px1 col1;
};
typedef struct px3 px3;
struct px3_ind
{
   OCIInd _atomic;
   struct px1_ind col1
};
typedef struct px3_ind px3_ind;
#endif
```

File tott95a.h is:

```
#ifndef TOTT95A_ORACLE
#define TOTT95A_ORACLE
#ifndef OCI_ORACLE
```

```
#include <oci.h>
#endif
typedef OCIRef px1_ref;
struct px1
{
   OCINumber col1;
   OCINumber col2;
}
typedef struct px1 px1;
struct px1_ind
{
   OCIInd _atomic;
   OCIInd col1;
   OCIInd col2;
}
typedef struct px1_ind px1_ind;
#endif
```

In this file, the symbol TOTT95B_ORACLE is defined first so that the programmer may conditionally include *tott95b.h* without having to worry whether *tott95b.h* depends on the include file using the following construct:

```
#ifndef TOTT95B_ORACLE
#include "tott95b.h"
#endif
```

Using this technique, you can include "tott95b.h" from some file, say "foo.h", without having to know whether some other file included by "foo.h" also includes "tott95b.h".

After the definition of the symbol TOTT95B_ORACLE, the file *oci.h* is `#included`. Every HFILE generated by OTT includes *oci.h*, that contains type and function declarations that the Pro*C / C++ or OCI programmer will find useful. This is the only case in which OTT uses angle brackets in an `#include`.

Next, the file *tott95a.h* is included because it contains the declaration of "struct px1", that *tott95b.h* requires. When the INTYPE file requests that type declarations be written to more than one file, OTT will determine which other files each HFILE must include, and will generate the necessary `#includes`.

Note that OTT uses quotes in this `#include`. When a program including *tott95b.h* is compiled, the search for *tott95a.h* begins where the source program was found, and will thereafter follow an implementation-defined search rule. If *tott95a.h* cannot be found in this way, a complete file name (for example, a UNIX absolute pathname

beginning with /) should be used in the INTYPE file to specify the location of *tott95a.h*.

SCHEMA_NAMES Usage

This parameter affects whether the name of a type from the default schema to which OTT is connected is qualified with a schema name in the OUTTYPE file.

The name of a type from a schema other that the default schema is always qualified with a schema name in the OUTTYPE file.

The schema name, or its absence, determines in which schema the type is found during program execution.

There are three settings:

- SCHEMA_NAMES=ALWAYS(default)

  All type names in the OUTTYPE file are qualified with a schema name.

- SCHEMA_NAMES=IF_NEEDED

  The type names in the OUTTYPE file that belong to the default schema are not qualified with a schema name. As always, type names belonging to other schemas are qualified with the schema name.

- SCHEMA_NAMES=FROM_INTYPE

  A type mentioned in the INTYPE file is qualified with a schema name in the OUTTYPE file if, and only if, it was qualified with a schema name in the INTYPE file. A type in the default schema that is not mentioned in the INTYPE file but that has to be generated because of type dependencies is written with a schema name only if the first type encountered by OTT that depends on it was written with a schema name. However, a type that is not in the default schema to which OTT is connected is always written with an explicit schema name.

The OUTTYPE file generated by OTT is the Pro*C/C++ INTYPE file. This file matches database type names to C struct names. This information is used at runtime to make sure that the correct database type is selected into the struct. If a type appears with a schema name in the OUTTYPE file (Pro*C/C++ INTYPE file), the type will be found in the named schema during program execution. If the type appears without a schema name, the type will be found in the default schema to which the program connects, that may be different from the default schema OTT used.

An example

If SCHEMA_NAMES is set to FROM_INTYPE, and the INTYPE file reads:

```
TYPE Person
TYPE joe.Dept
TYPE sam.Company
```

then the Pro*C/C++ application that uses the OTT-generated structs will use the types *sam.Company, joe.Dept, and Person*. *Person* without a schema name refers to the Person type in the schema to which the application is connected.

If OTT and the application both connect to schema joe, the application will use the same type (joe.Person) that OTT used. If OTT connected to schema *joe* but the application connects to schema mary, the application will use the type mary.Person. This behavior is appropriate only if the same "CREATE TYPE Person" statement has been executed in schema joe and schema mary.

On the other hand, the application will use type joe.Dept regardless of to which schema the application is connected. If this is the behavior you want, be sure to include schema names with your type names in the INTYPE file.

In some cases, OTT translates a type that the user did not explicitly name. For example, consider the following SQL declarations:

```
CREATE TYPE Address AS OBJECT
(
street    VARCHAR2(40),
city      VARCHAR(30),
state     CHAR(2),
zip_code  CHAR(10)
);

CREATE TYPE Person AS OBJECT
(
name      CHAR(20),
age       NUMBER,
addr      ADDRESS
);
```

If that OTT connects to schema joe, SCHEMA_NAMES=FROM_INTYPE is specified, and the user's INTYPE files include either

```
TYPE Person or TYPE joe.Person
```

but do not mention the type joe.Address, that is used as a nested object type in type *joe.Person*. If "TYPE joe.Person" appeared in the INTYPE file, "TYPE joe.Person" and "TYPE joe.Address" will appear in the OUTTYPE file. If "Type Person" appeared in

the INTYPE file, "TYPE Person" and "TYPE Address" will appear in the OUTTYPE file.

If the *joe.Address* type is embedded in several types translated by OTT, but is not explicitly mentioned in the INTYPE file, the decision of whether to use a schema name is made the first time OTT encounters the embedded *joe.Address* type. If, for some reason, the user wants type *joe.Address* to have a schema name but does not want type *Person* to have one, you must explicitly request

```
TYPE      joe.Address
```
in the INTYPE FILE.

In the usual case in which each type is declared in a single schema, it is safest for you to qualify all type names with schema names in the INTYPE file.

Default Name Mapping

When OTT creates a C identifier name for an object type or attribute, it translates the name from the database character set to a legal C identifier. First, the name is translated from the database character set to the character set used by OTT. Next, if a translation of the resulting name is supplied in the INTYPE file, that translation is used. Otherwise, OTT translates the name character-by-character to the compiler character set, applying the CASE option. This process is described in more detail below:

When OTT reads the name of a database entity, the name is automatically translated from the database character set to the character set used by OTT. In order for OTT to read the name of the database entity successfully, all the characters of the name must be found in the OTT character set, although a character may have different encodings in the two character sets.

The easiest way to guarantee that the character set used by OTT contains all the necessary characters is to make it the same as the database character set. Note, however, that the OTT character set must be a superset of the compiler character set. That is, if the compiler character set is 7-bit ASCII, the OTT character set must include 7-bit ASCII as a subset, and if the compiler character set is 7-bit EBCDIC, the OTT character set must include 7-bit EBCDIC as a subset. The user specifies the character set that OTT uses by setting the NLS_LANG environment variable, or by some other platform-specific mechanism.

Once OTT has read the name of a database entity, it translates the name from the character set used by OTT to the compiler's character set. If a translation of the name appears in the INTYPE file, OTT uses that translation.

Otherwise, OTT attempts to translate the name as follows:

First, if the OTT character set is a multi-byte character set, all multi-byte characters in the name that have single-byte equivalents are converted to those single-byte equivalents. Next, the name is converted from the OTT character set to the compiler character set. The compiler character set is a single-byte character set such as US7ASCII. Finally, the case of letters is set according to the CASE option in effect, and any character that is not legal in a C identifier, or that has no translation in the compiler character set, is replaced by an underscore. If at least one character is replaced by an underscore, OTT gives a warning message. If all the characters in a name are replaced by underscores, OTT gives an error message.

Character-by-character name translation does not alter underscores, digits, or single-byte letters that appear in the compiler character set, so legal C identifiers are not altered.

Name translation may, for example, translate accented single-byte characters such as "o" with an umlaut or "a" with an accent grave to "o" or "a", and may translate a multi-byte letter to its single-byte equivalent. Name translation will typically fail if the name contains multi-byte characters that lack single-byte equivalents. In this case, the user must specify name translations in the INTYPE file.

OTT will not detect a naming clash caused by two or more database identifiers being mapped to the same C name, nor will it detect a naming problem where a database identifier is mapped to a C keyword.

Restrictions

File Name Comparison

Currently, OTT determines if two files are the same by comparing the file names provided by the user on the command line or in the INTYPE file. But one potential problem can occur when OTT needs to know if two file names refer to the same file. For example, if the OTT-generated file foo.h requires a type declaration written to foo1.h, and another type declaration written to /private/smith/foo1.h, OTT should generate one `#include` if the two files are the same, and two `#includes` if the files are different. In practice, though, it concludes that the two files are different, and generates two `#includes`, as follows:

```
#ifndef FOO1_ORACLE
#include "foo1.h"
#endif
#ifndef FOO1_ORACLE
#include "/private/smith/foo1.h"
#endif
```

If foo1.h and /private/smith/foo1.h are different files, only the first one will be included. If foo1.h and /private/smith/foo1.h are the same file, a redundant `#include` will be written.

Therefore, if a file is mentioned several times on the command line or in the INTYPE file, each mention of the file should use exactly the same file name.

A

New Features

This appendix lists the new features offered in the Pro*C/C++ Precompiler, release 8.0. Each new feature is described briefly, and a reference to the more complete description in the chapters is provided.

Topics are:

- Array of Structs
- Changing Passwords at Runtime
- Support for National Character Sets
- CHAR_MAP Precompiler Option
- New Names for SQLLIB Functions
- New Actions in WHENEVER Statement
- Object Type Support
- Object Type Translator
- Migration From Pro*C/C++ Release 2

Array of Structs

Pro*C/C++ supports the use of arrays of structs which enable you to perform multi-row, multi-column operations. With this enhancement, Pro*C/C++ can handle simple arrays of structs of scalars as bind variables in embedded SQL statements for easier processing of user data. This makes programming more intuitive, and allows users greater flexibility in organizing their data.

In addition to supporting arrays of structs as bind variables, Pro*C/C++ now also supports arrays of indicator structs when used in conjunction with an array of structs declaration. See "Arrays of Structs" on page 12-17.

Changing Passwords at Runtime

Pro*C/C++ provides client applications with a convenient way to change a user password at runtime through a simple extension to the EXEC SQL CONNECT statement. See "Changing Passwords at Runtime" on page 4-32.

Support for National Character Sets

Pro*C/C++ supports multi-byte character sets (NCHAR) with database support, when NLS_LOCAL=NO. When NLS_LOCAL=NO, and the new environmental variable NLS_NCHAR is set to a valid National Character Set, the Oracle8 database supports NCHAR. See "Environment Variable NLS_NCHAR" on page 4-5.

The clause CHARACTER SET [IS] NCHAR_CS can be specified in character variable declarations. This has the same effect as naming the variable in the NLS_CHAR precompiler option. See "CHARACTER SET [IS] NCHAR_CS" on page 4-4.

A new clause, CONVBUFSZ, is available in the EXEC SQL VAR statement, for character set conversion. See "Using the EXEC SQL VAR and TYPE Directives" on page 3-61.

CHAR_MAP Precompiler Option

This option specifies the default mapping of C host char variables. Character strings are CHARZ (fixed-length blank-padded and 0-terminated) by default in Oracle8. For more information, see "National Language Support" on page 4-2.

New Names for SQLLIB Functions

SQLLIB functions have new aliases, which co-exist with the old function names for this release of Pro*C/C++. See "New Names for SQLLIB Public Functions" on page 4-35.

New Actions in WHENEVER Statement

The DO BREAK and DO CONTINUE actions are now supported by the embedded SQL directive WHENEVER. See "Using the WHENEVER Statement" on page 11-24 and "WHENEVER (Embedded SQL Directive)" on page F-77.

Object Type Support

Pro*C/C++ now allows you to map C structures to Object types that you defined for the Oracle8 server.

See Chapter 8, “Object Support in Pro*C/C++” for a description of how to access objects in a Pro*C/C++ program using an associative interface and a navigational interface (Executable Embedded SQL Extensions).

A sample program that illustrates how to access objects is listed in "Sample Code for Navigational Access" on page 8-25.

Object Type Translator

A new chapter describes the Object Type Translator (OTT) utility, which maps database object types to C structs for use in OCI and Pro*C/C++ applications. OTT is run before running the precompiler.

You can mix OCI function calls with embedded SQL statements in your application. New OCI interoperability functions, are available, as well as library routines to manipulate OCIString and OCINumber datatypes. For a description of Pro*C/C++ object support, see Chapter 8, “Object Support in Pro*C/C++”.

See Chapter 16, “Using the Object Type Translator”.

Migration From Pro*C/C++ Release 2

Existing applications written in Pro*C/C++ will work unchanged with an Oracle8 server. To upgrade to Oracle8 before adding new functionality to your application, re-link with the new SQLLIB library.

Pro*C/C++ release 8 applications will work with an Oracle7 server, if they do not use any new features.

When the new object support is added to an existing Pro*C/C++ application, use the OTT, the Pro*C/C++ release 8 precompiler, compile and link.

B

Oracle Reserved Words, Keywords, and Namespaces

This appendix lists words that have a special meaning to Oracle. Each word plays a specific role in the context in which it appears. For example, in an INSERT statement, the reserved word INTO introduces the tables to which rows will be added. But, in a FETCH or SELECT statement, the reserved word INTO introduces the output host variables to which column values will be assigned.

Topics are:

- Oracle Reserved Words and Keywords
- Oracle Reserved Namespaces

Oracle Reserved Words and Keywords

|	&	:
,	-	=
>	[	<
(	.	+
]	)	!
/	*	^
@		ACCESS
ACCOUNT	ACTIVATE	ADD
ADMIN	ADVISE	AFTER
ALL	ALL_ROWS	ALLOCATE
ALTER	ANALYZE	AND
ANY	ARCHIVE	ARCHIVELOG
ARRAY	AS	ASC
AT	AUDIT	AUTHENTICATED
AUTHORIZATION	AUTOEXTEND	AUTOMATIC
BACKUP	BECOME	BEFORE
BEGIN	BETWEEN	BFILE
BITMAP	BLOB	BLOCK
BODY	BY	CACHE
CACHE_INSTANCES	CANCEL	CASCADE
CAST	CFILE	CHAINED
CHANGE	CHAR	CHAR_CS
CHARACTER	CHECK	CHECKPOINT
CHOOSE	CHUNK	CLEAR
CLOB	CLONE	CLOSE
CLOSE_CACHED_OPEN_CURSORS	CLUSTER	COALESCE
COLUMN	COLUMNS	COMMENT

COMMIT	COMMITTED	COMPATIBILITY
COMPILE	COMPLETE	COMPOSITE_LIMIT
COMPRESS	COMPUTE	CONNECT
CONNECT_TIME	CONSTRAINT	CONSTRAINTS
CONTENTS	CONTINUE	CONTROLFILE
CONVERT	COST	CPU_PER_CALL
CPU_PER_SESSION	CREATE	CURRENT
CURRENT_SCHEMA	CURRENT_USER	CURSOR
CYCLE	DANGLING	DATABASE
DATAFILE	DATAFILES	DATAOBJNO
DATE	DBA	DBHIGH
DBLOW	DBMAC	DEALLOCATE
DEBUG	DEC	DECIMAL
DECLARE	DEFAULT	DEFERRABLE
DEFERRED	DEGREE	DELETE
DEREF	DESC	DIRECTORY
DISABLE	DISCONNECT	DISMOUNT
DISTINCT	DISTRIBUTED	DML
DOUBLE	DROP	DUMP
EACH	ELSE	ENABLE
END	ENFORCE	ENTRY
ESCAPE	ESTIMATE	EVENTS
EXCEPT	EXCEPTIONS	EXCHANGE
EXCLUDING	EXCLUSIVE	EXECUTE
EXISTS	EXPIRE	EXPLAIN
EXTENT	EXTENTS	EXTERNALLY
FAILED_LOGIN_ATTEMPTS	FALSE	FAST
FILE	FIRST_ROWS	FLAGGER
FLOAT		FLUSH

FOR	FORCE	FOREIGN
FREELIST	FREELISTS	FROM
FULL	FUNCTION	
GLOBAL	GLOBALLY	GLOBAL_NAME
GRANT	GROUP	GROUPS
HASH	HASHKEYS	HAVING
HEADER	HEAP	IDENTIFIED
IDGENERATORS	IDLE_TIME	IF
IMMEDIATE	IN	INCLUDING
INCREMENT	INDEX	INDEXED
INDEXES	INDICATOR	IND_PARTITION
INITIAL	INITIALLY	INITRANS
INSERT	INSTANCE	INSTANCES
INSTEAD	INT	INTEGER
INTERMEDIATE	INTERSECT	INTO
IS	ISOLATION	ISOLATION_LEVEL
KEEP	KEY	KILL
LABEL	LAYER	LESS
LEVEL	LIBRARY	LIKE
LIMIT	LINK	LIST
LOB	LOCAL	LOCK
LOCKED	LOG	LOGFILE
LOGGING	LOGICAL_READS_PER_CALL	LOGICAL_READS_PER_SESSION
LONG	MANAGE	MASTER
MAX	MAXARCHLOGS	MAXDATAFILES
MAXEXTENTS	MAXINSTANCES	MAXLOGFILES
MAXLOGHISTORY	MAXLOGMEMBERS	MAXSIZE
MAXTRANS	MAXVALUE	MIN
MEMBER	MINIMUM	MINEXTENTS

MINUS	MINVALUE	MLSLABEL
MLS_LABEL_FORMAT	MODE	MODIFY
MOUNT	MOVE	MTS_DISPATCHERS
MULTISET	NATIONAL	NCHAR
NCHAR_CS	NCLOB	NEEDED
NESTED	NETWORK	NEW
NEXT	NOARCHIVELOG	NOAUDIT
NOCACHE	NOCOMPRESS	NOCYCLE
NOFORCE	NOLOGGING	NOMAXVALUE
NOMINVALUE	NONE	NOORDER
NOOVERRIDE	NOPARALLEL	NORESETLOGS
NOREVERSE	NORMAL	NOSORT
NOT	NOTHING	NOWAIT
NULL	NUMBER	NUMERIC
NVARCHAR2	OBJECT	OBJNO
OBJNO_REUSE	OF	OFF
OFFLINE	OID	OIDINDEX
OLD	ON	ONLINE
ONLY	OPCODE	OPEN
OPTIMAL	OPTIMIZER_GOAL	OPTION
OR	ORDER	ORGANIZATION
OSLABEL	OVERFLOW	OWN
PACKAGE	PARALLEL	PARTITION
PASSWORD	PASSWORD_GRACE_TIME	PASSWORD_LIFE_TIME
PASSWORD_LOCK_TIME	PASSWORD_REUSE_MAX	PASSWORD_REUSE_TIME
PASSWORD_VERIFY_FUNCTION	PCTFREE	PCTINCREASE
PCTTHRESHOLD	PCTUSED	PCTVERSION
PERCENT	PERMANENT	PLAN
PLSQL_DEBUG	POST_TRANSACTION	PRECISION

PRESERVE	PRIMARY	PRIOR
PRIVATE	PRIVATE_SGA	PRIVILEGE
PRIVILEGES	PROCEDURE	PROFILE
PUBLIC	PURGE	QUEUE
QUOTA	RANGE	RAW
RBA	READ	READUP
REAL	REBUILD	RECOVER
RECOVERABLE	RECOVERY	REF
REFERENCES	REFERENCING	REFRESH
RENAME	REPLACE	RESET
RESETLOGS	RESIZE	RESOURCE
RESTRICTED	RETURN	RETURNING
REUSE	REVERSE	REVOKE
ROLE	ROLES	ROLLBACK
ROW	ROWID	ROWNUM
ROWS	RULE	SAMPLE
SAVEPOINT	SB4	SCAN_INSTANCES
SCHEMA	SCN	SCOPE
SD_ALL	SD_INHIBIT	SD_SHOW
SEGMENT	SEG_BLOCK	SEG_FILE
SELECT	SEQUENCE	SERIALIZABLE
SESSION	SESSION_CACHED_CURSORS	SESSIONS_PER_USER
SET	SHARE	SHARED
SHARED_POOL	SHRINK	SIZE
SKIP	SKIP_UNUSABLE_INDEXES	SMALLINT
SNAPSHOT	SOME	SORT
SPECIFICATION	SPLIT	SQL_TRACE
STANDBY	START	STATEMENT_ID
STATISTICS	STOP	STORAGE

STORE	STRUCTURE	SUCCESSFUL
SWITCH	SYS_OP_ENFORCE_NOT_NULL$	SYS_OP_NTCIMG$
SYNONYM	SYSDATE	SYSDBA
SYSOPER	SYSTEM	TABLE
TABLES	TABLESPACE	TABLESPACE_NO
TABNO	TEMPORARY	THAN
THE	THEN	THREAD
TIMESTAMP	TIME	TO
TOPLEVEL	TRACE	TRACING
TRANSACTION	TRANSITIONAL	TRIGGER
TRIGGERS	TRUE	TRUNCATE
TX	TYPE	UB2
UBA	UID	UNARCHIVED
UNDO	UNION	UNIQUE
UNLIMITED	UNLOCK	UNRECOVERABLE
UNTIL	UNUSABLE	UNUSED
UPDATABLE	UPDATE	USAGE
USE	USER	USING
VALIDATE	VALIDATION	VALUE
VALUES	VARCHAR	VARCHAR2
VARYING	VIEW	WHEN
WHENEVER	WHERE	WITH
WITHOUT	WORK	WRITE
WRITEDOWN	WRITEUP	XID

Oracle Reserved Namespaces

Table 0–1 contains a list of namespaces that are reserved by Oracle. The initial characters of function names in Oracle libraries are restricted to the character strings in this list. Because of potential name conflicts, use function names that do not begin with these characters.

For example, the SQL*Net Transparent Network Service functions all begin with the characters “NS,” so you need to avoid writing functions whose names begin with ”NS.”

Table 0–1 Oracle Reserved Namespaces

Namespace	Library
O	OCI functions
S	function names from SQLLIB and system-dependent libraries
XA	external functions for XA applications only
GEN KP L NA NC ND NL NM NR NS NT NZ TTC UPI	Internal functions

C

Performance Tuning

This appendix shows you some simple, easy-to-apply methods for improving the performance of your applications. Using these methods, you can often reduce processing time by 25% or more.

Topics are:

- What Causes Poor Performance?
- How Can Performance Be Improved?
- Using Host Arrays
- Using Embedded PL/SQL
- Optimizing SQL Statements
- Using Indexes
- Taking Advantage of Row-Level Locking
- Eliminating Unnecessary Parsing

What Causes Poor Performance?

One cause of poor performance is high Oracle communication overhead. Oracle must process SQL statements one at a time. Thus, each statement results in another call to Oracle and higher overhead. In a networked environment, SQL statements must be sent over the network, adding to network traffic. Heavy network traffic can slow down your application significantly.

Another cause of poor performance is inefficient SQL statements. Because SQL is so flexible, you can get the same result with two different statements, but one statement might be less efficient. For example, the following two SELECT statements return the same rows (the name and number of every department having at least one employee):

