Database Compatibility for Oracle®
Developer’s Guide

EDB Postgres™ Advanced  Server 10

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1 Introduction

Database Compatibility for Oracle means that an application runs in an Oracle environment as well as in the EDB Postgres Advanced Server (Advanced Server) environment with minimal or no changes to the application code. Developing an application that is compatible with Oracle databases in the Advanced Server requires special attention to which features are used in the construction of the application. For example, developing a compatible application means choosing compatible:

- System and built-in functions for use in SQL statements and procedural logic.
- Stored Procedure Language (SPL) when creating database server-side application logic for stored procedures, functions, triggers, and packages.
- Data types that are compatible with Oracle databases
- SQL statements that are compatible with Oracle SQL
- System catalog views that are compatible with Oracle’s data dictionary

For detailed information about the compatible SQL syntax, data types, and views, please see the Database Compatibility for Oracle Developers Reference Guide.

The compatibility offered by the procedures and functions that are part of the Built-in packages is documented in the Database Compatibility for Oracle Developers Built-in Packages Guide.

For information about using the compatible tools and utilities (EDB*Plus, EDB*Loader, DRITA, and EDB*Wrap) that are included with an Advanced Server installation, please see the Database Compatibility for Oracle Developers Tools and Utilities Guide.

For applications written using the Oracle Call Interface (OCI), EnterpriseDB’s Open Client Library (OCL) provides interoperability with these applications. For detailed information about using the Open Client Library, please see the EDB Postgres Advanced Server OCI Connector Guide.

Advanced Server contains a rich set of features that enables development of database applications for either PostgreSQL or Oracle. For more information about all of the features of Advanced Server, please consult the user documentation available at the EnterpriseDB website.

Advanced Server documentation is available at:

http://www.enterprisedb.com/products-services-training/products/documentation
1.1 What’s New

The following database compatibility for Oracle features have been added to Advanced Server 9.6 to create Advanced Server 10:

- Advanced Server now supports a BIGINT return value for SQL%ROWCOUNT. Previously, an INTEGER value was returned. For more information, see Section 3.4.8.

1.2 Typographical Conventions Used in this Guide

Certain typographical conventions are used in this manual to clarify the meaning and usage of various commands, statements, programs, examples, etc. This section provides a summary of these conventions.

In the following descriptions a term refers to any word or group of words which may be language keywords, user-supplied values, literals, etc. A term’s exact meaning depends upon the context in which it is used.

- Italic font introduces a new term, typically, in the sentence that defines it for the first time.
- Fixed-width (mono-spaced) font is used for terms that must be given literally such as SQL commands, specific table and column names used in the examples, programming language keywords, etc. For example, SELECT * FROM emp;
- Italic fixed-width font is used for terms for which the user must substitute values in actual usage. For example, DELETE FROM table_name;
- A vertical pipe | denotes a choice between the terms on either side of the pipe. A vertical pipe is used to separate two or more alternative terms within square brackets (optional choices) or braces (one mandatory choice).
- Square brackets [ ] denote that one or none of the enclosed term(s) may be substituted. For example, [ a | b ], means choose one of “a” or “b” or neither of the two.
- Braces {} denote that exactly one of the enclosed alternatives must be specified. For example, { a | b }, means exactly one of “a” or “b” must be specified.
- Ellipses ... denote that the proceeding term may be repeated. For example, [ a | b ] ... means that you may have the sequence, “b a a b a”.

1.3 Configuration Parameters Compatible with Oracle Databases

EDB Postgres Advanced Server supports the development and execution of applications compatible with PostgreSQL and Oracle. Some system behaviors can be altered to act in a more PostgreSQL or in a more Oracle compliant manner; these behaviors are controlled by configuration parameters. Modifying the parameters in the `postgresql.conf` file changes the behavior for all databases in the cluster, while a user or group can set the parameter value on the command line, effecting only their session. These parameters are:

- **edb_redwood_date** – Controls whether or not a time component is stored in `DATE` columns. For behavior compatible with Oracle databases, set `edb_redwood_date` to `TRUE`. See Section 1.3.1.
- **edb_redwood_raw_names** – Controls whether database object names appear in uppercase or lowercase letters when viewed from Oracle system catalogs. For behavior compatible with Oracle databases, `edb_redwood_raw_names` is set to its default value of `FALSE`. To view database object names as they are actually stored in the PostgreSQL system catalogs, set `edb_redwood_raw_names` to `TRUE`. See Section 1.3.2.
- **edb_redwood_strings** – Equates `NULL` to an empty string for purposes of string concatenation operations. For behavior compatible with Oracle databases, set `edb_redwood_strings` to `TRUE`. See Section 1.3.3.
- **edb_stmt_level_tx** – Isolates automatic rollback of an aborted SQL command to statement level rollback only – the entire, current transaction is not automatically rolled back as is the case for default PostgreSQL behavior. For behavior compatible with Oracle databases, set `edb_stmt_level_tx` to `TRUE`; however, use only when absolutely necessary. See Section 1.3.4.
- **oracle_home** – Point Advanced Server to the correct Oracle installation directory. See Section 1.3.5.
1.3.1 edb_redwood_date

When `DATE` appears as the data type of a column in the commands, it is translated to `TIMESTAMP` at the time the table definition is stored in the database if the configuration parameter `edb_redwood_date` is set to `TRUE`. Thus, a time component will also be stored in the column along with the date. This is consistent with Oracle’s `DATE` data type.

If `edb_redwood_date` is set to `FALSE` the column’s data type in a `CREATE TABLE` or `ALTER TABLE` command remains as a native PostgreSQL `DATE` data type and is stored as such in the database. The PostgreSQL `DATE` data type stores only the date without a time component in the column.

Regardless of the setting of `edb_redwood_date`, when `DATE` appears as a data type in any other context such as the data type of a variable in an SPL declaration section, or the data type of a formal parameter in an SPL procedure or SPL function, or the return type of an SPL function, it is always internally translated to a `TIMESTAMP` and thus, can handle a time component if present.

See the Database Compatibility for Oracle Developers Reference Guide for more information about date/time data types.

1.3.2 edb_redwood_raw_names

When `edb_redwood_raw_names` is set to its default value of `FALSE`, database object names such as table names, column names, trigger names, program names, user names, etc. appear in uppercase letters when viewed from Oracle catalogs (for a complete list of supported catalog views, see the Database Compatibility for Oracle Developers Reference Guide). In addition, quotation marks enclose names that were created with enclosing quotation marks.

When `edb_redwood_raw_names` is set to `TRUE`, the database object names are displayed exactly as they are stored in the PostgreSQL system catalogs when viewed from the Oracle catalogs. Thus, names created without enclosing quotation marks appear in lowercase as expected in PostgreSQL. Names created with enclosing quotation marks appear exactly as they were created, but without the quotation marks.

For example, the following user name is created, and then a session is started with that user.

```
CREATE USER reduser IDENTIFIED BY password;
edb=# \c - reduser
Password for user reduser:
You are now connected to database "edb" as user "reduser".
```
When connected to the database as `reduser`, the following tables are created.

```sql
CREATE TABLE all_lower (col INTEGER);
CREATE TABLE ALL_UPPER (COL INTEGER);
CREATE TABLE "Mixed_Case" ("Col" INTEGER);
```

When viewed from the Oracle catalog, `USER_TABLES`, with `edb_redwood_raw_names` set to the default value `FALSE`, the names appear in uppercase except for the `Mixed_Case` name, which appears as created and also with enclosing quotation marks.

```
edb=> SELECT * FROM USER_TABLES;
schema_name | table_name  | tablespace_name | status | temporary
-------------+------------+-----------------+--------+------------
REDUSER      | ALL_LOWER  |                 | VALID  | N          
REDUSER      | ALL_UPPER  |                 | VALID  | N          
REDUSER      | "Mixed_Case" |                 | VALID  | N
(3 rows)
```