```
EXEC SQL SELECT dname, deptno
     FROM dept
     WHERE deptno IN (SELECT deptno FROM emp);

EXEC SQL SELECT dname, deptno
     FROM dept
     WHERE EXISTS
     (SELECT deptno FROM emp WHERE dept.deptno = emp.deptno);
```

However, the first statement is slower because it does a time-consuming full scan of the EMP table for every department number in the DEPT table. Even if the DEPTNO column in EMP is indexed, the index is not used because the subquery lacks a WHERE clause naming DEPTNO.

A third cause of poor performance is unnecessary parsing and binding. Recall that before executing a SQL statement, Oracle must parse and bind it. Parsing means examining the SQL statement to make sure it follows syntax rules and refers to valid database objects. Binding means associating host variables in the SQL statement with their addresses so that Oracle can read or write their values.

Many applications manage cursors poorly. This results in unnecessary parsing and binding, which adds noticeably to processing overhead.

How Can Performance Be Improved?

If you are unhappy with the performance of your precompiled programs, there are several ways you can reduce overhead.

You can greatly reduce Oracle communication overhead, especially in networked environments, by

- using host arrays
- using embedded PL/SQL

You can reduce processing overhead—sometimes dramatically—by

- optimizing SQL statements
- using indexes
- taking advantage of row-level locking
- eliminating unnecessary parsing

The following sections look at each of these ways to cut overhead.

Using Host Arrays

Host arrays can increase performance because they let you manipulate an entire collection of data with a single SQL statement. For example, suppose you want to INSERT salaries for 300 employees into the EMP table. Without arrays your program must do 300 individual INSERTs—one for each employee. With arrays, only one INSERT is necessary. Consider the following statement:

```
EXEC SQL INSERT INTO emp (sal) VALUES (:salary);
```

If *salary* is a simple host variable, Oracle executes the INSERT statement once, inserting a single row into the EMP table. In that row, the SAL column has the value of *salary*. To insert 300 rows this way, you must execute the INSERT statement 300 times.

However, if *salary* is a host array of size 300, Oracle inserts all 300 rows into the EMP table at once. In each row, the SAL column has the value of an element in the *salary* array.

For more information, see Chapter 12, “Using Host Arrays”.

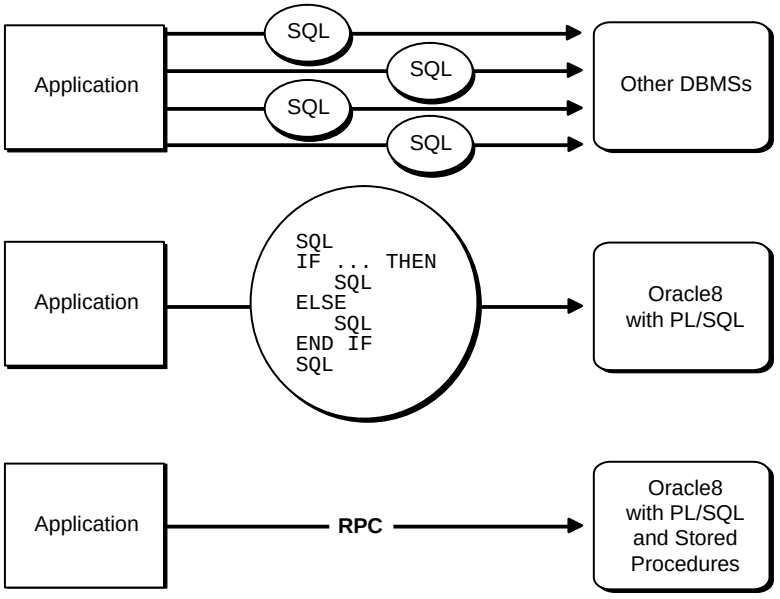
Using Embedded PL/SQL

As Figure 0–1 shows, if your application is database-intensive, you can use control structures to group SQL statements in a PL/SQL block, then send the entire block to Oracle. This can drastically reduce communication between your application and Oracle.

Also, you can use PL/SQL subprograms to reduce calls from your application to Oracle. For example, to execute ten individual SQL statements, ten calls are

required, but to execute a subprogram containing ten SQL statements, only one call is required.

Figure 0–1 PL/SQL Boosts Performance



PL/SQL can also cooperate with Oracle application development tools such as SQL*Forms, SQL*Menu, and SQL*ReportWriter. By adding procedural processing power to these tools, PL/SQL boosts performance. Using PL/SQL, a tool can do any computation quickly and efficiently without calling on Oracle. This saves time and reduces network traffic.

For more information, see Chapter 6, "Using Embedded PL/SQL", and the *PL/SQL User's Guide and Reference*.

Optimizing SQL Statements

For every SQL statement, the Oracle optimizer generates an *execution plan*, which is a series of steps that Oracle takes to execute the statement. These steps are determined by rules given in *Oracle8 Application Developer's Guide*. Following these rules will help you write optimal SQL statements.

Optimizer Hints

In some cases, you can suggest to Oracle the way to optimize a SQL statement. These suggestions, called *hints*, let you influence decisions made by the optimizer.

Hints are not directives; they merely help the optimizer do its job. Some hints limit the scope of information used to optimize a SQL statement, while others suggest overall strategies.

You can use hints to specify the

- optimization approach for a SQL statement
- access path for each referenced table
- join order for a join
- method used to join tables

Hence, hints fall into the following four categories:

- Optimization Approach
- Access Path
- Join Order
- Join Operation

For example, the two optimization approach hints, COST and NOCOST, invoke the cost-based optimizer and the rule-based optimizer, respectively.

You give hints to the optimizer by placing them in a C-style comment immediately after the verb in a SELECT, UPDATE, INSERT, or DELETE statement. For instance, the optimizer uses the cost-based approach for the following statement:

```
SELECT /*+ COST */ ename, sal INTO ...
```

For C++ code, optimizer hints in the form //+ are also recognized.

For more information about optimizer hints, see *Oracle8 Application Developer's Guide*.

Trace Facility

You can use the SQL trace facility and the EXPLAIN PLAN statement to identify SQL statements that might be slowing down your application.

The SQL trace facility generates statistics for every SQL statement executed by Oracle. From these statistics, you can determine which statements take the most time to process. Then, you can concentrate your tuning efforts on those statements.

The EXPLAIN PLAN statement shows the execution plan for each SQL statement in your application. An *execution plan* describes the database operations that Oracle must carry out to execute a SQL statement. You can use the execution plan to identify inefficient SQL statements.

For instructions on using these tools and analyzing their output, see *Oracle8 Application Developer's Guide*.

Using Indexes

Using ROWIDs, an *index* associates each distinct value in a table column with the rows containing that value. An index is created with the CREATE INDEX statement. For details, see *Oracle8 SQL Reference*.

You can use indexes to boost the performance of queries that return less than 15% of the rows in a table. A query that returns 15% or more of the rows in a table is executed faster by a *full scan*, that is, by reading all rows sequentially.

Any query that names an indexed column in its WHERE clause can use the index. For guidelines that help you choose which columns to index, see *Oracle8 Application Developer's Guide*.

Taking Advantage of Row-Level Locking

By default, Oracle locks data at the row level rather than the table level. Row-level locking allows multiple users to access different rows in the same table concurrently. The resulting performance gain is significant.

You can specify table-level locking, but it lessens the effectiveness of the transaction processing option. For more information about table locking, see the section "Using LOCK TABLE" on page 10-11.

Applications that do online transaction processing benefit most from row-level locking. If your application relies on table-level locking, modify it to take advantage of row-level locking. In general, avoid explicit table-level locking.

Eliminating Unnecessary Parsing

Eliminating unnecessary parsing requires correct handling of cursors and selective use of the following cursor management options:

- MAXOPENCURSORS
- HOLD_CURSOR
- RELEASE_CURSOR

These options affect implicit and explicit cursors, the cursor cache, and private SQL areas.

Handling Explicit Cursors

Recall that there are two types of cursors: implicit and explicit. Oracle implicitly declares a cursor for all data definition and data manipulation statements. However, for queries that return more than one row, you must explicitly declare a cursor (or use host arrays). You use the DECLARE CURSOR statement to declare an explicit cursor. The way you handle the opening and closing of explicit cursors affects performance.

If you need to reevaluate the active set, simply reOPEN the cursor. OPEN will use any new host-variable values. You can save processing time if you do not CLOSE the cursor first.

> **Note:** To make performance tuning easier, Oracle lets you reOPEN an already open cursor. However, this is ANSI extension. So, when MODE=ANSI, you must CLOSE a cursor before reOPENing it.

Only CLOSE a cursor when you want to free the resources (memory and locks) acquired by OPENing the cursor. For example, your program should CLOSE all cursors before exiting.

Cursor Control

In general, there are three ways to control an explicitly declared cursor:

- use DECLARE, OPEN, and CLOSE
- use PREPARE, DECLARE, OPEN, and CLOSE
- COMMIT closes the cursor when MODE=ANSI

With the first way, beware of unnecessary parsing. OPEN does the parsing, but only if the parsed statement is unavailable because the cursor was CLOSEd or never OPENed. Your program should DECLARE the cursor, reOPEN it every time

the value of a host variable changes, and CLOSE it only when the SQL statement is no longer needed.

With the second way (for dynamic SQL Methods 3 and 4), PREPARE does the parsing, and the parsed statement is available until a CLOSE is executed. Your program should PREPARE the SQL statement and DECLARE the cursor, reOPEN the cursor every time the value of a host variable changes, rePREPARE the SQL statement and reOPEN the cursor if the SQL statement changes, and CLOSE the cursor only when the SQL statement is no longer needed.

When possible, avoid placing OPEN and CLOSE statements in a loop; this is a potential cause of unnecessary reparsing of the SQL statement. In the next example, both the OPEN and CLOSE statements are inside the outer *while* loop. When MODE=ANSI, the CLOSE statement must be positioned as shown, because ANSI requires a cursor to be CLOSEd before being reOPENed.

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
     SELECT ename, sal from emp where sal >  :salary and
                                       sal <= :salary + 1000;
salary = 0;
while (salary < 5000)
{
     EXEC SQL OPEN emp_cursor;
     while (SQLCODE==0)
     {
         EXEC SQL FETCH emp_cursor INTO ....
         ...
     }
     salary += 1000;
     EXEC SQL CLOSE emp_cursor;
}
```

With MODE=ORACLE, however, a CLOSE statement can execute without the cursor being OPENed. By placing the CLOSE statement outside the outer *while* loop, you can avoid possible reparsing at each iteration of the OPEN statement.

```
...
while (salary < 5000)
{
     EXEC SQL OPEN emp_cursor;
     while (sqlca.sqlcode==0)
     {
         EXEC SQL FETCH emp_cursor INTO ....
         ...
     }
```

```
     salary += 1000;
}
EXEC SQL CLOSE emp_cursor;
```

Using the Cursor Management Options

A SQL statement need be parsed only once unless you change its makeup. For example, you change the makeup of a query by adding a column to its select list or WHERE clause. The HOLD_CURSOR, RELEASE_CURSOR, and MAXOPENCURSORS options give you some control over how Oracle manages the parsing and reparsing of SQL statements. Declaring an explicit cursor gives you maximum control over parsing.

SQL Areas and Cursor Cache

When a data manipulation statement is executed, its associated cursor is linked to an entry in the Pro*C/C++ cursor cache. The cursor cache is a continuously updated area of memory used for cursor management. The cursor cache entry is in turn linked to a private SQL area.

The private SQL area, a work area created dynamically at run time by Oracle, contains the addresses of host variables, and other information needed to process the statement. An explicit cursor lets you name a SQL statement, access the information in its private SQL area, and, to some extent, control its processing.

Figure 0–2 Cursors Linked via the Cursor Cache

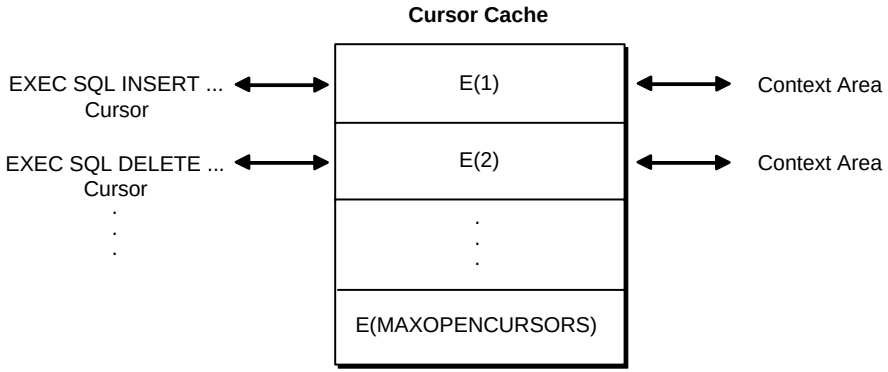


Figure 0–2 represents the cursor cache after your program has done an INSERT and a DELETE.

Resource Use

The maximum number of open cursors per user session is set by the Oracle initialization parameter OPEN_CURSORS.

MAXOPENCURSORS specifies the *initial* size of the cursor cache. If a new cursor is needed and there are no free cache entries, Oracle tries to reuse an entry. Its success depends on the values of HOLD_CURSOR and RELEASE_CURSOR and, for explicit cursors, on the status of the cursor itself.

If the value of MAXOPENCURSORS is less than the number of cache entries actually needed, Oracle uses the first cache entry marked as reusable. For example, suppose an INSERT statement's cache entry *E*(1) is marked as reusable, and the number of cache entries already equals MAXOPENCURSORS. If the program executes a new statement, cache entry *E*(1) and its private SQL area might be reassigned to the new statement. To re-execute the INSERT statement, Oracle would have to reparse it and reassign another cache entry.

Oracle allocates an additional cache entry if it cannot find one to reuse. For example, if MAXOPENCURSORS=8 and all eight entries are active, a ninth is created. If necessary, Oracle keeps allocating additional cache entries until it runs out of memory or reaches the limit set by OPEN_CURSORS. This dynamic allocation adds to processing overhead.

Thus, specifying a low value for MAXOPENCURSORS saves memory but causes potentially expensive dynamic allocations and deallocations of new cache entries. Specifying a high value for MAXOPENCURSORS assures speedy execution but uses more memory.

Infrequent Execution

Sometimes, the link between an *infrequently* executed SQL statement and its private SQL area should be temporary.

When HOLD_CURSOR=NO (the default), after Oracle executes the SQL statement and the cursor is closed, the precompiler marks the link between the cursor and cursor cache as reusable. The link is reused as soon as the cursor cache entry to which it points is needed for another SQL statement. This frees memory allocated to the private SQL area and releases parse locks. However, because a PREPAREd cursor must remain active, its link is maintained even when HOLD_CURSOR=NO.

When RELEASE_CURSOR=YES, after Oracle executes the SQL statement and the cursor is closed, the private SQL area is automatically freed and the parsed statement lost. This might be necessary if, for example, MAXOPENCURSORS is set low at your site to conserve memory.

If a data manipulation statement precedes a data definition statement and they reference the same tables, specify RELEASE_CURSOR=YES for the data manipulation statement. This avoids a conflict between the parse lock obtained by the data manipulation statement and the exclusive lock required by the data definition statement.

When RELEASE_CURSOR=YES, the link between the private SQL area and the cache entry is immediately removed and the private SQL area freed. Even if you specify HOLD_CURSOR=YES, Oracle must still reallocate memory for a private SQL area and reparse the SQL statement before executing it because RELEASE_CURSOR=YES overrides HOLD_CURSOR=YES.

However, when RELEASE_CURSOR=YES, the reparse might still require no extra processing because Oracle caches the parsed representations of SQL statements and PL/SQL blocks in its *Shared SQL Cache*. Even if its cursor is closed, the parsed representation remains available until it is aged out of the cache.

Frequent Execution

The links between a *frequently* executed SQL statement and its private SQL area should be maintained because the private SQL area contains all the information needed to execute the statement. Maintaining access to this information makes subsequent execution of the statement much faster.

When HOLD_CURSOR=YES, the link between the cursor and cursor cache is maintained after Oracle executes the SQL statement. Thus, the parsed statement and allocated memory remain available. This is useful for SQL statements that you want to keep active because it avoids unnecessary reparsing.

When RELEASE_CURSOR=NO (the default), the link between the cache entry and the private SQL area is maintained after Oracle executes the SQL statement and is not reused unless the number of open cursors exceeds the value of MAXOPENCURSORS. This is useful for SQL statements that are executed often because the parsed statement and allocated memory remain available.

> **Note:** With prior versions of Oracle, when RELEASE_CURSOR=NO and HOLD_CURSOR=YES, after Oracle executes a SQL statement, its parsed representation remains available. But, with Oracle8, when RELEASE_CURSOR=NO and HOLD_CURSOR=YES, the parsed representation remains available only until it is aged out of the Shared SQL Cache. Normally, this is not a problem,

but you might get unexpected results if the definition of a referenced object changes before the SQL statement is reparsed.

Parameter Interactions

Table 0–2 shows how HOLD_CURSOR and RELEASE_CURSOR interact. Notice that HOLD_CURSOR=NO overrides RELEASE_CURSOR=NO and that RELEASE_CURSOR=YES overrides HOLD_CURSOR=YES.

Table 0–2 HOLD_CURSOR and RELEASE _CURSOR Interactions

HOLD_CURSOR	RELEASE_CURSOR	Links are ...
NO	NO	marked as reusable
YES	NO	maintained
NO	YES	removed immediately
YES	YES	removed immediately

D

Syntactic and Semantic Checking

By checking the syntax and semantics of embedded SQL statements and PL/SQL blocks, the Pro*C/C++ Precompiler helps you quickly find and fix coding mistakes. This appendix shows you how to use the SQLCHECK option to control the type and extent of checking.

Topics are:

- What Is Syntactic and Semantic Checking?
- Controlling the Type and Extent of Checking
- Specifying SQLCHECK=SEMANTICS
- Specifying SQLCHECK=SYNTAX
- Entering the SQLCHECK Option

What Is Syntactic and Semantic Checking?

Rules of syntax specify how language elements are sequenced to form valid statements. Thus, *syntactic checking* verifies that keywords, object names, operators, delimiters, and so on are placed correctly in your SQL statement. For example, the following embedded SQL statements contain syntax errors:

```
EXEC SQL DELETE FROM EMP WHER DEPTNO = 20;
     -- misspelled keyword WHERE
EXEC SQL INSERT INTO EMP COMM, SAL VALUES (NULL, 1500);
     -- missing parentheses around column names COMM and SAL
```

Rules of semantics specify how valid external references are made. Thus, *semantic checking* verifies that references to database objects and host variables are valid and that host variable datatypes are correct. For example, the following embedded SQL statements contain semantic errors:

```
EXEC SQL DELETE FROM empp WHERE deptno = 20;
     -- nonexistent table, EMPP
EXEC SQL SELECT * FROM emp WHERE ename = :emp_name;
     -- undeclared host variable, emp_name
```

The rules of SQL syntax and semantics are defined in *Oracle8 SQL Reference*.

Controlling the Type and Extent of Checking

You control the type and extent of checking by specifying the SQLCHECK option on the command line. With SQLCHECK, the *type* of checking can be syntactic, semantic, or both. The *extent* of checking can include the following:

- data definition statements (such as CREATE and GRANT)
- data manipulation statements (such as SELECT and INSERT)
- PL/SQL blocks

However, SQLCHECK cannot check dynamic SQL statements because they are not fully defined until run time.

You can specify the following values for SQLCHECK:

- SEMANTICS
- SYNTAX

The default value is SYNTAX.

The use of SQLCHECK does not affect the normal syntax checking done on data control, cursor control, and dynamic SQL statements.

Specifying SQLCHECK=SEMANTICS

When SQLCHECK=SEMANTICS, the precompiler checks the syntax and semantics of

- data manipulation statements (INSERT, UPDATE, and so on)
- PL/SQL blocks
- host variable datatypes

as well as the syntax of

- data definition statements (CREATE, ALTER, and so on)

However, only syntactic checking is done on data manipulation statements that use the AT *db_name* clause.

When SQLCHECK=SEMANTICS, the precompiler gets information needed for a semantic check by using embedded DECLARE TABLE statements or if you specify the USERID option on the command line, by connecting to Oracle and accessing the data dictionary. You need not connect to Oracle if every table referenced in a data manipulation statement or PL/SQL block is defined in a DECLARE TABLE statement.

If you connect to Oracle, but some needed information cannot be found in the data dictionary, you must use DECLARE TABLE statements to supply the missing information. A DECLARE TABLE definition overrides a data dictionary definition if they conflict.

If you embed PL/SQL blocks in a host program, you *must* specify SQLCHECK=SEMANTICS.

When checking data manipulation statements, the precompiler uses the Oracle8 set of syntax rules found in the *Oracle8 Server SQL Reference*, but uses a stricter set of semantic rules. In particular, stricter datatype checking is done. As a result, existing applications written for earlier versions of Oracle might not precompile successfully when SQLCHECK=SEMANTICS.

Specify SQLCHECK=SEMANTICS when you precompile new programs or want stricter datatype checking.

Enabling a Semantic Check

When SQLCHECK=SEMANTICS, the precompiler can get information needed for a semantic check in either of the following ways:

- Connect to Oracle and access the data dictionary.
- Use embedded DECLARE TABLE and DECLARE TYPE statements.

Connecting to Oracle

To do a semantic check, the precompiler can connect to an Oracle database that maintains definitions of tables, types, and views referenced in your host program.

After connecting to Oracle, the precompiler accesses the data dictionary for needed information. The *data dictionary* stores table and column names, table and column constraints, column lengths, column datatypes, and so on.

If some of the needed information cannot be found in the data dictionary (because your program refers to a table not yet created, for example), you must supply the missing information using the DECLARE TABLE statement (discussed later in this appendix).

To connect to Oracle, specify the USERID option on the command line, using the syntax

```
USERID=username/password
```

where *username* and *password* comprise a valid Oracle userid. If you omit the password, you are prompted for it.

If, instead of a username and password, you specify

```
USERID=/
```

the precompiler attempts to automatically connect to Oracle. The attempt succeeds only if an existing Oracle username matches your operating system ID prefixed with "OPS$", or whatever value the parameter OS_AUTHENT_PREFIX is set to in the INIT.ORA file. For example, if your operating system ID is MBLAKE, an automatic connect only succeeds if OPS$MBLAKE is a valid Oracle username.

If you omit the USERID option, the precompiler must get needed information from embedded DECLARE TABLE statements.

If you try connecting to Oracle but cannot (because the database is unavailable, for example), an error message is issued and your program is not precompiled.

Using DECLARE TABLE

The precompiler can do a semantic check without connecting to Oracle. To do the check, the precompiler must get information about tables and views from embedded DECLARE TABLE statements. Thus, every table referenced in a data manipulation statement or PL/SQL block must be defined in a DECLARE TABLE statement.

The syntax of the DECLARE TABLE statement is:

```
EXEC SQL DECLARE table_name TABLE
     (col_name col_datatype [DEFAULT expr] [NULL|NOT NULL], ...);
```

where *expr* is an integer that can be used as a default column value in the CREATE TABLE statement.

For user-defined object datatypes,the size is optional because it is not used.

If you use DECLARE TABLE to define a database table that already exists, the precompiler uses your definition, ignoring the one in the data dictionary.

Using DECLARE TYPE

Similarly, for TYPE, there is a DECLARE TYPE statement whose syntax is:

```
EXEC SQL DECLARE type TYPE
     (col_name col_datatype, ...);
```

This allows for better type-checking for user-defined types when SQLCHECK=FULL at precompile-time. When SQLCHECK=SYNTAX, the DECLARE TYPE statements serve as documentation only and are commented out and ignored.

Specifying SQLCHECK=SYNTAX

When SQLCHECK=SYNTAX, the precompiler checks the syntax of

- data manipulation statements
- host-variable expressions

No semantic check is done, and the following restrictions apply:

- No connection to Oracle is attempted and USERID becomes an invalid option. If you specify USERID, a warning message is issued.
- DECLARE TABLE and DECLARE TYPE statements are ignored; they serve only as documentation.

- PL/SQL blocks are not allowed. If the precompiler finds a PL/SQL block, an error message is issued.

When checking data manipulation statements, the precompiler uses Oracle8 syntax rules. These rules are downwardly compatible, so specify SQLCHECK=SYNTAX when migrating your precompiled programs.

Entering the SQLCHECK Option

You can enter the SQLCHECK option inline or on the command line. However, the level of checking you specify inline cannot be higher than the level you specify (or accept by default) on the command line. For example, if you specify SQLCHECK=SYNTAX on the command line, you cannot specify SQLCHECK=SEMANTICS inline.

E

System-Specific References

This appendix groups together in one place all references in this guide to system-specific information.

System-Specific Information

System-specific information is described in the appropriate Oracle system-specific documentation for your platform.

Location of Standard Header Files

The location of the standard Pro*C/C++ header files—*sqlca.h*, *oraca.h*, and *sqlda.h*—is system specific. For other your system, see your Oracle system-specific documentation.

Specifying Location of Included Files for the C Compiler

When you use the Pro*C/C++ command-line option INCLUDE= to specify the location of a non-standard file to be included, you should also specify the same location for the C compiler. The way you do this is system specific. See"Migrating From Earlier Pro*C/C++ Releases" on page 3-9 .

ANSI C Support

Use the CODE= option to make the C code that Pro*C/C++ generates compatible with your system's C compiler. See "Function Prototyping" on page 3-12.

Struct Component Alignment

C compilers vary in the way they align struct components, usually depending on the system hardware. Use the *sqlvcp()* function to determine the padding added to the *.arr* component of a VARCHAR struct. See the section "Finding the Length of the VARCHAR Array Component" on page 3-46.

Size of an Integer and ROWID

The size in bytes of integer datatypes and the binary external size of ROWID datatypes are system dependent. See the section "INTEGER" on page 3-21 and the section "ROWID" on page 3-23.

Byte Ordering

The order of bytes in a word is platform dependent. See the section "UNSIGNED" on page 3-24.

Connecting to Oracle

Connecting to Oracle using the Net8 drivers involves system-specific network protocols. See the section "Connecting to Oracle8" on page 4-21 for more details.

Linking in an XA Library

You link in your XA library in a system-dependent way. See the section "Linking" on page 4-62, and your Oracle installation or user's guides, for more information.

Location of the Pro*C/C++ Executable

The location of the Pro*C/C++ Precompiler is system specific. See the section "The Precompiler Command" on page 9-2, and your installation or user's guides, for more information.

System Configuration File

Each precompiler installation has a system configuration file. This file is not shipped with the precompiler; it must be created by the system administrator. The location (directory path) which Pro*C/C++ searches for the system configuration file is system dependent. See the section "Configuration Files" on page 9-5 for more information.

INCLUDE Option Syntax

The syntax for the value of the INCLUDE command-line option is system specific. See "INCLUDE" on page 9-22.

Compiling and Linking

Compiling and linking your Pro*C/C++ output to get an executable application is always system dependent. See the section "Compiling and Linking" on page 9-41, and the following sections, for additional information.

User Exits

Compiling and linking Oracle Forms user exits is system specific. See Chapter 15, "Writing User Exits".

F

Embedded SQL Commands and Directives

This appendix contains descriptions of both the SQL92 embedded commands and directives, as well as the Oracle embedded SQL extensions.

Note: Only statements which differ in syntax from non-embedded SQL are described in this appendix. For details of the non-embedded SQL statements, see the *Oracle8 SQL Reference.*

This appendix has the following sections:

- Summary of Precompiler Directives and Embedded SQL Commands
- About The Command Descriptions
- How to Read Syntax Diagrams
- ALLOCATE (Executable Embedded SQL Extension)
- CACHE FREE ALL (Executable Embedded SQL Extension)
- CLOSE (Executable Embedded SQL)
- COMMIT (Executable Embedded SQL)
- CONNECT (Executable Embedded SQL Extension)
- CONTEXT ALLOCATE (Executable Embedded SQL Extension)
- CONTEXT FREE (Executable Embedded SQL Extension)
- CONTEXT OBJECT OPTION GET (Executable Embedded SQL Extension)
- CONTEXT OBJECT OPTION SET (Executable Embedded SQL Extension)T
- DECLARE CURSOR (Embedded SQL Directive)
- DECLARE DATABASE (Oracle Embedded SQL Directive)
- DECLARE STATEMENT (Embedded SQL Directive)

- DECLARE TABLE (Oracle Embedded SQL Directive)
- DECLARE TYPE (Oracle Embedded SQL Directive)
- DELETE (Executable Embedded SQL)
- DESCRIBE (Executable Embedded SQL)
- ENABLE THREADS (Executable Embedded SQL Extension)
- EXECUTE ... END-EXEC (Executable Embedded SQL Extension)
- EXECUTE (Executable Embedded SQL)
- EXECUTE IMMEDIATE (Executable Embedded SQL)
- FETCH (Executable Embedded SQL)
- FREE (Executable Embedded SQL Extension)
- INSERT (Executable Embedded SQL)
- OPEN (Executable Embedded SQL)
- PREPARE (Executable Embedded SQL)
- ROLLBACK (Executable Embedded SQL)
- SAVEPOINT (Executable Embedded SQL)
- SELECT (Executable Embedded SQL)
- TYPE (Oracle Embedded SQL Directive)
- UPDATE (Executable Embedded SQL)
- VAR (Oracle Embedded SQL Directive)
- WHENEVER (Embedded SQL Directive)

Summary of Precompiler Directives and Embedded SQL Commands

Embedded SQL commands place DDL, DML, and Transaction Control statements within a Pro*C/C++ program. Table 0–3 provides a functional summary of the embedded SQL commands and directives.

The *Source/Type* column in Table 0–3 is displayed in the format:

Source	is either SQL92 standard SQL (S) or an Oracle extension (O).
Type	is either an executable (E) statement or a directive (D).

Table 0–3 Precompiler Directives and Embedded SQL Commands and Clauses

EXEC SQL Statement	Source/Type	Purpose
ALLOCATE	O/E	To allocate memory for a cursor variable or an Object type.
CACHE FREE ALL	O/E	Frees all allocated object cache memory.
CLOSE	S/E	To disable a cursor, releasing the resources it holds.
COMMIT	S/E	To end the current transaction, making all database change permanent (optionally frees resources and disconnects from the database)
CONNECT	O/E	To log on to an Oracle8 instance.
CONTEXT ALLOCATE	O/E	To allocate memory for a SQLLIB runtime context.
CONTEXT FREE	O/E	To free memory for a SQLLIB runtime context.
CONTEXT OBJECT OPTION GET	O/E	To determine how options are set.
CONTEXT OBJECT OPTION SET	O/E	To set options.
CONTEXT USE	O/D	To specify which SQLLIB runtime context to use for subsequent executable SQL statements when multiple threads are used.
DECLARE CURSOR	S/D	To declare a cursor, associating it with a query.
DECLARE DATABASE	O/D	To declare an identifier for a non-default database to be accessed in subsequent embedded SQL statements.
DECLARE STATEMENT	S/D	To assign a SQL variable name to a SQL statement.

Table 0–3 Precompiler Directives and Embedded SQL Commands and Clauses

EXEC SQL Statement	Source/Type	Purpose
DECLARE TABLE	O/D	To declare the table structure for semantic checking of embedded SQL statements by Pro*C/C++.
DECLARE TYPE	O/D	To declare the type structure for semantic checking of embedded SQL statements by Pro*C/C++.
DELETE	S/E	To remove rows from a table or from a view's base table.
DESCRIBE	S/E	To initialize a descriptor, a structure holding host variable descriptions.
ENABLE THREADS	O/E	To initialize a process that supports multiple threads.
EXECUTE...END-EXEC	O/E	To execute an anonymous PL/SQL block.
EXECUTE	S/E	To execute a prepared dynamic SQL statement.
EXECUTE IMMEDIATE	S/E	To prepare and execute a SQL statement with no host variables.
FETCH	S/E	To retrieve rows selected by a query.
FREE	O/E	To free memory allocated in the object cache
INSERT	S/E	To add rows to a table or to a view's base table.
OBJECT CREATE	O/E	To create a referenceable object in the cache.
OBJECT DELETE	O/E	To mark an object as deleted.
OBJECT DEREF	O/E	To dereference an object.
OBJECT FLUSH	O/E	To transmit persistent objects to server.
OBJECT GET	O/E	To convert an object attribute to a C type.
OBJECT RELEASE	O/E	To "unpin" an object in the cache.
OBJECT SET	O/E	To update object attributes in the cache.
OBJECT UPDATE	O/E	To mark an object in the cache as updated.
OPEN	S/E	To execute the query associated with a cursor.
PREPARE	S/E	To parse a dynamic SQL statement.
ROLLBACK	S/E	To end the current transaction, discard all changes in the current transaction, and release all locks (optionally release resources and disconnect from the database).
SAVEPOINT	S/E	To identify a point in a transaction to which you can later roll back.

Table 0–3 Precompiler Directives and Embedded SQL Commands and Clauses

EXEC SQL Statement	Source/Type	Purpose
SELECT	S/E	To retrieve data from one or more tables, views, or snapshots, assigning the selected values to host variables.
TYPE	O/D	To assign an Oracle8 external datatype to a whole class of host variables by equivalencing the external datatype to a user-defined datatype.
UPDATE	S/E	To change existing values in a table or in a view's base table.
VAR	O/D	To override the default datatype and assign a specific Oracle8 external datatype to a host variable.
WHENEVER	S/D	To specify handling for error and warning conditions.

About The Command Descriptions

The directives, commands, and clauses appear alphabetically. The description of each contains the following sections:

Purpose	describes the basic uses of the command.
Prerequisites	lists privileges you must have and steps that you must take before using the command. Unless otherwise noted, most commands also require that the database be open by your instance.
Syntax	shows the keywords and parameters of the command.
Keywords and Parameters	describes the purpose of each keyword and parameter.
Usage Notes	discusses how and when to use the command.
Examples	shows example statements of the command.
Related Topics	lists related commands, clauses, and sections of this manual.

How to Read Syntax Diagrams

Syntax diagrams are used to illustrate embedded SQL syntax. They are drawings that depict valid syntax paths.

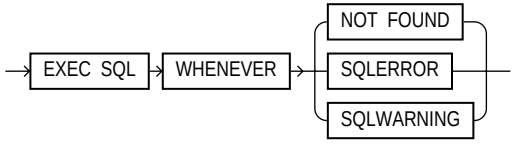
Trace each diagram from left to right, in the direction shown by the arrows.

Commands and other keywords appear in UPPER CASE inside rectangles. Type them exactly as shown in the rectangles. Parameters appear in lower case inside

ovals. Substitute variables for the parameters in statements you write. Operators, delimiters, and terminators appear in circles. Following the conventions defined in the Preface, a semicolon terminates statements.

If the syntax diagram has more than one path, you can choose any path to travel.