When viewed with `edb_redwood_raw_names` set to `TRUE`, the names appear in lowercase except for the `Mixed_Case` name, which appears as created, but now without the enclosing quotation marks.

```
edb=> SET edb_redwood_raw_names TO true;
SET edb=> SELECT * FROM USER_TABLES;
schema_name | table_name  | tablespace_name | status | temporary
-------------+------------+-----------------+--------+------------
reduser      | all_lower  |                 | VALID  | N          
reduser      | all_upper  |                 | VALID  | N          
reduser      | Mixed_Case |                 | VALID  | N
(3 rows)
```

These names now match the case when viewed from the PostgreSQL `pg_tables` catalog.

```
edb=> SELECT schemaname, tablename, tableowner FROM pg_tables WHERE tableowner = 'reduser';
schemaname | tablename  | tableowner
-----------+------------+-----------
reduser     | all_lower  | reduser   
reduser     | all_upper  | reduser   
reduser     | Mixed_Case | reduser   
(3 rows)
```

### 1.3.3 `edb_redwood_strings`

In Oracle, when a string is concatenated with a null variable or null column, the result is the original string; however, in PostgreSQL concatenation of a string with a null variable or null column gives a null result. If the `edb_redwood_strings` parameter is set to `TRUE`, the aforementioned concatenation operation results in the original string as done by Oracle. If `edb_redwood_strings` is set to `FALSE`, the native PostgreSQL behavior is maintained.
The following example illustrates the difference.

The sample application introduced in the next section contains a table of employees. This table has a column named `comm` that is null for most employees. The following query is run with `edb_redwood_strings` set to `FALSE`. The concatenation of a null column with non-empty strings produces a final result of null, so only employees that have a commission appear in the query result. The output line for all other employees is null.

```sql
SET edb_redwood_strings TO off;
SELECT RPAD(ename,10) || ' ' || TO_CHAR(sal,'99,999.99') || ' ' ||
     TO_CHAR(comm,'99,999.99') "EMPLOYEE COMPENSATION" FROM emp;

EMPLOYEE COMPENSATION
------------------------
ALLEN        1,600.00     300.00
WARD         1,250.00     500.00
MARTIN       1,250.00   1,400.00
TURNER       1,500.00        .00
(14 rows)
```

The following is the same query executed when `edb_redwood_strings` is set to `TRUE`. Here, the value of a null column is treated as an empty string. The concatenation of an empty string with a non-empty string produces the non-empty string. This result is consistent with the results produced by Oracle for the same query.

```sql
SET edb_redwood_strings TO on;
SELECT RPAD(ename,10) || ' ' || TO_CHAR(sal,'99,999.99') || ' ' ||
     TO_CHAR(comm,'99,999.99') "EMPLOYEE COMPENSATION" FROM emp;

EMPLOYEE COMPENSATION
------------------------
SMITH          800.00
ALLEN        1,600.00     300.00
WARD         1,250.00     500.00
JONES        2,975.00
MARTIN       1,250.00   1,400.00
BLAKE        2,850.00
CLARK        2,450.00
SCOTT        3,000.00
KING         5,000.00
TURNER       1,500.00        .00
ADAMS        1,100.00
JAMES         950.00
FORD         3,000.00
MILLER       1,300.00
(14 rows)
```
1.3.4 edb_stmt_level_tx

In Oracle, when a runtime error occurs in a SQL command, all the updates on the database caused by that single command are rolled back. This is called statement level transaction isolation. For example, if a single UPDATE command successfully updates five rows, but an attempt to update a sixth row results in an exception, the updates to all six rows made by this UPDATE command are rolled back. The effects of prior SQL commands that have not yet been committed or rolled back are pending until a COMMIT or ROLLBACK command is executed.

In PostgreSQL, if an exception occurs while executing a SQL command, all the updates on the database since the start of the transaction are rolled back. In addition, the transaction is left in an aborted state and either a COMMIT or ROLLBACK command must be issued before another transaction can be started.

If edb_stmt_level_tx is set to TRUE, then an exception will not automatically roll back prior uncommitted database updates, emulating the Oracle behavior. If edb_stmt_level_tx is set to FALSE, then an exception will roll back uncommitted database updates.

**Note:** Use edb_stmt_level_tx set to TRUE only when absolutely necessary, as this may cause a negative performance impact.

The following example run in PSQL shows that when edb_stmt_level_tx is FALSE, the abort of the second INSERT command also rolls back the first INSERT command. Note that in PSQL, the command \set AUTOCOMMIT off must be issued, otherwise every statement commits automatically defeating the purpose of this demonstration of the effect of edb_stmt_level_tx.

```sql
\set AUTOCOMMIT off
SET edb_stmt_level_tx TO off;
INSERT INTO emp (empno, ename, deptno) VALUES (9001, 'JONES', 40);
INSERT INTO emp (empno, ename, deptno) VALUES (9002, 'JONES', 00);
ERROR:  insert or update on table "emp" violates foreign key constraint "emp_ref_dept_fk"
DETAIL:  Key (deptno)=(0) is not present in table "dept".
COMMIT;
SELECT empno, ename, deptno FROM emp WHERE empno > 9000;
empno | ename | deptno
-------+-------+--------
(0 rows)
```

In the following example, with edb_stmt_level_tx set to TRUE, the first INSERT command has not been rolled back after the error on the second INSERT command. At this point, the first INSERT command can either be committed or rolled back.

```
\set AUTOCOMMIT off
```
SET edb_stmt_level_tx TO on;

INSERT INTO emp (empno,ename,deptno) VALUES (9001, 'JONES', 40);
INSERT INTO emp (empno,ename,deptno) VALUES (9002, 'JONES', 00);
ERROR: insert or update on table "emp" violates foreign key constraint "emp_ref_dept_fk"
DETAIL: Key (deptno)=(0) is not present in table "dept".

SELECT empno, ename, deptno FROM emp WHERE empno > 9000;

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>9001</td>
<td>JONES</td>
<td>40</td>
</tr>
</tbody>
</table>

(1 row)

COMMIT;

A ROLLBACK command could have been issued instead of the COMMIT command in which case the insert of employee number 9001 would have been rolled back as well.

1.3.5 oracle_home

Before creating a link to an Oracle server, you must direct Advanced Server to the correct Oracle home directory. Set the LD_LIBRARY_PATH environment variable on Linux (or PATH on Windows) to the lib directory of the Oracle client installation directory.

For Windows only, you can instead set the value of the oracle_home configuration parameter in the postgresql.conf file. The value specified in the oracle_home configuration parameter will override the Windows PATH environment variable.

The LD_LIBRARY_PATH environment variable on Linux (PATH environment variable or oracle_home configuration parameter on Windows) must be set properly each time you start Advanced Server.

When using a Linux service script to start Advanced Server, be sure LD_LIBRARY_PATH has been set within the service script so it is in effect when the script invokes the pg_ctl utility to start Advanced Server.

For Windows only: To set the oracle_home configuration parameter in the postgresql.conf file, edit the file, adding the following line:

```
oracle_home = 'lib_directory'
```

Substitute the name of the Windows directory that contains oci.dll for lib_directory.

After setting the oracle_home configuration parameter, you must restart the server for the changes to take effect. Restart the server from the Windows Services console.
1.4 About the Examples Used in this Guide

The examples shown in this guide are illustrated using the PSQL program. The prompt that normally appears when using PSQL is omitted in these examples to provide extra clarity for the point being demonstrated.

Examples and output from examples are shown in fixed-width, blue font on a light blue background.

Also note the following points:

- During installation of the EDB Postgres Advanced Server the selection for configuration and defaults compatible with Oracle databases must be chosen in order to reproduce the same results as the examples shown in this guide. A default compatible configuration can be verified by issuing the following commands in PSQL and obtaining the same results as shown below.

  ```sql
  SHOW edb_redwood_date;
  edb_redwood_date
  ------------------
  on
  SHOW datestyle;
  DateStyle
  --------------
  Redwood, DMY
  SHOW edb_redwood_strings;
  edb_redwood_strings
  ---------------------
  on
  ```

- The examples use the sample tables, `dept`, `emp`, and `jobhist`, created and loaded when Advanced Server is installed. The `emp` table is installed with triggers that must be disabled in order to reproduce the same results as shown in this guide. Log onto Advanced Server as the `enterprisedb` superuser and disable the triggers by issuing the following command.

  ```sql
  ALTER TABLE emp DISABLE TRIGGER USER;
  ```

  The triggers on the `emp` table can later be re-activated with the following command.

  ```sql
  ALTER TABLE emp ENABLE TRIGGER USER;
  ```
2 SQL Tutorial

This section is an introduction to the SQL language for those new to relational database management systems. Basic operations such as creating, populating, querying, and updating tables are discussed along with examples.