If you have the choice of more than one keyword, operator, or parameter, your options appear in a vertical list. In the following example, you can travel down the vertical line as far as you like, then continue along any horizontal line:



According to the diagram, all of the following statements are valid:

```
EXEC SQL WHENEVER NOT FOUND ...
EXEC SQL WHENEVER SQLERROR ...
EXEC SQL WHENEVER SQLWARNING ...
```

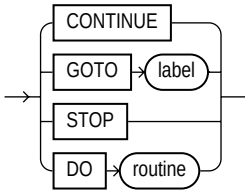
Required Keywords and Parameters

Required keywords and parameters can appear singly or in a vertical list of alternatives. Single required keywords and parameters appear on the *main path*, that is, on the horizontal line you are currently traveling. In the following example, *cursor* is a required parameter:

If there is a cursor named *emp_cursor*, then, according to the diagram, the following statement is valid:

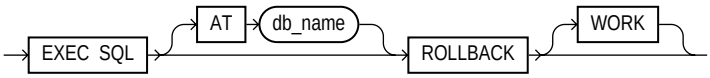
```
EXEC SQL CLOSE emp_cursor;
```

If any of the keywords or parameters in a vertical list appears on the main path, one of them is required. That is, you must choose one of the keywords or parameters, but not necessarily the one that appears on the main path. In the following example, you must choose one of the four actions:



Optional Keywords and Parameters

If keywords and parameters appear in a vertical list above the main path, they are optional. In the following example, instead of traveling down a vertical line, you can continue along the main path:

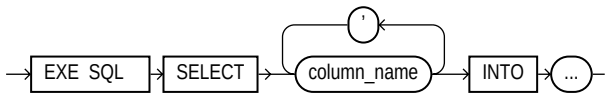


If there is a database named *oracle2*, then, according to the diagram, all of the following statements are valid:

```
EXEC SQL ROLLBACK;
EXEC SQL ROLLBACK WORK;
EXEC SQL AT oracle2 ROLLBACK;
```

Syntax Loops

Loops let you repeat the syntax within them as many times as you like. In the following example, *column_name* is inside a loop. So, after choosing one column name, you can go back repeatedly to choose another, separating the column names by a comma.



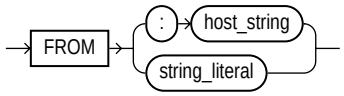
If DEBIT, CREDIT, and BALANCE are column names, then, according to the diagram, all of the following statements are valid:

```
EXEC SQL SELECT DEBIT INTO ...
EXEC SQL SELECT CREDIT, BALANCE INTO ...
```

```
EXEC SQL SELECT DEBIT, CREDIT, BALANCE INTO ...
```

Multi-part Diagrams

Read a multi-part diagram as if all the main paths were joined end-to-end. The following example is a two-part diagram:



According to the diagram, the following statement is valid:

```
EXEC SQL PREPARE statement_name FROM string_literal;
```

Database Objects

The names of Oracle objects, such as tables and columns, must not exceed 30 characters in length. The first character must be a letter, but the rest can be any combination of letters, numerals, dollar signs ($), pound signs (#), and underscores (_).

However, if an Oracle identifier is enclosed by quotation marks ("), it can contain any combination of legal characters, including spaces but excluding quotation marks.

Oracle identifiers are not case-sensitive except when enclosed by quotation marks.

Statement Terminator

In all embedded SQL diagrams, each statement is understood to end with the statement terminator ";".

ALLOCATE (Executable Embedded SQL Extension)

Purpose

To allocate a cursor variable to be referenced in a PL/SQL bloc, or to allocate space in the object cache.

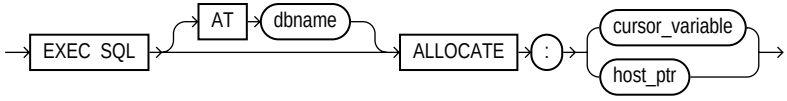
Prerequisites

A cursor variable (see Chapter 3, "Developing a Pro*C/C++ Application") of type SQL_CURSOR must be declared before allocating memory for the cursor variable.

Pointers to a host struct and, optionally, an indicator struct must be declared before allocating memory in the object cache.

An active connection to a database is required.

Syntax



Keywords and Parameters

dbname	a null-terminated string containing the database connection name, as established previously in a CONNECT statement. If omitted, or if an empty string, the default database connection is assumed.
cursor_variable	is the cursor variable to be allocated.
host_ptr	a pointer to a host struct generated by OTT for object types

Usage Notes

Whereas a cursor is static, a cursor variable is dynamic because it is not tied to a specific query. You can open a cursor variable for any type-compatible query.

For more information on this command, see *PL/SQL User's Guide and Reference* and *Oracle8 SQL Reference*.

Example

This partial example illustrates the use of the ALLOCATE command in a Pro*C/C++ embedded SQL program:

```
EXEC SQL BEGIN DECLARE SECTION;
   SQL_CURSOR emp_cv;
   struct{ ... } emp_rec;
EXEC SQL END DECLARE SECTION;
EXEC SQL ALLOCATE :emp_cv;
```

```
EXEC SQL EXECUTE
   BEGIN
      OPEN :emp_cv FOR SELECT * FROM emp;
   END;
END-EXEC;
for (;;)
   {
   EXEC SQL FETCH :emp_cv INTO :emp_rec;
   ...
   }
```

Related Topics

CACHE FREE ALL command on F-10.

CLOSE command on F-11

EXECUTE command on F-38

FETCH command on F-41

FREE command on F-44.

CACHE FREE ALL (Executable Embedded SQL Extension)

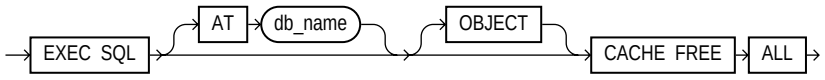
Purpose

To free all memory in the object cache.

Prerequisites

An active database connection must exist.

Syntax



Keywords and Parameters

db_name	a null-terminated string containing the database connection name, as established previously in a CONNECT statement. If omitted, or if an empty string, the default database connection is assumed.

Usage Notes

When the connection count drops to zero, SQLLIB automatically frees all object cache memory.For more information, see "CACHE FREE ALL" on page 8-7.

Example

```
EXEC SQL AT mydb CACHE FREE ALL ;
```

Related Topics

ALLOCATE command on F-8.

FREE command on F-44.

CLOSE (Executable Embedded SQL)

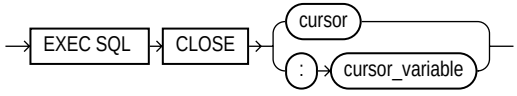
Purpose

To disable a cursor, freeing the resources acquired by opening the cursor, and releasing parse locks.

Prerequisites

The cursor or cursor variable must be open if MODE=ANSI.

Syntax



Keywords and Parameters

cursor	is a cursor to be closed.
cursor_variable	is a cursor variable to be closed.

Usage Notes

Rows cannot be fetched from a closed cursor. A cursor need not be closed to be reopened. The HOLD_CURSOR and RELEASE_CURSOR precompiler options alter the effect of the CLOSE command. For information on these options, see Chapter 9, "Running the Pro*C/C++ Precompiler".

Example

This example illustrates the use of the CLOSE command:

```
EXEC SQL CLOSE emp_cursor;
```

Related Topics

PREPARE command on F-60

DECLARE CURSOR command on F-22

OPEN command on F-58

COMMIT (Executable Embedded SQL)

Purpose

To end your current transaction, making permanent all its changes to the database and optionally freeing all resources and disconnecting from the Oracle8 Server.

Prerequisites

To commit your current transaction, no privileges are necessary.

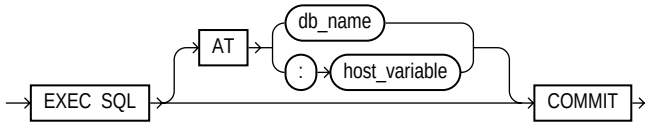
To manually commit a distributed in-doubt transaction that you originally committed, you must have FORCE TRANSACTION system privilege. To manually commit a distributed in-doubt transaction that was originally committed by another user, you must have FORCE ANY TRANSACTION system privilege.

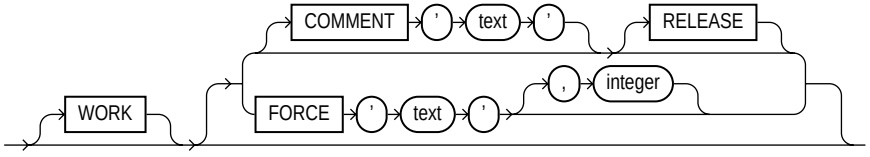
If you are using Trusted Oracle in DBMS MAC mode, you can only commit an in-doubt transaction if your DBMS label matches the transaction's label and the creation label of the user who originally committed the transaction; or, if you satisfy one of the following criteria:

- If the transaction's label or the user's creation label is higher than your DBMS label, you must have READUP and WRITEUP system privileges.
- If the transaction's label or the user's creation label is lower than your DBMS label, you must have WRITEDOWN system priivelege.

- If the transaction's label or the user's creation label is not comparable with your DBMS label, you must have READUP, WRITEUP, and WRITEDOWN system priveleges.

Syntax





Keyword and Parameters

AT — identifies the database to which the COMMIT statement is issued. The database can be identified by either:

- *db_name* — is a database identifier declared in a previous DECLARE DATABASE statement.
- :host_variable — is a host variable whose value is a db_name.

If you omit this clause, Oracle8 issues the statement to your default database.

WORK — is supported only for compliance with standard SQL. The statements COMMIT and COMMIT WORK are equivalent.

COMMENT — specifies a Comment to be associated with the current transaction. The 'text' is a quoted literal of up to 50 characters that Oracle8 stores in the data dictionary view DBA_2PC_PENDING along with the transaction ID if the transaction becomes in-doubt.

RELEASE — frees all resources and disconnects the application from the Oracle8 Server.

FORCE	manually commits an in-doubt distributed transaction. The transaction is identified by the 'text' containing its local or global transaction ID. To find the IDs of such transactions, query the data dictionary view DBA_2PC_PENDING. You can also use the optional integer to explicitly assign the transaction a system change number (SCN). If you omit the integer, the transaction is committed using the current SCN.

Usage Notes

Always explicitly commit or rollback the last transaction in your program by using the COMMIT or ROLLBACK command and the RELEASE option. Oracle8 automatically rolls back changes if the program terminates abnormally.

The COMMIT command has no effect on host variables or on the flow of control in the program. For more information on this command, see Chapter 10, "Defining and Controlling Transactions".

Example

This example illustrates the use of the embedded SQL COMMIT command:

```
EXEC SQL AT sales_db COMMIT RELEASE;
```

Related Topics

ROLLBACK command on F-61

SAVEPOINT command on F-64

CONNECT (Executable Embedded SQL Extension)

Purpose

To log on to an Oracle8 database.

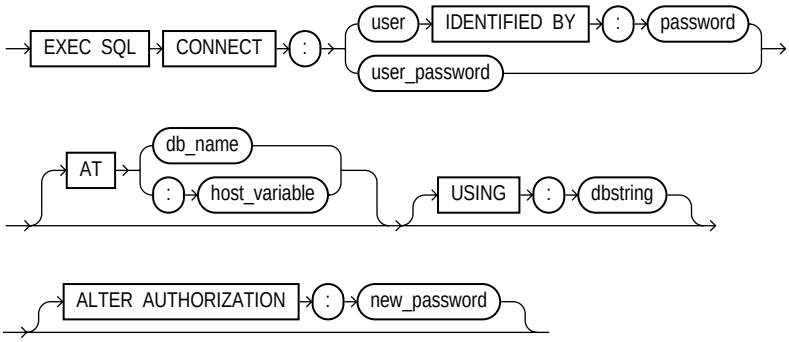
Prerequisites

You must have CREATE SESSION system privilege in the specified database.

If you are using Trusted Oracle in DBMS MAC mode, your operating system label must dominate both your creation label and the label at which you were granted CREATE SESSION system privilege. Your operating system label must also fall between the operating system equivalents of DBHIGH and DBLOW, inclusive.

If you are using Trusted Oracle in OS MAC mode, your operating system label must match the label of the database to which you are connecting.

Syntax



Keyword and Parameters

:user — specifies your username and password separately.

:password

:user_password — is a single host variable containing the Oracle8 username and password separated by a slash (/).

To allow Oracle8 to verify your connection through your operating system, specify "/" as the :*user_password* value.

AT — identifies the database to which the connection is made. The database can be identified by either:

- *db_name* — is a database identifier declared in a previous DECLARE DATABASE statement.
- *:host_variable* — is a host variable whose value is a previously declared db_name.

USING — specifies the Net8 database specification string used to connect to a non-default database. If you omit this clause, you are connected to your default database.

ALTER AUTHORIZATION — Change password to the following string.

:new_password — New password string.

Usage Notes

A program can have multiple connections, but can only connect once

to your default database. For more information on this command, see "Connecting to Oracle8" on page 4-21.

Example

The following example illustrate the use of CONNECT:

```
EXEC SQL CONNECT :username
    IDENTIFIED BY :password
```

You can also use this statement in which the value of :*userid* is the value of :*username* and :*password* separated by a "/" such as 'SCOTT/TIGER':

```
EXEC SQL CONNECT :userid
```

Related Topics

COMMIT command on F-12

DECLARE DATABASE command on F-24

ROLLBACK command on F-61

CONTEXT ALLOCATE (Executable Embedded SQL Extension)

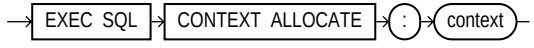
Purpose

To initialize a SQLLIB runtime context that is referenced in an EXEC SQL CONTEXT USE statement.

Prerequisites

The runtime context must be declared of type **sql_context**.

Syntax



Keywords and Parameters

:context	is the SQLLIB runtime context for which memory is to be allocated.

Usage Notes

In a multi-threaded application, execute this function once for each runtime context.

For more information on this command, see "Developing Multi-threaded Applications" on page 4-37.

Example

This example illustrates the use of a CONTEXT ALLOCATE command in a Pro*C/C++ embedded SQL program:

```
EXEC SQL CONTEXT ALLOCATE :ctx1;
```

Related Topics

CONTEXT FREE on F-17

CONTEXT USE on F-18

ENABLE THREADS on F-36

CONTEXT FREE (Executable Embedded SQL Extension)

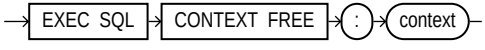
Purpose

To free all memory associated with a runtime context and place a null pointer in the host program variable.

Prerequisites

The CONTEXT ALLOCATE command must be used to allocate memory for the specified runtime context before the CONTEXT FREE command can free the memory allocated for it.

Syntax



Keywords and Parameters

context	is the allocated runtime context for which the memory is to be deallocated.

Usage Notes

For more information on this command, see "Developing Multi-threaded Applications" on page 4-37.

Example

This example illustrates the use of a CONTEXT FREE command in a Pro*C/C++ embedded SQL program:

```
EXEC SQL CONTEXT FREE :ctx1;
```

Related Topics

CONTEXT ALLOCATE on F-16

CONTEXT USE on F-18

ENABLE THREADS on F-36

CONTEXT OBJECT OPTION GET (Executable Embedded SQL Extension)

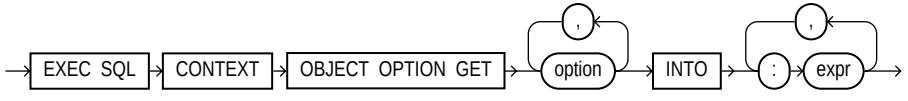
Purpose

To determine the values of options set by CONTEXT OBJECT OPTION SET for the context in use.

Prerequisites

Precompiler option OBJECTS must be set to YES.

Syntax



Keywords and Parameters

option	DATEFORMAT (format for Date conversion) or DATELANG (language for conversion)
expr	output of type STRING, VARCHAR, or CHARZ, in the same order as the *option* list.

Usage Notes

See "CONTEXT OBJECT OPTION SET" on page 8-18.

Example

```
char EuroFormat[50];
...
EXEC SQL CONTEXT OPTION GET DATEFORMAT INTO :EuroFormat ;
printf("Date format is ", %s\n");
```

Related Topics

CONTEXT ALLOCATE on page F-8.

CONTEXT FREE on page F-17

CONTEXT USE on page F-18

CONTEXT OBJECT OPTION SET on page F-19.

CONTEXT OBJECT OPTION SET (Executable Embedded SQL Extension)T

Purpose

To set options to specified values of Date attributes: DATEFORMAT, DATELANG for the context in use..

Prerequisites

Precompiler option OBJECTS must be set to YES.

Syntax

Keywords and Parameters

option	DATEFORMAT (format for Date conversion) or DATELANG (language for Date conversion)
expr	input of type STRING, VARCHAR, or CHARZ. In the same order as the *option* list.

Usage Notes

See "CONTEXT OBJECT OPTION GET" on page 8-19.

Example

```
char *new_format = "DD-MM-YYY";
cgar *new_lang = "French";
...
EXEC SQL CONTEXT OBJECT SET DATEFORMAT, DATELANG to :new_format, :new_lang;
```

Related Topics

CONTEXT ALLOCATE on page F-8.

CONTEXT FREE on page F-17.

CONTEXT USE on page F-18

CONTEXT OBJECT OPTION SET on page F-18

CONTEXT USE (Oracle Embedded SQL Directive)

Purpose

To instruct the precompiler to use the specified SQLLIB runtime context on subsequent executable SQL statements.

Prerequisites

The runtime context specified by the CONTEXT USE directive must be previously allocated using the CONTEXT ALLOCATE command.

Syntax

Keywords and Parameters

context is the allocated runtime context to use for subsequent executable SQL statements that follow it. For example, after specifying in your source code which context to use (multiple contexts can be allocated), you can connect to the Oracle Server and perform database operations within the scope of that context.

Usage Notes

This statement has no effect on declarative statements such as EXEC SQL INCLUDE or EXEC ORACLE OPTION. It works similarly to the EXEC SQL WHENEVER directive in that it affects all executable SQL statements which positionally follow it in a given source file without regard to standard C scope rules.

For more information on this command, see "Developing Multi-threaded Applications" on page 4-37.

Example

This example illustrates the use of a CONTEXT USE directive in a Pro*C/C++ embedded SQL program:

```
EXEC SQL CONTEXT USE :ctx1;
```

Related Topics

CONTEXT ALLOCATE on F-16

CONTEXT FREE on F-17

ENABLE THREADS on F-36

DECLARE CURSOR (Embedded SQL Directive)

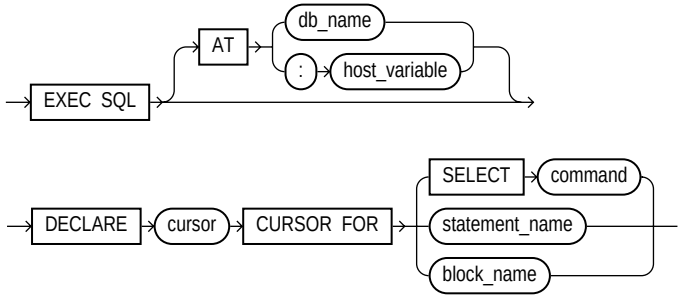
Purpose

To declare a cursor, giving it a name and associating it with a SQL statement or a PL/SQL block.

Prerequisites

If you associate the cursor with an identifier for a SQL statement or PL/SQL block, you must have declared this identifier in a previous DECLARE STATEMENT statement.

Syntax



Keywords and Parameters

AT	identifies the database on which the cursor is declared. The database can be identified by either:	
	db_name	is a database identifier declared in a previous DECLARE DATABASE statement.
	:host_variable	is a host variable whose value is a previously declared db_name.
		If you omit this clause, Oracle8 declares the cursor on your default database.
cursor	is the name of the cursor to be declared.	
SELECT *command*	is a SELECT statement to be associated with the cursor. The following statement cannot contain an INTO clause.	

statement_name *block_name*	identifies a SQL statement or PL/SQL block to be associated with the cursor. The statement_name or block_name must be previously declared in a DECLARE STATEMENT statement.