More advanced concepts such as view, foreign keys, and transactions are discussed as well.

2.1 Getting Started

Advanced Server is a relational database management system (RDBMS). That means it is a system for managing data stored in relations. A relation is essentially a mathematical term for a table. The notion of storing data in tables is so commonplace today that it might seem inherently obvious, but there are a number of other ways of organizing databases. Files and directories on Unix-like operating systems form an example of a hierarchical database. A more modern development is the object-oriented database.

Each table is a named collection of rows. Each row of a given table has the same set of named columns, and each column is of a specific data type. Whereas columns have a fixed order in each row, it is important to remember that SQL does not guarantee the order of the rows within the table in any way (although they can be explicitly sorted for display).

Tables are grouped into databases, and a collection of databases managed by a single Advanced Server instance constitutes a database cluster.
2.1.1 Sample Database

Throughout this documentation we will be working with a sample database to help explain some basic to advanced level database concepts.

2.1.1.1 Sample Database Installation

When Advanced Server is installed a sample database named, edb, is automatically created. This sample database contains the tables and programs used throughout this document.

The tables and programs in the sample database can be re-created at any time by executing the script, edb-sample.sql, located in the samples subdirectory of the Advanced Server home directory.

This script does the following:

- Creates the sample tables and programs in the currently connected database
- Grants all permissions on the tables to the PUBLIC group

The tables and programs will be created in the first schema of the search path in which the current user has permission to create tables and procedures. You can display the search path by issuing the command:

```
SHOW SEARCH_PATH;
```

Altering the search path can be done using commands in PSQL.

2.1.1.2 Sample Database Description

The sample database represents employees in an organization.

It contains three types of records: employees, departments, and historical records of employees.

Each employee has an identification number, name, hire date, salary, and manager. Some employees earn a commission in addition to their salary. All employee-related information is stored in the emp table.

The sample company is regionally diverse, so the database keeps track of the location of the departments. Each company employee is assigned to a department. Each department is identified by a unique department number and a short name. Each department is associated with one location. All department-related information is stored in the dept table.
The company also tracks information about jobs held by the employees. Some employees have been with the company for a long time and have held different positions, received raises, switched departments, etc. When a change in employee status occurs, the company records the end date of the former position. A new job record is added with the start date and the new job title, department, salary, and the reason for the status change. All employee history is maintained in the `jobhist` table.

The following is an entity relationship diagram of the sample database tables.

![Sample Database Tables Diagram](image-url)
The following is the `edb-sample.sql` script.

```sql
-- Script that creates the 'sample' tables, views, procedures, functions, triggers, etc.
-- Start new transaction - commit all or nothing
BEGIN;
/
--
-- Create and load tables used in the documentation examples.
--
-- Create the 'dept' table
--
CREATE TABLE dept (
    deptno          NUMBER(2) NOT NULL CONSTRAINT dept_pk PRIMARY KEY,
    dname           VARCHAR2(14) CONSTRAINT dept_dname_uq UNIQUE,
    loc             VARCHAR2(13)
); --
--
-- Create the 'emp' table
--
CREATE TABLE emp (
    empno           NUMBER(4) NOT NULL CONSTRAINT emp_pk PRIMARY KEY,
    ename           VARCHAR2(10),
    job             VARCHAR2(9),
    mgr             NUMBER(4),
    hiredate        DATE,
    sal             NUMBER(7,2) CONSTRAINT emp_sal_ck CHECK (sal > 0),
    comm            NUMBER(7,2),
    deptno          NUMBER(2) CONSTRAINT emp_ref_dept_fk REFERENCES dept(deptno)
); --
--
-- Create the 'jobhist' table
--
CREATE TABLE jobhist (
    empno           NUMBER(4) NOT NULL,
    startdate       DATE NOT NULL,
    enddate         DATE,
    job             VARCHAR2(9),
    sal             NUMBER(7,2),
    comm            NUMBER(7,2),
    deptno          NUMBER(2),
    chgdesc         VARCHAR2(80),
    CONSTRAINT jobhist_pk PRIMARY KEY (empno, startdate),
    CONSTRAINT jobhist_ref_emp_fk FOREIGN KEY (empno) REFERENCES emp(empno) ON DELETE CASCADE,
    CONSTRAINT jobhist_ref_dept_fk FOREIGN KEY (deptno) REFERENCES dept(deptno) ON DELETE SET NULL,
    CONSTRAINT jobhist_date_chk CHECK (startdate <= enddate)
); --
-- Create the 'salesemp' view
--
CREATE OR REPLACE VIEW salesemp AS
SELECT empno, ename, hiredate, sal, comm FROM emp WHERE job = 'SALESMAN'; --
--
-- Sequence to generate values for function 'new_empno'.
```
CREATE SEQUENCE next_empno START WITH 8000 INCREMENT BY 1;

-- Issue PUBLIC grants
--
GRANT ALL ON emp TO PUBLIC;
GRANT ALL ON dept TO PUBLIC;
GRANT ALL ON jobhist TO PUBLIC;
GRANT ALL ON salesemp TO PUBLIC;
GRANT ALL ON next_empno TO PUBLIC;

-- Load the 'dept' table
--
INSERT INTO dept VALUES (10,'ACCOUNTING','NEW YORK');
INSERT INTO dept VALUES (20,'RESEARCH','DALLAS');
INSERT INTO dept VALUES (30,'SALES','CHICAGO');
INSERT INTO dept VALUES (40,'OPERATIONS','BOSTON');

-- Load the 'emp' table
--
INSERT INTO emp VALUES (7369,'SMITH','CLERK',7902,'17-DEC-80',800,NULL,20);
INSERT INTO emp VALUES (7499,'ALLEN','SALESMAN',7698,'20-FEB-81',1600,300,30);
INSERT INTO emp VALUES (7521,'WARD','SALESMAN',7698,'22-FEB-81',1250,500,30);
INSERT INTO emp VALUES (7566,'JONES','MANAGER',7839,'02-APR-81',2975,NULL,20);
INSERT INTO emp VALUES (7654,'MARTIN','SALESMAN',7698,'28-SEP-81',1250,1400,30);
INSERT INTO emp VALUES (7698,'BLAKE','MANAGER',7839,'01-MAY-81',2850,NULL,30);
INSERT INTO emp VALUES (7782,'CLARK','MANAGER',7839,'09-JUN-81',2450,NULL,10);
INSERT INTO emp VALUES (7788,'SCOTT','ANALYST',7566,'19-APR-87',3000,NULL,20);
INSERT INTO emp VALUES (7839,'KING','PRESIDENT',NULL,'17-NOV-81',5000,NULL,10);
INSERT INTO emp VALUES (7844,'TURNER','SALESMAN',7698,'08-SEP-81',1500,0,30);
INSERT INTO emp VALUES (7876,'ADAMS','CLERK',7788,'23-MAY-82',1100,NULL,20);
INSERT INTO emp VALUES (7900,'JAMES','CLERK',7698,'03-DEC-81',950,NULL,30);
INSERT INTO emp VALUES (7902,'FORD','ANALYST',7566,'03-DEC-81',3000,NULL,20);
INSERT INTO emp VALUES (7934,'MILLER','CLERK',7782,'23-JAN-82',1300,NULL,10);