Usage Notes

You must declare a cursor before referencing it in other embedded SQL statements. The scope of a cursor declaration is global within its precompilation unit and the name of each cursor must be unique in its scope. You cannot declare two cursors with the same name in a single precompilation unit.

You can reference the cursor in the WHERE clause of an UPDATE or DELETE statement using the CURRENT OF syntax, provided that the cursor has been opened with an OPEN statement and positioned on a row with a FETCH statement. For more information on this command, see "Using Cursors" on page 6-19.

Example

This example illustrates the use of a DECLARE CURSOR statement:

```
EXEC SQL DECLARE emp_cursor CURSOR
    FOR SELECT ename, empno, job, sal
        FROM emp
        WHERE deptno = :deptno
        FOR UPDATE OF sal;
```

Related Topics

CLOSE command on F-11

DECLARE DATABASE command on F-24

DECLARE STATEMENT command on F-25

DELETE command on F-30

FETCH command on F-41

OPEN command on F-58

PREPARE command on F-60

SELECT command on F-66

UPDATE command on F-71

DECLARE DATABASE (Oracle Embedded SQL Directive)

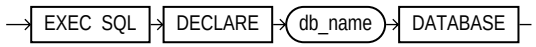
Purpose

To declare an identifier for a non-default database to be accessed in subsequent embedded SQL statements.

Prerequisites

You must have access to a username on the non-default database.

Syntax



Keywords and Parameters

db_name is the identifier established for the non-default database.

Usage Notes

You declare a *db_name* for a non-default database so that other embedded SQL statements can refer to that database using the AT clause. Before issuing a CONNECT statement with an AT clause, you must declare a *db_name* for the non-default database with a DECLARE DATABASE statement.

For more information on this command, see "Single Explicit Connections" on page 4-25.

Example

This example illustrates the use of a DECLARE DATABASE directive:

```
EXEC SQL DECLARE oracle3 DATABASE
```

Related Topics

COMMIT command on F-12

CONNECT command on F-14

DECLARE CURSOR command on F-22

DECLARE STATEMENT (Embedded SQL Directive)

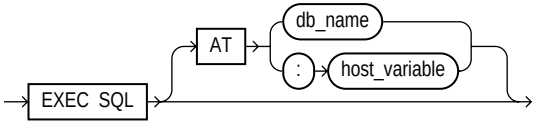
Purpose

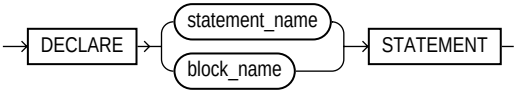
To declare an identifier for a SQL statement or PL/SQL block to be used in other embedded SQL statements.

Prerequisites

None.

Syntax





Keywords and Parameters

AT	identifies the database on which the SQL statement or PL/SQL block is declared. The database can be identified by either: *db_name* is a database identifier declared in a previous DECLARE DATABASE statement. *:host_variable* is a host variable whose value is a db_name. If you omit this clause, Oracle8 declares the SQL statement or PL/SQL block on your default database.
statement_name, block_name	is the declared identifier for the statement.

Usage Notes

You must declare an identifier for a SQL statement or PL/SQL block with a DECLARE STATEMENT statement only if a DECLARE CURSOR statement referencing the identifier appears physically (not logically) in the embedded SQL program before the PREPARE statement that parses the statement or block and associates it with its identifier.

The scope of a statement declaration is global within its precompilation unit, like a cursor declaration. For more information on this command, see Chapter 3, "Developing a Pro*C/C++ Application" and Chapter 13, "Using Dynamic SQL".

Example I

This example illustrates the use of the DECLARE STATEMENT statement:

```
EXEC SQL AT remote_db DECLARE my_statement STATEMENT;
EXEC SQL PREPARE my_statement FROM :my_string;
EXEC SQL EXECUTE my_statement;
```

Example II

In this example from a Pro*C/C++ embedded SQL program, the DECLARE STATEMENT statement is required because the DECLARE CURSOR statement precedes the PREPARE statement:

```
EXEC SQL DECLARE my_statement STATEMENT;
EXEC SQL DECLARE emp_cursor CURSOR FOR my_statement;
EXEC SQL PREPARE my_statement FROM :my_string;
```

. . .

Related Topics

CLOSE command on F-11

DECLARE DATABASE command on F-24

FETCH command on F-41

PREPARE command on F-60

OPEN command on F-58

DECLARE TABLE (Oracle Embedded SQL Directive)

Purpose

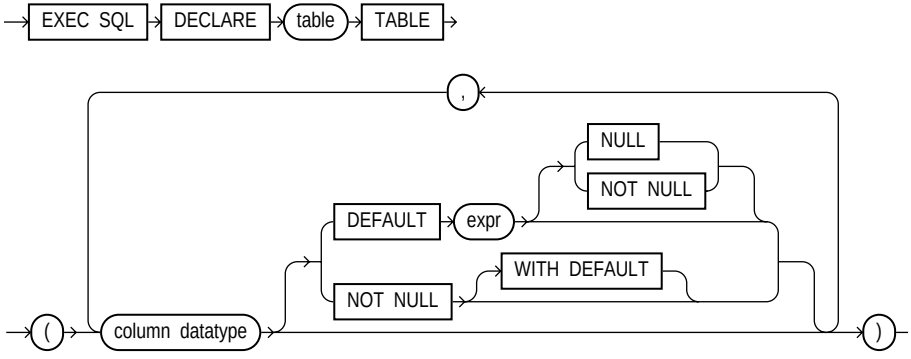
To define the structure of a table or view, including each column's datatype, default value, and NULL or NOT NULL specification for semantic checking by the Oracle Precompilers.

Prerequisites

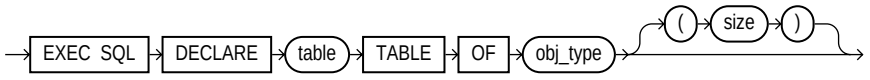
None.

Syntax

For relational tables, the syntax is:



For object tables, the syntax is:.



Keywords and Parameters

table	is the name of the declared table.
column	is a column of the table.
datatype	is the datatype of a column. For information on Oracle8 datatypes, see "Oracle Datatypes" on page 3-17. If the datatype is a user-defined object, a *size* may be entered in parentheses. The size cannot be a macro or a complex C expression. The size can be omitted. See examples.
DEFAULT	specifies the default value of a column.
expr	is any expression usable as a default column value in a CREATE TABLE statement.
NULL	specifies that a column can contain nulls.
NOT NULL	specifies that a column cannot contain nulls.
WITH DEFAULT	is supported for compatibility with the IBM DB2 database.

Usage Notes

For information on using this command, see “Using DECLARE TABLE” on page D-5.

Examples

The following statement declares the PARTS table with the PARTNO, BIN, and QTY columns:

```
EXEC SQL DECLARE parts TABLE
     (partno NUMBER  NOT NULL,
      bin    NUMBER,
      qty    NUMBER);
```

For an object datatype, the use of size in a parenthesis is optional:

```
EXEC SQL DECLARE person TYPE AS OBJECT (name VARCHAR2(20), age INT);
...
EXEC SQL DECLARE odjtab1 TABLE OF person;
```

Alternatively, the equivalent table declaration can be (size cannot be given as a macro or a complex C expression):

```
EXEC SQL DECLARE odjtab2 TABLE OF person(20);
```

Related Topics

See DECLARE TYPE on F-29.

DECLARE TYPE (Oracle Embedded SQL Directive)

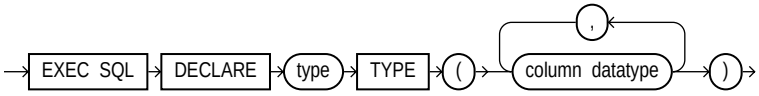
Purpose

To define the attributes of a type for a semantics check by the precompiler.

Prerequisites

None.

Syntax



Keywords and Parameters

type	is the name of the declared type
column	is a column
datatype	is the datatype of the column

Usage Notes

For information on using this command, see "Using DECLARE TYPE" on page D-5.

Example

```
EXEC SQL DECLARE project_type TYPE (
              pno           CHAR(5),
              pname         CHAR(20),
              budget        NUMBER);
```

Related Topics

DECLARE TABLE directive on F-27.

DELETE (Executable Embedded SQL)

Purpose

To remove rows from a table or from a view's base table.

Prerequisites

For you to delete rows from a table, the table must be in your own schema or you must have DELETE privilege on the table.

For you to delete rows from the base table of a view, the owner of the schema containing the view must have DELETE privilege on the base table. Also, if the view is in a schema other than your own, you must be granted DELETE privilege on the view.

The DELETE ANY TABLE system privilege also allows you to delete rows from any table or any view's base table.

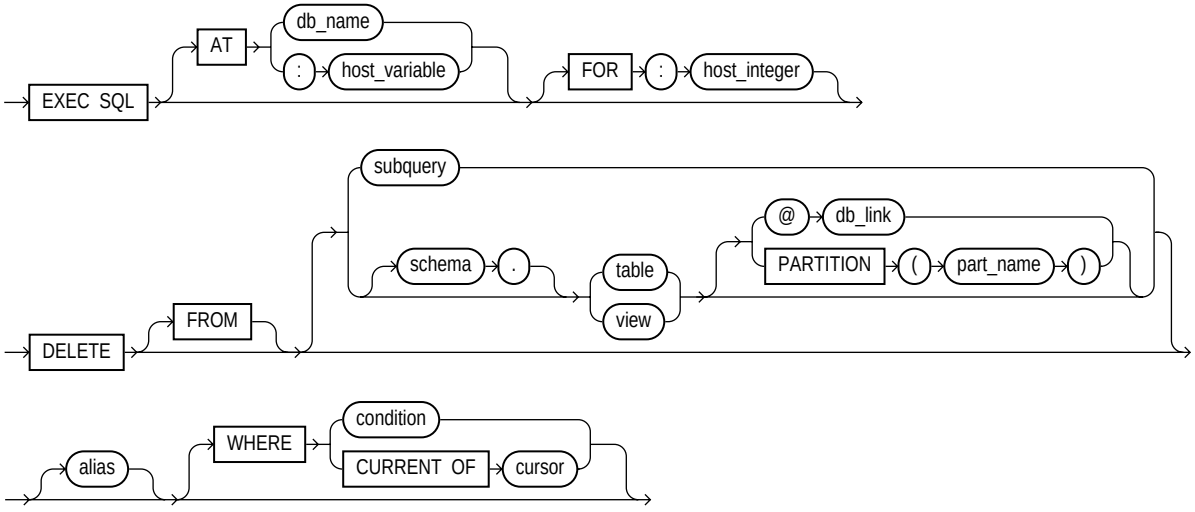
If you are using Trusted Oracle in DBMS MAC mode, your DBMS label must dominate the creation label of the table or view or you must meet one of the following criteria:

- If the creation label of the table or view is higher than your DBMS label, you must have READUP and WRITEUP system privileges.
- If the creation label of your table or view is not comparable to your DBMS label, you must have READUP, WRITEUP, and WRITEDOWN system privileges.

In addition, for each row to be deleted, your DBMS label must match the row's label or you must meet one of the following criteria:

- If the row's label is higher than your DBMS label, you must have READUP and WRITEUP system privileges.
- If the row's label is lower than your DBMS label, you must have WRITEDOWN system privilege.
- If the row label is not comparable to your DBMS label, you must have READUP, WRITEUP, and WRITEDOWN system privileges.

Syntax



Keywords and Parameters

AT identifies the database to which the DELETE statement is issued. The database can be identified by either:

db_name is a database identifier declared in a previous DECLARE DATABASE statement.

:host_integer is a host variable whose value is a previously declared *db_name*

If you omit this clause, the DELETE statement is issued to your default database.

FOR *:host_integer* — limits the number of times the statement is executed if the WHERE clause contains array host variables. If you omit this clause, Oracle8 executes the statement once for each component of the smallest array.

schema — is the schema containing the table or view. If you omit schema, Oracle8 assumes the table or view is in your own schema.

table view — is the name of a table from which the rows are to be deleted. If you specify view, Oracle8 deletes rows from the view's base table.

db_link — is the complete or partial name of a database link to a remote database where the table or view is located. For information on referring to database links, see the *Oracle8 SQL Reference* . You can only delete rows from a remote table or view if you are using Oracle8 with the distributed option.

If you omit *dblink*, Oracle8 assumes that the table or view is located on the local database.

part_name — is a partition within the table

alias — is an alias assigned to the table. Aliases are generally used in DELETE statements with correlated queries.

WHERE — specifies which rows are deleted:

- *condition* — deletes only rows that satisfy the condition. This condition can contain host variables and optional indicator variables. See the syntax description of condition in *Oracle8 SQL Reference* .
- CURRENT OF — deletes only the row most recently fetched by the cursor. The cursor cannot be associated with a SELECT statement that performs a join, unless its FOR UPDATE clause specifically locks only one table.

If you omit this clause entirely, Oracle8 deletes all rows from the table or view.

Usage Notes

The host variables in the WHERE clause must be either all scalars or all arrays. If they are scalars, Oracle8 executes the DELETE statement only once. If they are arrays, Oracle8 executes the statement once for each set of array components. Each execution may delete zero, one, or multiple rows.

Array host variables in the WHERE clause can have different sizes. In this case, the number of times Oracle8 executes the statement is determined by the smaller of the following values:

- the size of the smallest array
- the value of the :*host_integer* in the optional FOR clause

If no rows satisfy the condition, no rows are deleted and the SQLCODE returns a NOT_FOUND condition.

The cumulative number of rows deleted is returned through the SQLCA. If the WHERE clause contains array host variables, this value reflects the total number of rows deleted for all components of the array processed by the DELETE statement.

If no rows satisfy the condition, Oracle8 returns an error through the SQLCODE of the SQLCA. If you omit the WHERE clause, Oracle8 raises a warning flag in the fifth component of SQLWARN in the SQLCA. For more information on this command and the SQLCA, see Chapter 11, “Handling Runtime Errors”.

You can use Comments in a DELETE statement to pass instructions, or *hints*, to the Oracle8 optimizer. The optimizer uses hints to choose an execution plan for the statement. For more information on hints, see *Oracle8 Tuning*.

Example

This example illustrates the use of the DELETE statement within a Pro*C/C++ embedded SQL program:

```
EXEC SQL DELETE FROM emp
    WHERE deptno = :deptno
    AND job = :job; ...
EXEC SQL DECLARE emp_cursor CURSOR
    FOR SELECT empno, comm
        FROM emp;
EXEC SQL OPEN emp_cursor;
EXEC SQL FETCH c1
    INTO :emp_number, :commission;
```

```
EXEC SQL DELETE FROM emp
    WHERE CURRENT OF emp_cursor;
```

Related Topics

DECLARE DATABASE command on F-24

DECLARE STATEMENT command on F-25

DESCRIBE (Executable Embedded SQL)

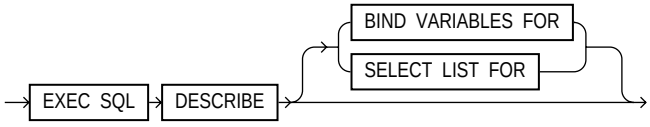
Purpose

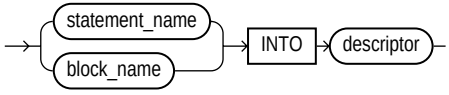
To initialize a descriptor to hold descriptions of host variables for a dynamic SQL statement or PL/SQL block.

Prerequisites

You must have prepared the SQL statement or PL/SQL block in a previous embedded SQL PREPARE statement.

Syntax





Keywords and Parameters

BIND VARIABLES	initializes the descriptor to hold information about the input variables for the SQL statement or PL/SQL block.
SELECT LIST FOR	initializes the descriptor to hold information about the select list of a SELECT statement. The default is SELECT LIST FOR.

statement_name *block_name*	identifies a SQL statement or PL/SQL block previously prepared with a PREPARE statement.
descriptor	is the name of the descriptor to be initialized.

Usage Notes

You must issue a DESCRIBE statement before manipulating the bind or select descriptor within an embedded SQL program.

You cannot describe both input variables and output variables into the same descriptor.

The number of variables found by a DESCRIBE statement is the total number of place-holders in the prepare SQL statement or PL/SQL block, rather than the total number of uniquely named place-holders. For more information on this command, see Chapter 13, “Using Dynamic SQL”.

Example

This example illustrates the use of the DESCRIBE statement in a Pro*C/C++ embedded SQL program:

```
EXEC SQL PREPARE my_statement FROM :my_string;
EXEC SQL DECLARE emp_cursor
    FOR SELECT empno, ename, sal, comm
            FROM emp
            WHERE deptno = :dept_number;
EXEC SQL DESCRIBE BIND VARIABLES FOR my_statement
    INTO bind_descriptor;
EXEC SQL OPEN emp_cursor
    USING bind_descriptor;
EXEC SQL DESCRIBE SELECT LIST FOR my_statement
    INTO select_descriptor;
EXEC SQL FETCH emp_cursor
    INTO select_descriptor;
```

Related Topics

PREPARE command on F-60

ENABLE THREADS (Executable Embedded SQL Extension)

Purpose

To initialize a process that supports multiple threads.

Prerequisites

You must be developing a precompiler application for and compiling it on a platform that supports multi-threaded applications, and THREADS=YES must be specified on the command line.

Syntax

Keywords and Parameters

None.

Usage Notes

The ENABLE THREADS command must be executed before any other executable SQL statement and before spawning any thread. This command does not require a host-variable specification.

For more information on this command, see "Developing Multi-threaded Applications" on page 4-37.

Example

This example illustrates the use of the ENABLE THREADS command in a Pro*C/C++ embedded SQL program:

```
EXEC SQL ENABLE THREADS;
```

Related Topics

CONTEXT ALLOCATE on F-16

CONTEXT FREE on F-17

CONTEXT USE on F-18

EXECUTE ... END-EXEC (Executable Embedded SQL Extension)

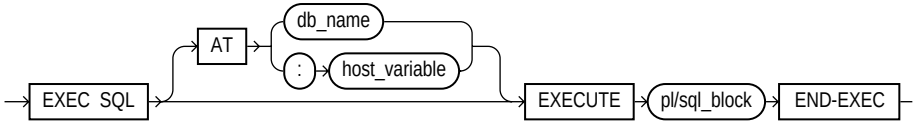
Purpose

To embed an anonymous PL/SQL block into an Oracle Precompiler program.

Prerequisites

None.

Syntax



Keywords and Parameters

AT — identifies the database on which the PL/SQL block is executed. The database can be identified by either:

- *db_name* — is a database identifier declared in a previous DECLARE DATABASE statement.
- *:host_variable* — is a host variable whose value is a previously declared db_name.

If you omit this clause, the PL/SQL block is executed on your default database.

pl/sql_block — For information on PL/SQL, including how to write PL/SQL blocks, see the *PL/SQL User's Guide and Reference.*

END-EXEC — must appear after the embedded PL/SQL block, regardless of which programming language your Oracle Precompiler program uses. The keyword END-EXEC must be followed by the C/C++ statement terminator, ";".

Usage Notes

Since the Oracle Precompilers treat an embedded PL/SQL block like a single embedded SQL statement, you can embed a PL/SQL block anywhere in an Oracle Precompiler program that you can embed a SQL statement. For more information on embedding PL/SQL blocks in Oracle Precompiler programs, see Chapter 6, "Using Embedded PL/SQL".

Example

Placing this EXECUTE statement in a Pro*C/C++ program embeds a PL/SQL block in the program:

```
EXEC SQL EXECUTE
    BEGIN
        SELECT ename, job, sal
            INTO :emp_name:ind_name, :job_title, :salary
            FROM emp
            WHERE empno = :emp_number;
        IF :emp_name:ind_name IS NULL
            THEN RAISE name_missing;
        END IF;
    END;
END-EXEC;
```

Related Topics

EXECUTE IMMEDIATE embedded SQL command on F-40

EXECUTE (Executable Embedded SQL)

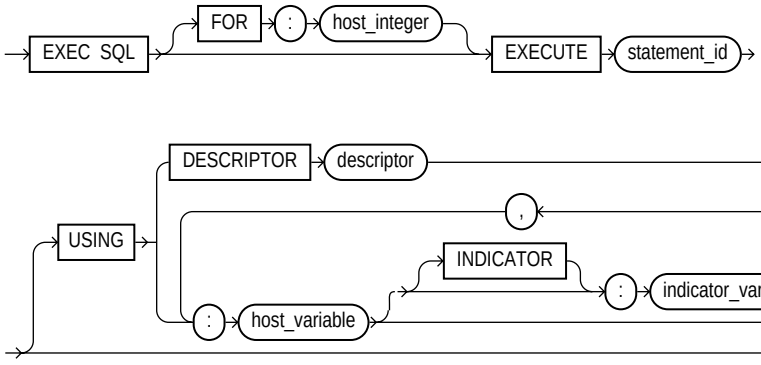
Purpose

To execute a DELETE, INSERT, or UPDATE statement or a PL/SQL block that has been previously prepared with an embedded SQL PREPARE statement.

Prerequisites

You must first prepare the SQL statement or PL/SQL block with an embedded SQL PREPARE statement.

Syntax



Keywords and Parameters

FOR *:host_integer* — limits the number of times the statement is executed when the USING clause contains array host variables If you omit this clause, Oracle8 executes the statement once for each component of the smallest array.

statement_id — is a precompiler identifier associated with the SQL statement or PL/SQL block to be executed. Use the embedded SQL PREPARE command to associate the precompiler identifier with the statement or PL/SQL block.

USING — specifies a list of host variables with optional indicator variables that Oracle8 substitutes as input variables into the statement to be executed. The host and indicator variables must be either all scalars or all arrays.

Usage Notes

For more information on this command, see Chapter 13, “Using Dynamic SQL”.

Example

This example illustrates the use of the EXECUTE statement in a Pro*C/C++ embedded SQL program:

```
EXEC SQL PREPARE my_statement
    FROM :my_string;
EXEC SQL EXECUTE my_statement
```

```
    USING :my_var;
```

Related Topics

DECLARE DATABASE command on F-24

PREPARE command on F-60

EXECUTE IMMEDIATE (Executable Embedded SQL)

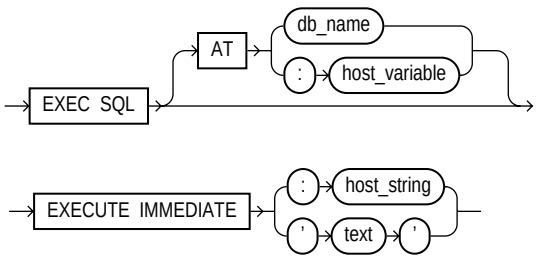
Purpose

To prepare and execute a DELETE, INSERT, or UPDATE statement or a PL/SQL block containing no host variables.

Prerequisites

None.

Syntax



Keywords and Parameters

AT — identifies the database on which the SQL statement or PL/SQL block is executed. The database can be identified by either:

- *db_name* — is a database identifier declared in a previous DECLARE DATABASE statement.
- *:host_variable* — is a host variable whose value is a previously declared db_name.

	If you omit this clause, the statement or block is executed on your default database.
text	is a quoted text literal containing the SQL statement or PL/SQL block to be executed. The SQL statement can only be a DELETE, INSERT, or UPDATE statement.

Usage Notes

When you issue an EXECUTE IMMEDIATE statement, Oracle8 parses the specified SQL statement or PL/SQL block, checking for errors, and executes it. If any errors are encountered, they are returned in the SQLCODE component of the SQLCA.

For more information on this command, see Chapter 13, "Using Dynamic SQL".

Example

This example illustrates the use of the EXECUTE IMMEDIATE statement:

```
EXEC SQL EXECUTE IMMEDIATE 'DELETE FROM emp WHERE empno = 9460'
```

Related Topics

PREPARE command on F-60

EXECUTE command on F-38

FETCH (Executable Embedded SQL)

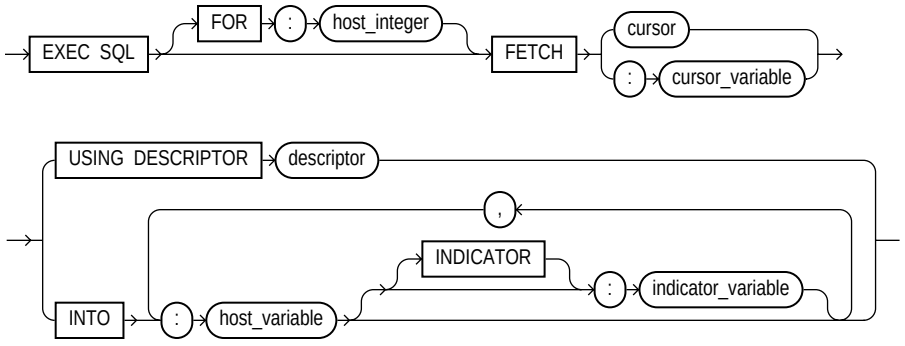
Purpose

To retrieve one or more rows returned by a query, assigning the select list values to host variables.

Prerequisites

You must first open the cursor with an the OPEN statement.

Syntax



Keywords and Parameters

FOR :*host_integer*	limits the number of rows fetched if you are using array host variables. If you omit this clause, Oracle8 fetches enough rows to fill the smallest array.
cursor	is a cursor that is declared by a DECLARE CURSOR statement. The FETCH statement returns one of the rows selected by the query associated with the cursor.
:*cursor_variable*	is a cursor variable is allocated an ALLOCATE statement. The FETCH statement returns one of the rows selected by the query associated with the cursor variable.
INTO	specifies a list of host variables and optional indicator variables into which data is fetched. These host variables and indicator variables must be declared within the program.
USING	specifies the descriptor referenced in a previous DESCRIBE statement. Only use this clause with dynamic embedded SQL, method 4. Also, the USING clause does not apply when a cursor variable is used.

Usage Notes

The FETCH statement reads the rows of the active set and names the output variables which contain the results. Indicator values are set to -1 if their associated host variable is null. The first FETCH statement for a cursor also sorts the rows of the active set, if necessary.

The number of rows retrieved is specified by the size of the output host variables and the value specified in the FOR clause. The host variables to receive the data must be either all scalars or all arrays. If they are scalars, Oracle8 fetches only one row. If they are arrays, Oracle8 fetches enough rows to fill the arrays.

Array host variables can have different sizes. In this case, the number of rows Oracle8 fetches is determined by the smaller of the following values:

- the size of the smallest array
- the value of the :*host_integer* in the optional FOR clause

Of course, the number of rows fetched can be further limited by the number of rows that actually satisfy the query.

If a FETCH statement does not retrieve all rows returned by the query, the cursor is positioned on the next returned row. When the last row returned by the query has been retrieved, the next FETCH statement results in an error code returned in the SQLCODE element of the SQLCA.

Note that the FETCH command does not contain an AT clause. You must specify the database accessed by the cursor in the DECLARE CURSOR statement.

You can only move forward through the active set with FETCH statements. If you want to revisit any of the previously fetched rows, you must reopen the cursor and fetch each row in turn. If you want to change the active set, you must assign new values to the input host variables in the cursor's query and reopen the cursor. For more information, see "Using the FETCH Statement" on page 5-13.

Example

This example illustrates the FETCH command:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
    SELECT job, sal FROM emp WHERE deptno = 30;
EXEC SQL OPEN emp_cursor;
...
EXEC SQL WHENEVER NOT FOUND GOTO ...
for(;;)
    {
    EXEC SQL FETCH emp_cursor INTO :job_title1, :salary1;
    EXEC SQL FETCH emp_cursor INTO :job_title2, :salary2;
    ...
    }
```

Related Topics

PREPARE command on F-60

DECLARE CURSOR command on F-22

OPEN command on F-58

CLOSE command on F-11

FREE (Executable Embedded SQL Extension)

Purpose

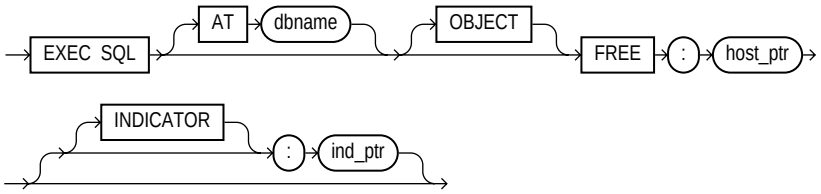
To free memory in the object cache.

Prerequisites

The memory has to have been already allocated.

An active database connection must exist.

Syntax



Keywords and Parameters

dbname	a null-terminated string containing the database connection name, as established previously in a CONNECT statement. If omitted, or if an empty string, the default database connection is assumed.
host_ptr	a pointer to a host struct generated by OTT for an object type in the object cache

Usage Notes

Any memory in the object cache will be freed automatically when the connection is terminated. See "FREE" on page 8-6 for more information.

Example

```
EXEC SQL FREE :ptr;
```

Related Topics

ALLOCATE command on F-8.

CACHE FREE ALL command on F-10.

INSERT (Executable Embedded SQL)

Purpose

To add rows to a table or to a view's base table.

Prerequisites

For you to insert rows into a table, the table must be in your own schema or you must have INSERT privilege on the table.

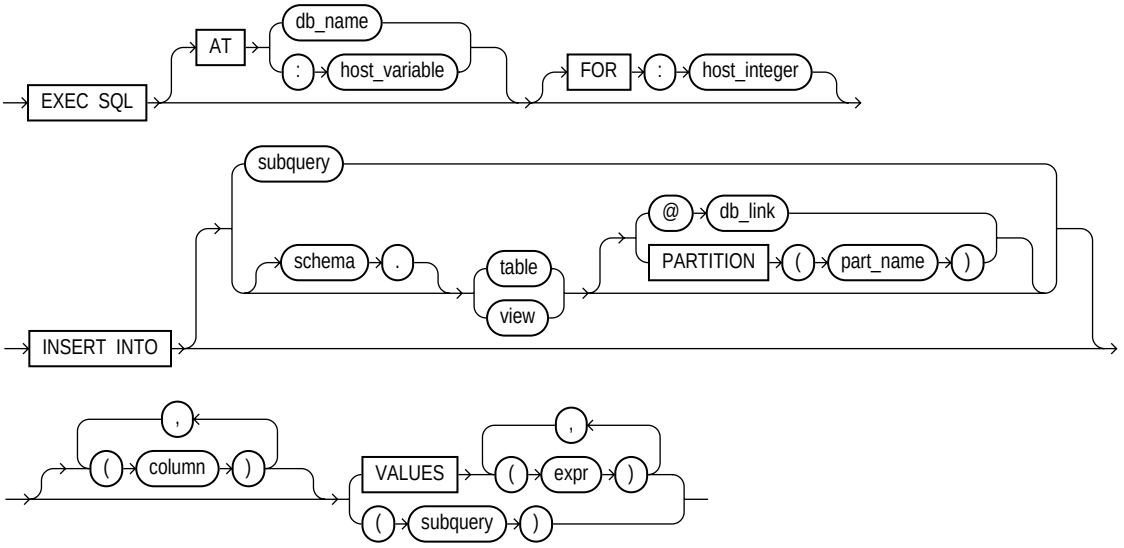
For you to insert rows into the base table of a view, the owner of the schema containing the view must have INSERT privilege on the base table. Also, if the view is in a schema other than your own, you must have INSERT privilege on the view.

The INSERT ANY TABLE system privilege also allows you to insert rows into any table or any view's base table.

If you are using Trusted Oracle in DBMS MAC mode, your DBMS label must match the creation label of the table or view:

- If the creation label of the table or view is higher than your DBMS label, you must have WRITEUP system privileges.
- If the creation label of the table or view is lower than your DBMS label, you must have WRITEDOWN system privilege.
- If the creation label of your table or view is not comparable to your DBMS label, you must have WRITEUP and WRITEDOWN system privileges.

Syntax



Keywords and Parameters

AT — identifies the database on which the INSERT statement is executed. The database can be identified by either:

- *db_name* — is a database identifier declared in a previous DECLARE DATABASE statement.
- :*host_variable* — is a host variable whose value is a db_name

If you omit this clause, the INSERT statement is executed on your default database.

FOR :*host_integer* — limits the number of times the statement is executed if the VALUES clause contains array host variables. If you omit this clause, Oracle8 executes the statement once for each component in the smallest array.

schema — is the schema containing the table or view. If you omit schema, Oracle8 assumes the table or view is in your own schema.

table *view*	is the name of the table into which rows are to be inserted. If you specify view, Oracle8 inserts rows into the view's base table.
db_link	is a complete or partial name of a database link to a remote database where the table or view is located. For information on referring to database links, see the *Oracle8 SQL Reference* . You can only insert rows into a remote table or view if you are using Oracle8 with the distributed option. If you omit dblink, Oracle8 assumes that the table or view is on the local database.
part_name	is a partition in the table
column	is a column of the table or view. In the inserted row, each column in this list is assigned a value from the VALUES clause or the query.
part_name	is the name of partition in the table If you omit one of the table's columns from this list, the column's value for the inserted row is the column's default value as specified when the table was created. If you omit the column list altogether, the VALUES clause or query must specify values for all columns in the table.
VALUES	specifies a row of values to be inserted into the table or view. See the syntax description in *Oracle8 SQL Reference*. Note that the expressions can be host variables with optional indicator variables. You must specify an expression in the VALUES clause for each column in the column list.
subquery	is a subquery that returns rows that are inserted into the table. The select list of this subquery must have the same number of columns as the column list of the INSERT statement. For the syntax description of a subquery, see "SELECT" in *Oracle8 SQL Reference*.

Usage Notes

Any host variables that appear in the WHERE clause must be either all scalars or all arrays. If they are scalars, Oracle8 executes the INSERT statement once. If they are arrays, Oracle8 executes the INSERT statement once for each set of array components, inserting one row each time.

Array host variables in the WHERE clause can have different sizes. In this case, the number of times Oracle8 executes the statement is determined by the smaller of the following values:

- size of the smallest array
- the value of the :*host_integer* in the optional FOR clause.

For more information on this command, see "Using the INSERT Statement" on page 5-9.

Example I

This example illustrates the use of the embedded SQL INSERT command:

```
EXEC SQL
     INSERT INTO emp (ename, empno, sal)
     VALUES (:ename, :empno, :sal);
```

Example II

This example shows an embedded SQL INSERT command with a subquery:

```
EXEC SQL
   INSERT INTO new_emp (ename, empno, sal)
   SELECT ename, empno, sal FROM emp
   WHERE deptno = :deptno;
```

Related Topics

DECLARE DATABASE command on F-24

OBJECT CREATE (Executable Embedded SQL Extension)

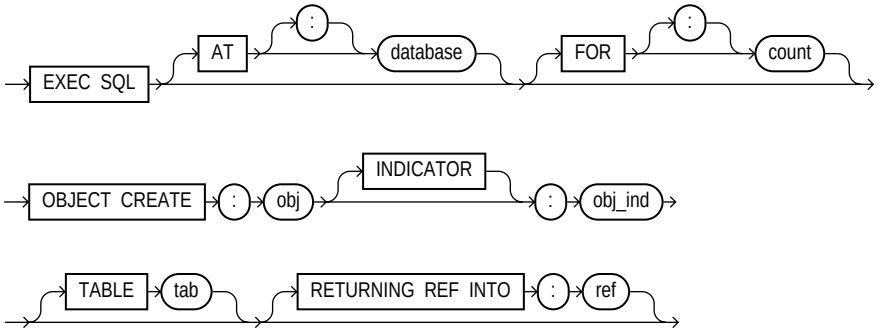
Purpose

To create a referenceable object in the object cache.

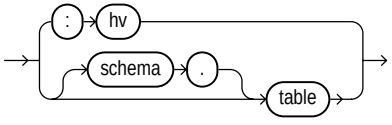
Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



where *tab* is:



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT CREATE" on page 8-10.

Example

```
person *pers_p;
person_ind *pers_ind;
person_ref *pers_ref;
...
EXEC SQL CREATE :pers_p:pers_ind TABLE PERSON_TAB
          RETURNING REF INTO :pers_ref;
```

Related Topics

See all other OBJECT statements in this appendix.

OBJECT DELETE (Executable Embedded SQL Extension)

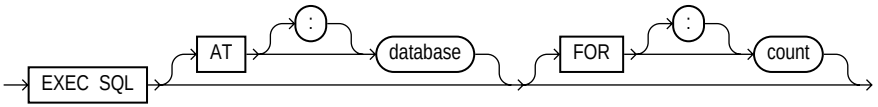
Purpose

To mark a persistent object or array of objects as deleted in the object cache.

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT DELETE" on page 8-12.

Example

```
customer *cust_p;
...
EXEC SQL OBJECT DELETE :cust_p;
```

Related Topics

See all other OBJECT statements in this Appendix.For persistent objects,this statement marks an object or array of objects as deleted in the object cache.

OBJECT DEREF (Executable Embedded SQL Extension)

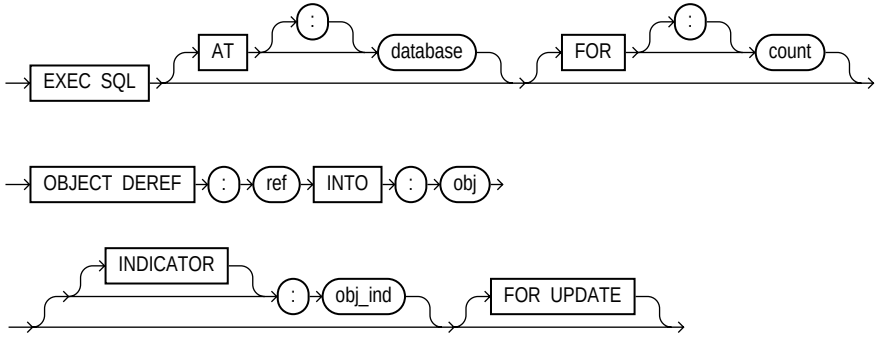
Purpose

To pin an object or array of objects in the object cache.

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT DEREF" on page 8-11.

Example