-- Load the 'jobhist' table
--
INSERT INTO jobhist VALUES (7369,'17-DEC-80',NULL,'CLERK',800,NULL,20,'New Hire');
INSERT INTO jobhist VALUES (7499,'20-FEB-81',NULL,'SALESMAN',1600,300,30,'New Hire');
INSERT INTO jobhist VALUES (7521,'22-FEB-81',NULL,'SALESMAN',1250,500,30,'New Hire');
INSERT INTO jobhist VALUES (7566,'02-APR-81',NULL,'MANAGER',2975,NULL,20,'New Hire');
INSERT INTO jobhist VALUES (7654,'28-SEP-81',NULL,'SALESMAN',1250,1400,30,'New Hire');
INSERT INTO jobhist VALUES (7698,'01-MAY-81',NULL,'MANAGER',2850,NULL,30,'New Hire');
INSERT INTO jobhist VALUES (7782,'09-JUN-81',NULL,'MANAGER',2450,NULL,10,'New Hire');
INSERT INTO jobhist VALUES (7788,'19-APR-87','12-APR-88','CLERK',1000,NULL,20,'New Hire');
INSERT INTO jobhist VALUES (7788,'13-APR-88','04-MAY-89','CLERK',1040,NULL,20,'Raise');
```sql
INSERT INTO jobhist VALUES (7788,'05-MAY-90',NULL,'ANALYST',3000,NULL,20,'Promoted to Analyst');
INSERT INTO jobhist VALUES (7839,'17-NOV-81',NULL,'PRESIDENT',5000,NULL,10,'New Hire');
INSERT INTO jobhist VALUES (7844,'08-SEP-81',NULL,'SALES MAN',1500,0,30,'New Hire');
INSERT INTO jobhist VALUES (7876,'23-MAY-87',NULL,'CLERK',1100,NULL,20,'New Hire');
INSERT INTO jobhist VALUES (7900,'03-DEC-81','14-JAN-83','CLERK',950,NULL,10,'New Hire');
INSERT INTO jobhist VALUES (7900,'15-JAN-83',NULL,'CLERK',950,NULL,30,'Changed to Dept 30');
INSERT INTO jobhist VALUES (7902,'03-DEC-81',NULL,'ANALYST',3000,NULL,20,'New Hire');
INSERT INTO jobhist VALUES (7934,'23-JAN-82',NULL,'CLERK',1300,NULL,10,'New Hire');

-- Populate statistics table and view (pg_statistic/pg_stats)
--
ANALYZE dept;
ANALYZE emp;
ANALYZE jobhist;
--
-- Procedure that lists all employees' numbers and names
-- from the 'emp' table using a cursor.
--
CREATE OR REPLACE PROCEDURE list_emp
IS
  v_empno NUMBER(4);
  v_ename VARCHAR2(10);
CURSOR emp_cur IS
  SELECT empno, ename FROM emp ORDER BY empno;
BEGIN
  OPEN emp_cur;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  LOOP
    FETCH emp_cur INTO v_empno, v_ename;
    EXIT WHEN emp_cur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
  END LOOP;
  CLOSE emp_cur;
END;
/
--
-- Procedure that selects an employee row given the employee
-- number and displays certain columns.
--
CREATE OR REPLACE PROCEDURE select_emp (p_empno IN NUMBER)
IS
  v_ename emp.ename%TYPE;
  v_hiredate emp.hiredate%TYPE;
  v_sal emp.sal%TYPE;
  v_comm emp.comm%TYPE;
  v_dname dept.dname%TYPE;
  v_disp_date VARCHAR2(10);
BEGIN
  SELECT ename, hiredate, sal, NVL(comm, 0), dname
  INTO v_ename, v_hiredate, v_sal, v_comm, v_dname
  FROM emp e, dept d
  WHERE empno = p_empno
END;
```
AND e.deptno = d.deptno;

v_disp_date := TO_CHAR(v_hiredate, 'MM/DD/YYYY');

DBMS_OUTPUT.PUT_LINE('Number    : ' || p_empno);
DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
DBMS_OUTPUT.PUT_LINE('Hire Date : ' || v_disp_date);
DBMS_OUTPUT.PUT_LINE('Salary    : ' || v_sal);
DBMS_OUTPUT.PUT_LINE('Commission: ' || v_comm);
DBMS_OUTPUT.PUT_LINE('Department: ' || v_dname);