```
person *pers_p;
person_ref *pers_ref;
...
/* Pin the person REF, returning a pointer to the person object */
EXEC SQL OBJECT DEREF :pers_ref INTO :pers_p;
```

Related Topics

See all other OBJECT statements in this Appendix. See “ALLOCATE (Executable Embedded SQL Extension)” on page F-8.

OBJECT FLUSH (Executable Embedded SQL Extension)

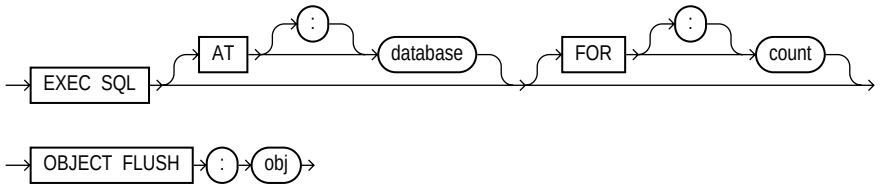
Purpose

To flush persistent objects that have been marked as updated, deleted, or created, to the server.

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT FLUSH" on page 8-12.

Example

```
person *pers_p;
...
EXEC SQL OBJECT DELETE :pers_p;
/* Flush the changes, effectively deleting the person object */
EXEC SQL OBJECT FLUSH :pers_p;
```

```
/* Finally, free all object cache memory and logoff */
EXEC SQL OBJECT CACHE FREE ALL;
EXEC SQL COMMIT WORK RELEASE;
```

Related Topics

See all other OBJECT statements in this Appendix.

OBJECT GET (Executable Embedded SQL Extension)

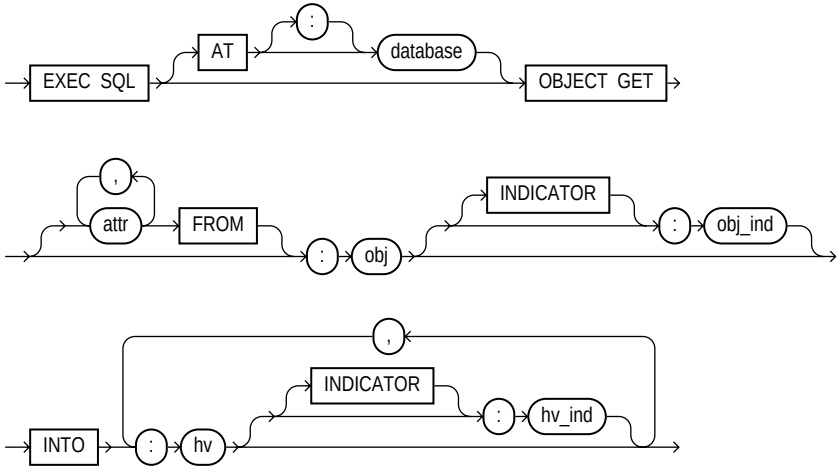
Purpose

To convert attributes of an object type to native C types

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT GET" on page 8-17.

Example

```
person *pers_p;
struct { char lname[21], fname[21]; int age; } pers;
...
/* Convert object types to native C types */
EXEC SQL OBJECT GET lastname, firstname, age FROM :pers_p INTO :pers;
printf("Last Name: %s\nFirstName: %s\nAge: %d\n",
        pers.lname, pers.fname, pers.age );
```

Related Topics

See all other OBJECT statements in this Appendix.

OBJECT RELEASE (Executable Embedded SQL Extension)

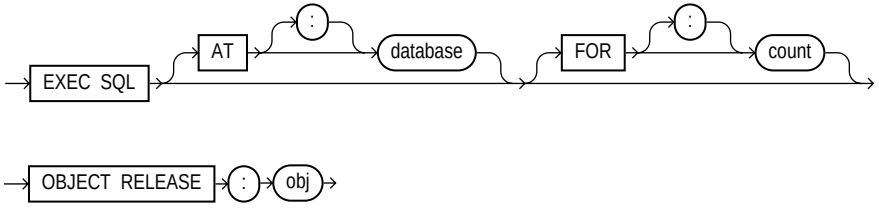
Purpose

To unpin an object in the object cache. When an object is not pinned and not updated, it is eligible for implicit freeing.

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT RELEASE" on page 8-12.

Example

```
person *pers_p;
...
EXEC SQL OBJECT RELEASE :pers_p;
```

Related Topics

See all other OBJECT statements in this Appendix.

OBJECT SET (Executable Embedded SQL Extension)

Purpose

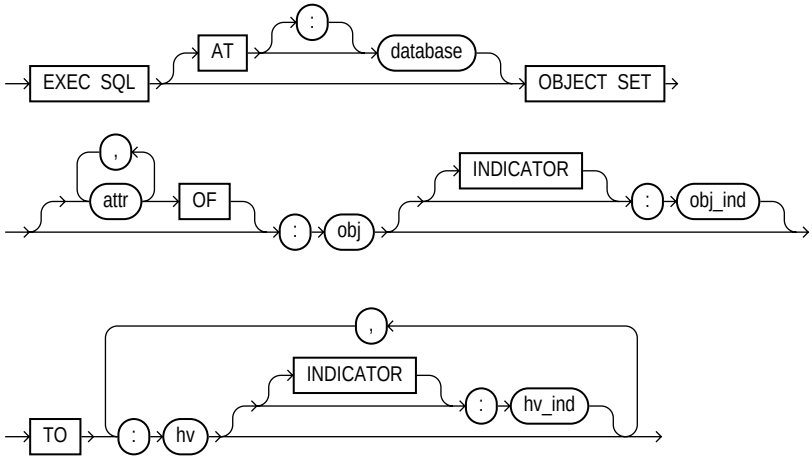
To update attributes of persistent objects, marking them eligible for writing to the server when the object is flushed or the cache is flushed.

To update the attributes of a transient object.

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see "OBJECT SET" on page 8-15.

Example

```
person *pers_p;
struct {int num; char street[61], city[31], state[3], zip[11];} addr1;
...
addr1.num = 500;
strcpy((char *)addr1.street , (char *)"Oracle Parkway");
strcpy((char *)addr1.city,    (char *)"Redwood Shores");
strcpy((char *)addr1.state,   (char *)"CA");
strcpy((char *)addr1.zip,     (char *)"94065");

/* Convert native C types to object types */
```

```
EXEC SQL OBJECT SET :pers_p->addr TO :addr1;
```

Related Topics

See all other OBJECT statements in this Appendix.

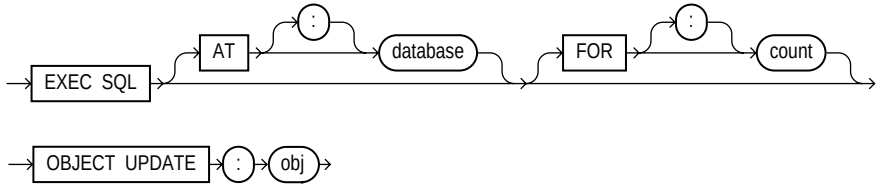
OBJECT UPDATE (Executable Embedded SQL Extension)

Purpose

Prerequisites

Precompiler option OBJECTS must be set to YES. The INTYPE option must specify the OTT-generated type files. Include OTT-generated header files in your program.

Syntax



Keywords and Parameters

Usage Notes

For usage notes as well as keywords and parameters, see OBJECT UPDATE.

Example

```
person *pers_p;
...
/* Mark as updated */
EXEC SQL OBJECT UPDATE :pers_p;
```

Related Topics

See all other OBJECT statements in this Appendix.

OPEN (Executable Embedded SQL)

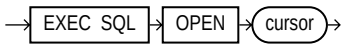
Purpose

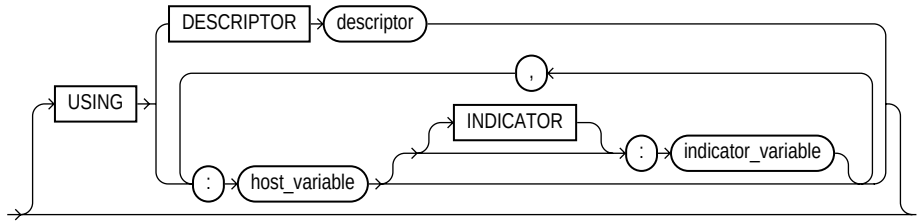
To open a cursor, evaluating the associated query and substituting the host variable names supplied by the USING clause into the WHERE clause of the query.

Prerequisites

You must declare the cursor with a DECLARE CURSOR embedded SQL statement before opening it.

Syntax





Keywords and Parameters

cursor	is the cursor to be opened.
USING	specifies the host variables to be substituted into the WHERE clause of the associated query.
:host_variable	specifies a host variable with an optional indicator variable to be substituted into the statement associated with the cursor.

DESCRIPTOR	specifies a descriptor that describes the host variables to be substituted into the WHERE clause of the associated query. The descriptor must be initialized in a previous DESCRIBE statement. The substitution is based on position. The host variable names specified in this statement can be different from the variable names in the associated query.

Usage Notes

The OPEN command defines the active set of rows and initializes the cursor just before the first row of the active set. The values of the host variables at the time of the OPEN are substituted in the statement. This command does not actually retrieve rows; rows are retrieved by the FETCH command.

Once you have opened a cursor, its input host variables are not reexamined until you reopen the cursor. To change any input host variables and therefore the active set, you must reopen the cursor.

All cursors in a program are in a closed state when the program is initiated or when they have been explicitly closed using the CLOSE command.

You can reopen a cursor without first closing it. For more information on this command, see "Using the INSERT Statement" on page 5-9.

Example

This example illustrates the use of the OPEN command in a Pro*C/C++ embedded SQL program:

```
EXEC SQL DECLARE emp_cursor CURSOR FOR
    SELECT ename, empno, job, sal
    FROM emp
    WHERE deptno = :deptno;
EXEC SQL OPEN emp_cursor;
```

Related Topics

PREPARE command on F-60

DECLARE CURSOR command on F-22

FETCH command on F-41

CLOSE command on F-11

PREPARE (Executable Embedded SQL)

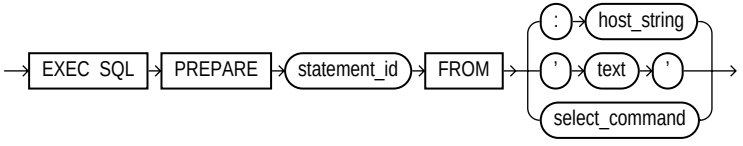
Purpose

To parse a SQL statement or PL/SQL block specified by a host variable and associate it with an identifier.

Prerequisites

None.

Syntax



Keywords and Parameters

statement_id	is the identifier to be associated with the prepared SQL statement or PL/SQL block. If this identifier was previously assigned to another statement or block, the prior assignment is superseded.
:host_string	is a host variable whose value is the text of a SQL statement or PL/SQL block to be prepared.
text	is a string literal containing a SQL statement or PL/SQL block to be prepared.
select_command	is a select command

Usage Notes

Any variables that appear in the *:host_string* or *text* are placeholders. The actual host variable names are assigned in the USING clause of the OPEN command (input host variables) or in the INTO clause of the FETCH command (output host variables).

A SQL statement is prepared only once, but can be executed any number of times. For more information, see "PREPARE" on page 13-19.

Example

This example illustrates the use of a PREPARE statement in a Pro*C/C++ embedded SQL program:

```
EXEC SQL PREPARE my_statement FROM :my_string;
EXEC SQL EXECUTE my_statement;
```

Related Topics

DECLARE CURSOR command on F-22

OPEN command on F-58

FETCH command on F-41

CLOSE command on F-11

ROLLBACK (Executable Embedded SQL)

Purpose

To undo work done in the current transaction.

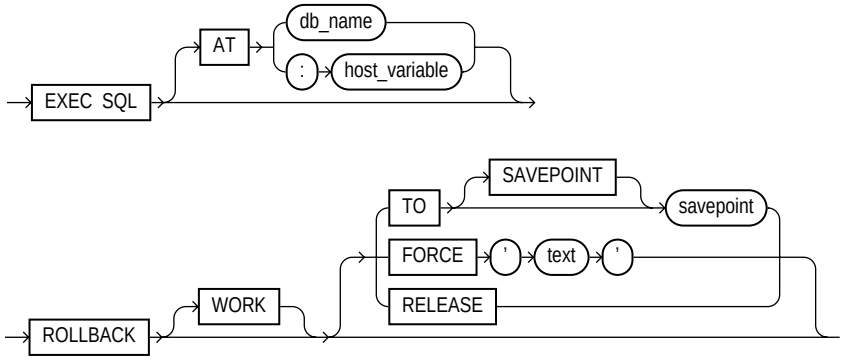
You can also use this command to manually undo the work done by an in-doubt distributed transaction.

Prerequisites

To roll back your current transaction, no privileges are necessary.

To manually roll back an in-doubt distributed transaction that you originally committed, you must have FORCE TRANSACTION system privilege. To manually roll back an in-doubt distributed transaction originally committed by another user, you must have FORCE ANY TRANSACTION system privilege.

Syntax



Keywords and Parameters

WORK	is optional and is provided for ANSI compatibility.
TO	rolls back the current transaction to the specified savepoint. If you omit this clause, the ROLLBACK statement rolls back the entire transaction.
FORCE	manually rolls back an in-doubt distributed transaction. The transaction is identified by the text containing its local or global transaction ID. To find the IDs of such transactions, query the data dictionary view DBA_2PC_PENDING. ROLLBACK statements with the FORCE clause are not supported in PL/SQL.
RELEASE	frees all resources and disconnects the application from the Oracle8 Server. The RELEASE clause is not allowed with SAVEPOINT and FORCE clauses.

Usage Notes

A transaction (or a logical unit of work) is a sequence of SQL statements that Oracle8 treats as a single unit. A transaction begins with the first executable SQL statement after a COMMIT, ROLLBACK or connection to the database. A transaction ends with a COMMIT statement, a ROLLBACK statement, or disconnection (intentional or unintentional) from the database. Note that Oracle8 issues an implicit COMMIT statement before and after processing any Data Definition Language statement.

Using the ROLLBACK command without the TO SAVEPOINT clause performs the following operations:

- ends the transaction
- undoes all changes in the current transaction
- erases all savepoints in the transaction
- releases the transaction's locks

Using the ROLLBACK command with the TO SAVEPOINT clause performs the following operations:

- rolls back just the portion of the transaction after the savepoint.
- loses all savepoints created after that savepoint. Note that the named savepoint is retained, so you can roll back to the same savepoint multiple times. Prior savepoints are also retained.
- releases all table and row locks acquired since the savepoint. Note that other transactions that have requested access to rows locked after the savepoint must continue to wait until the transaction is committed or rolled back. Other transactions that have not already requested the rows can request and access the rows immediately.

It is recommended that you explicitly end transactions in application programs using either a COMMIT or ROLLBACK statement. If you do not explicitly commit the transaction and the program terminates abnormally, Oracle8 rolls back the last uncommitted transaction.

Example I

The following statement rolls back your entire current transaction:

```
EXEC SQL ROLLBACK;
```

Example II

The following statement rolls back your current transaction to savepoint SP5:

```
EXEC SQL ROLLBACK TO SAVEPOINT sp5;
```

Distributed Transactions Oracle8 with the distributed option allows you to perform distributed transactions, or transactions that modify data on multiple databases. To commit or roll back a distributed transaction, you need only issue a COMMIT or ROLLBACK statement as you would any other transaction.

If there is a network failure during the commit process for a distributed transaction, the state of the transaction may be unknown, or in-doubt. After consultation with the administrators of the other databases involved in the transaction, you may decide to manually commit or roll back the transaction on your local database. You can manually roll back the transaction on your local database by issuing a ROLLBACK statement with the FORCE clause.

For more information on when to roll back in-doubt transactions, see *Oracle8 Distributed Database Systems.*

You cannot manually roll back an in-doubt transaction to a savepoint.

A ROLLBACK statement with a FORCE clause only rolls back the specified transaction. Such a statement does not affect your current transaction.

Example III

The following statement manually rolls back an in-doubt distributed transaction:

```
EXEC SQL
    ROLLBACK WORK
    FORCE '25.32.87';
```

Related Topics

COMMIT command on F-12

SAVEPOINT command on

SAVEPOINT (Executable Embedded SQL)

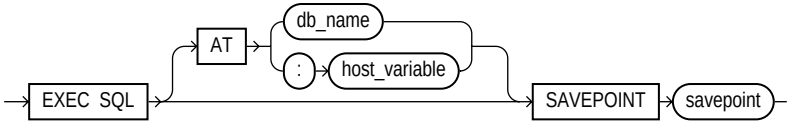
Purpose

To identify a point in a transaction to which you can later roll back.

Prerequisites

None.

Syntax



Keywords and Parameters

AT — identifies the database on which the savepoint is created. The database can be identified by either:

- *db_name* — is a database identifier declared in a previous DECLARE DATABASE statement.
- :*host_variable* — is a host variable whose value is a previously declared db_name.

If you omit this clause, the savepoint is created on your default database.

savepoint — is the name of the savepoint to be created.

Usage Notes

For more information on this command, see "Using the SAVEPOINT Statement" on page 10-5.

Example

This example illustrates the use of the embedded SQL SAVEPOINT command:

```
EXEC SQL SAVEPOINT save3;
```

Related Topics

COMMIT command on F-12

ROLLBACK command on F-61

SELECT (Executable Embedded SQL)

Purpose

To retrieve data from one or more tables, views, or snapshots, assigning the selected values to host variables.

Prerequisites

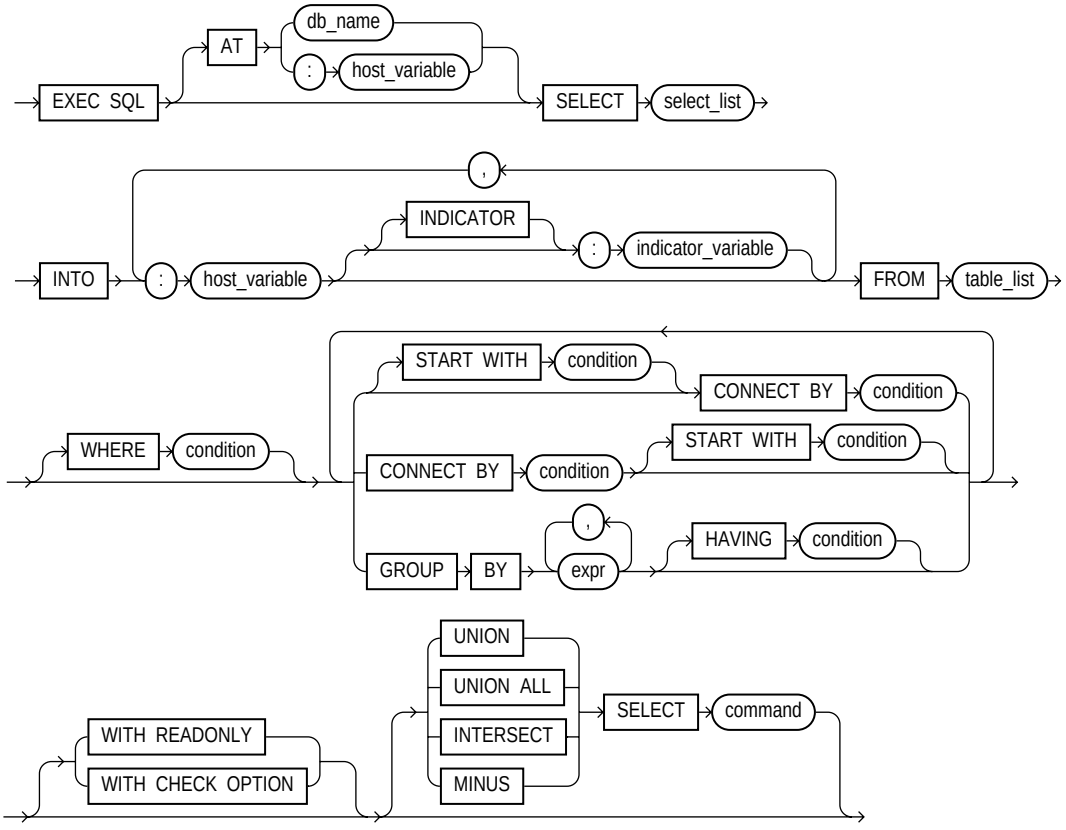
For you to select data from a table or snapshot, the table or snapshot must be in your own schema or you must have SELECT privilege on the table or snapshot.

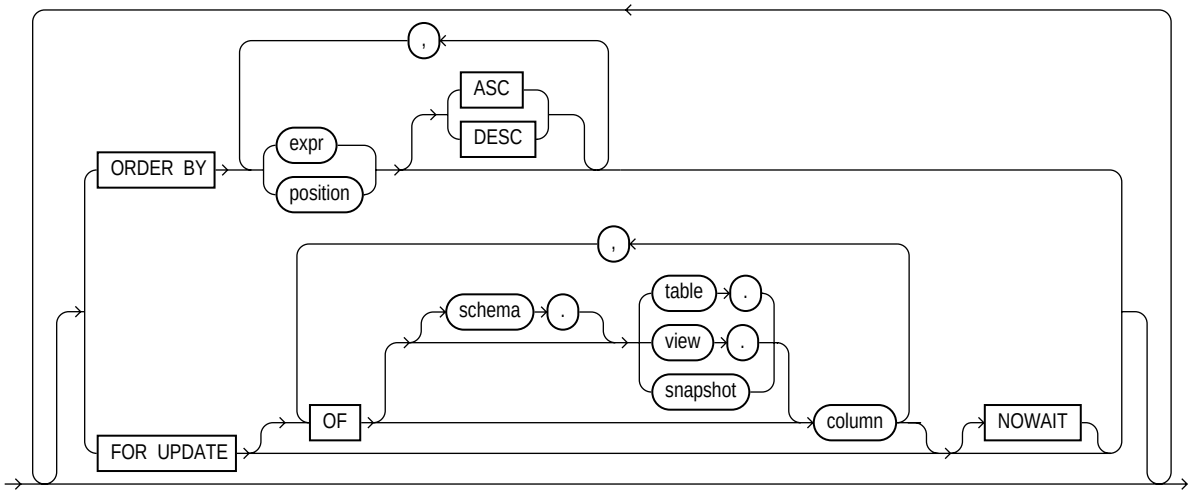
For you to select rows from the base tables of a view, the owner of the schema containing the view must have SELECT privilege on the base tables. Also, if the view is in a schema other than your own, you must have SELECT privilege on the view.

The SELECT ANY TABLE system privilege also allows you to select data from any table or any snapshot or any view's base table.

If you are using Trusted Oracle in DBMS MAC mode, your DBMS label must dominate the creation label of each queried table, view, or snapshot or you must have READUP system privileges.

Syntax


EXEC SQL
AT
db_name
:
host_variable
SELECT
select_list
INTO
,
:
host_variable
INDICATOR
:
indicator_variable
FROM
table_list
WHERE
condition
START WITH
condition
CONNECT BY
condition
CONNECT BY
condition
START WITH
condition
GROUP
BY
,
expr
HAVING
condition
WITH READONLY
WITH CHECK OPTION
UNION
UNION ALL
INTERSECT
MINUS
SELECT
command



Keywords and Parameters

AT — Identifies the database to which the SELECT statement is issued. The database can be identified by either:

- *db_name* — A database identifier declared in a previous DECLARE DATABASE statement.
- *:host_variable* — Host variable whose value is a previously declared db_name.

If you omit this clause, the SELECT statement is issued to your default database.

select_list — Identical to the non-embedded SELECT command except that a host variables can be used in place of literals.

INTO — Specifies output host variables and optional indicator variables to receive the data returned by the SELECT statement. Note that these variables must be either all scalars or all arrays, but arrays need not have the same size.

WHERE — Restricts the rows returned to those for which the condition is TRUE. See the syntax description of condition in *Oracle8 SQL Reference* . The condition can contain host variables, but cannot contain indicator variables. These host variables can be either scalars or arrays.

All other keywords and parameters are identical to the non-embedded SQL SELECT command. ASC, *ascending*, is the default for the ORDER BY clause.

Usage Notes

If no rows meet the WHERE clause condition, no rows are retrieved and Oracle8 returns an error code through the SQLCODE component of the SQLCA.

You can use Comments in a SELECT statement to pass instructions, or *hints*, to the Oracle8 optimizer. The optimizer uses hints to choose an execution plan for the statement. For more information on hints, see *Oracle8 Tuning*.

Example

This example illustrates the use of the embedded SQL SELECT command:

```
EXEC SQL SELECT ename, sal + 100, job
    INTO :ename, :sal, :job
    FROM emp
    WHERE empno = :empno;
```

Related Topics

DECLARE DATABASE command on F-24

DECLARE CURSOR command on F-22

EXECUTE command on F-38

FETCH command on F-41

PREPARE command on F-60

TYPE (Oracle Embedded SQL Directive)

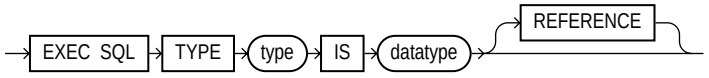
Purpose

To perform *user-defined type equivalencing*, or to assign an Oracle8 external datatype to a whole class of host variables by equivalencing the external datatype to a user-defined datatype.

Prerequisites

The user-defined datatype must be previously declared in an embedded SQL program.

Syntax



Keywords and Parameters

type	is the user-defined datatype to be equivalenced with an Oracle8 external datatype.
datatype	is an Oracle8 external datatype recognized by the Oracle Precompilers (not an Oracle8 internal datatype). The datatype may include a length, precision, or scale. This external datatype is equivalenced to the user-defined type and assigned to all host variables assigned the type. For a list of external datatypes, see "Oracle Datatypes" on page 3-17.
REFERENCE	makes the equivalenced type a pointer type.

Usage Notes

User defined type equivalencing is one kind of datatype equivalencing. You can only perform user-defined type equivalencing with the embedded SQL TYPE command in a Pro*C/C++ program. You may want to use datatype equivalencing for one of the following purposes:

- to automatically null-terminate a character host variable
- to store program data as binary data in the database
- to override default datatype conversion

Pro*C/C++ also supports the embedded SQL VAR command for host variable equivalencing. For more information, see "User-Defined Type Equivalencing" on page 3-60.

Example I

This example shows an embedded SQL TYPE statement in a Pro*C/C++ Precompiler program:

```
struct screen {
    short len;
    char  buff[4002];
};
```

```
typedef struct screen graphics;

    EXEC SQL TYPE graphics IS VARRAW(4002);
    graphics crt;  -- host variable of type graphics
    ...
```

Related Topics

VAR directive on page F-75

UPDATE (Executable Embedded SQL)

Purpose

To change existing values in a table or in a view's base table.

Prerequisites

For you to update values in a table or snapshot, the table must be in your own schema or you must have UPDATE privilege on the table.

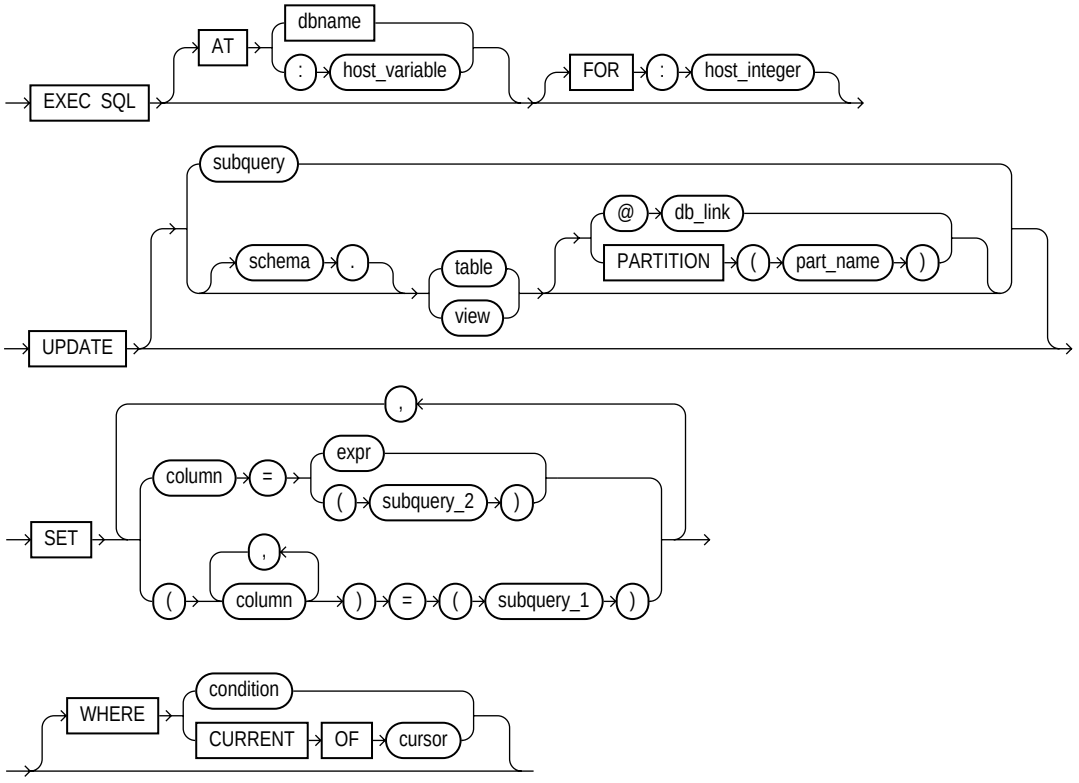
For you to update values in the base table of a view, the owner of the schema containing the view must have UPDATE privilege on the base table. Also, if the view is in a schema other than your own, you must have UPDATE privilege on the view.

The UPDATE ANY TABLE system privilege also allows you to update values in any table or any view's base table.

If you are using Trusted Oracle in DBMS MAC mode, your DBMS label must match the creation label of the table or view:

- If the creation label of the table or view is higher than your DBMS label, you must have READUP and WRITEUP system privileges
- If the creation label of the table or view is lower than your DBMS label, you must have WRITEDOWN system privilege.
- If the creation label of your table or view is not comparable to your DBMS label, you must have READUP, WRITEUP, and WRITEDOWN system privileges.

Syntax



Keywords and Parameters

AT — identifies the database to which the UPDATE statement is issued. The database can be identified by either:

- *dbname* — is a database identifier declared in a previous DECLARE DATABASE statement.
- *:host_variable* — is a host variable whose value is a previously declared db_name.

If you omit this clause, the UPDATE statement is issued to your default database.

FOR *:host_integer* — limits the number of times the UPDATE statement is executed if the SET and WHERE clauses contain array host variables. If you omit this clause, Oracle8 executes the statement once for each component of the smallest array.

schema — is the schema containing the table or view. If you omit schema, Oracle8 assumes the table or view is in your own schema.

table, view — is the name of the table to be updated. If you specify view, Oracle8 updates the view's base table.

dblink — is a complete or partial name of a database link to a remote database where the table or view is located. For information on referring to database links, see the *Oracle8 SQL Reference*. You can only use a database link to update a remote table or view if you are using Oracle8 with the distributed option.

part_name — name of partition

alias — is a name used to reference the table, view, or subquery elsewhere in the statement.

column — is the name of a column of the table or view that is to be updated. If you omit a column of the table from the SET clause, that column's value remains unchanged.

expr — is the new value assigned to the corresponding column. This expression can contain host variables and optional indicator variables. See the syntax of expr in the *Oracle8 SQL Reference*.

subquery_1 — is a subquery that returns new values that are assigned to the corresponding columns. For the syntax of a subquery, see "SELECT" in *Oracle8 SQL Reference*. .

subquery_2 — is a subquery that return a new value that is assigned to the corresponding column. For the syntax of a subquery, see "SELECT" in the *Oracle8 SQL Reference*. .

WHERE — specifies which rows of the table or view are updated:

- *condition* — updates only rows for which this condition is true. This condition can contain host variables and optional indicator variables. See the syntax of condition in the *Oracle8 SQL Reference*. .

CURRENT OF	updates only the row most recently fetched by the cursor. The cursor cannot be associated with a SELECT statement that performs a join unless its FOR UPDATE clause explicitly locks only one table.

If you omit this clause entirely, Oracle8 updates all rows of the table or view.

Usage Notes

Host variables in the SET and WHERE clauses must be either all

scalars or all arrays. If they are scalars, Oracle8 executes the UPDATE statement only once. If they are arrays, Oracle8 executes the statement once for each set of array components. Each execution may update zero, one, or multiple rows.

Array host variables can have different sizes. In this case, the number of times Oracle8 executes the statement is determined by the smaller

of the following values:

- the size of the smallest array
- the value of the :*host_integer* in the optional FOR clause

The cumulative number of rows updated is returned through the third element of the SQLERRD component of the SQLCA. When arrays are used as input host variables, this count reflects the total number of updates for all components of the array processed in the UPDATE statement. If no rows satisfy the condition, no rows are updated and Oracle8 returns an error message through the SQLCODE element of the SQLCA. If you omit the WHERE clause, all rows are updated and Oracle8 raises a warning flag in the fifth component of the SQLWARN element of the SQLCA.

You can use Comments in an UPDATE statement to pass instructions, or *hints*, to the Oracle8 optimizer. The optimizer uses hints to choose an execution plan for the statement. For more information on hints, see *Oracle8 Tuning*.

For more information on this command, see Chapter 5, “Using Embedded SQL”, and Chapter 10, “Defining and Controlling Transactions”.

Examples

The following examples illustrate the use of the embedded SQL UPDATE command:

```
EXEC SQL UPDATE emp
    SET sal = :sal, comm = :comm INDICATOR :comm_ind
    WHERE ename = :ename;

EXEC SQL UPDATE emp
    SET (sal, comm) =
        (SELECT AVG(sal)*1.1, AVG(comm)*1.1
         FROM emp)
    WHERE ename = 'JONES';
```

Related Topics

DECLARE DATABASE command on F-24

VAR (Oracle Embedded SQL Directive)

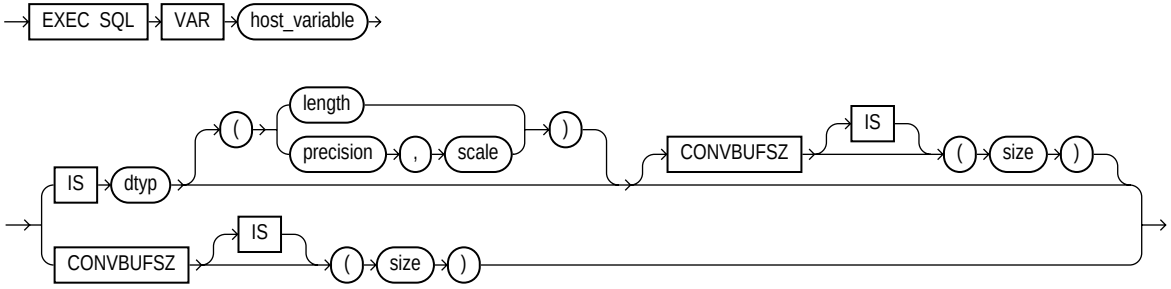
Purpose

To perform *host variable equivalencing*, or to assign a specific Oracle8 external datatype to an individual host variable, overriding the default datatype assignment. Also has an optional CONVBUFSZ clause that specifies the size of a buffer for character set conversion.

Prerequisites

The host variable must be previously declared in the Pro*C/C++ program.

Syntax



Keywords and Parameters

host_variable	is the host variable to be assigned an Oracle8 external datatype.
dtyp	is an Oracle8 external datatype recognized by the Oracle Precompilers (not an Oracle8 internal datatype). The datatype may include a length, precision, or scale. This external datatype is assigned to the host_variable. For a list of external datatypes, see Chapter 3.
len	length of the datatype
prec	precision
scale	scale
size	is the size in bytes of a buffer in the Oracle8 runtime library used to perform conversion between character sets of the host_variable

Usage Notes

len, prec, scale and buf can be constant expressions.

Host variable equivalencing is one kind of datatype equivalencing. Datatype equivalencing is useful for any of the following purposes:

- to automatically null-terminate a character host variable
- to store program data as binary data in the database
- to override default datatype conversion

The Pro*C/C++ Precompiler also supports the precompiler TYPE directive for user-defined type equivalencing. See also "Host Variable Equivalencing" on page 3-59.

Example

This example equivalences the host variable DEPT_NAME to the datatype STRING and the host variable BUFFER to the datatype RAW(200):

```
EXEC SQL BEGIN DECLARE SECTION;
    ...
    char dept_name[15];               -- default datatype is CHAR
    EXEC SQL VAR dept_name IS STRING; -- reset to STRING
    ...
    char buffer[200];                 -- default datatype is CHAR
    EXEC SQL VAR buffer IS RAW(200); -- refer to RAW
    ...
```

```
EXEC SQL END DECLARE SECTION;
```

Related Topics

TYPE directive on page F-69

WHENEVER (Embedded SQL Directive)

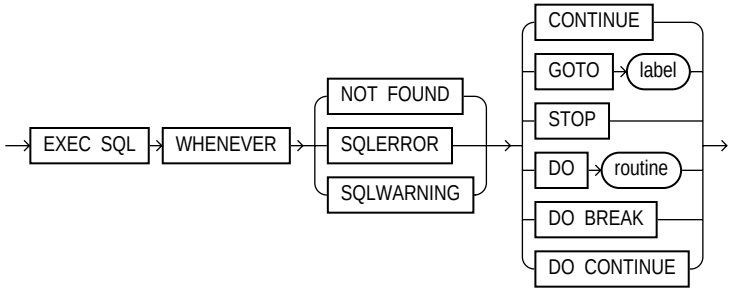
Purpose

To specify the action to be taken when an error or warning results from executing an embedded SQL program.

Prerequisites

None.

Syntax



Keywords and Parameters

NOT FOUND	Identifies any exception condition that returns an error code of +1403 to SQLCODE (or a +100 code when MODE=ANSI).
SQLERROR	Identifies a condition that results in a negative return code.
SQLWARNING	Identifies a non-fatal warning condition.
CONTINUE	Indicates that the program should progress to the next statement.
GOTO	Indicates that the program should branch to the statement named by label.

STOP	Stops program execution.
DO	Indicates that the program should call a function that is named *routine*
DO BREAK	Performs a **break** statement from a loop when the condition is met.
DO CONTINUE	Performs a **continue** statement from a loop when the condition is met.

Usage Notes

The WHENEVER command allows your program to transfer control to an error handling routine in the event an embedded SQL statement results in an error or warning.

The scope of a WHENEVER statement is positional, rather than logical. A WHENEVER statement applies to all embedded SQL statements that textually follow it in the source file, not in the flow of the program logic. A WHENEVER statement remains in effect until it is superseded by another WHENEVER statement checking for the same condition.

For more information on this command, see "Using the WHENEVER Statement" on page 11-24.

Do not confuse the WHENEVER embedded SQL command with the WHENEVER SQL*Plus command.

Example

The following example illustrates the use of the WHENEVER command in an embedded SQL program:

```
EXEC SQL WHENEVER NOT FOUND CONTINUE;
...
EXEC SQL WHENEVER SQLERROR GOTO sql_error;
...
sql_error:
    EXEC SQL WHENEVER SQLERROR CONTINUE;
    EXEC SQL ROLLBACK RELEASE;
...
```

Related Topics

None

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