EXCEPTION
WHEN NO_DATA_FOUND THEN
  DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno || ' not found');
WHEN OTHERS THEN
  DBMS_OUTPUT.PUT_LINE('The following is SQLERRM: ');
  DBMS_OUTPUT.PUT_LINE(SQLERRM);
  DBMS_OUTPUT.PUT_LINE('The following is SQLCODE: ');
  DBMS_OUTPUT.PUT_LINE(SQLCODE);
END;
/
--
-- Procedure that queries the 'emp' table based on
-- department number and employee number or name. Returns
-- employee number and name as IN OUT parameters and job,
-- hire date, and salary as OUT parameters.
--
CREATE OR REPLACE PROCEDURE emp_query (  
p_deptno        IN     NUMBER,
p_empno         IN OUT NUMBER,
p_ename         IN OUT VARCHAR2,
p_job           OUT    VARCHAR2,
p_hiredate      OUT    DATE,
p_sal           OUT    NUMBER  
)  
IS  
BEGIN  
SELECT empno, ename, job, hiredate, sal  
  INTO p_empno, p_ename, p_job, p_hiredate, p_sal  
FROM emp  
WHERE deptno = p_deptno  
  AND (empno = p_empno  
    OR ename = UPPER(p_ename));  
END;
/
--
-- Procedure to call 'emp_query_caller' with IN and IN OUT
-- parameters. Displays the results received from IN OUT and
-- OUT parameters.
--
CREATE OR REPLACE PROCEDURE emp_query_caller  
IS  
v_deptno        NUMBER(2);  
v_empno         NUMBER(4);  
v_ename         VARCHAR2(10);  
v_job           VARCHAR2(9);  
v_hiredate      DATE;  
v_sal           NUMBER;  
BEGIN  
v_deptno := 30;  
v_empno  := 0;  
v_ename := 'Martin';  
emp_query(v_deptno, v_empno, v_ename, v_job, v_hiredate, v_sal);  
DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);  
DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);  
DBMS_OUTPUT.PUT_LINE('Name      : ' || v_ename);
```
DBMS_OUTPUT.PUT_LINE('Job        : ' || v_job);
DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || v_hiredate);
DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);

EXCEPTION
  WHEN TOO_MANY_ROWS THEN
    DBMS_OUTPUT.PUT_LINE('More than one employee was selected');
  WHEN NO_DATA_FOUND THEN
    DBMS_OUTPUT.PUT_LINE('No employees were selected');
END;
/

-- Function to compute yearly compensation based on semimonthly salary.

CREATE OR REPLACE FUNCTION emp_comp (  
  p_sal           NUMBER,  
  p_comm          NUMBER) RETURN NUMBER  
IS  
  BEGIN  
    RETURN (p_sal + NVL(p_comm, 0)) * 24;
  END;
/

-- Function that gets the next number from sequence, 'next_empno', and ensures it is not already in use as an employee number.

CREATE OR REPLACE FUNCTION new_empno RETURN NUMBER  
IS  
  v_cnt           INTEGER := 1;
  v_new_empno     NUMBER;
  BEGIN  
    WHILE v_cnt > 0 LOOP  
      SELECT next_empno.nextval INTO v_new_empno FROM dual;
      SELECT COUNT(*) INTO v_cnt FROM emp WHERE empno = v_new_empno;
    END LOOP;
    RETURN v_new_empno;
  END;
/

-- EDB-SPL function that adds a new clerk to table 'emp'. This function uses package 'emp_admin'.

CREATE OR REPLACE FUNCTION hire_clerk (  
  p_ename         VARCHAR2,  
  p_deptno        NUMBER) RETURN NUMBER  
IS  
  v_empno         NUMBER(4);
  v_ename         VARCHAR2(10);
  v_job           VARCHAR2(9);
  v_mgr           NUMBER(4);
  v_hiredate      DATE;
  v_sal           NUMBER(7,2);
  v_comm          NUMBER(7,2);
  v_deptno        NUMBER(2);
  BEGIN  
    v_empno := new_empno;
    INSERT INTO emp VALUES (v_empno, p_ename, 'CLERK', 7782,  
      TRUNC(SYSDATE), 950.00, NULL, p_deptno);
    SELECT empno, ename, job, mgr, hiredate, sal, comm, deptno INTO  
      v_empno, v_ename, v_job, v_mgr, v_hiredate, v_sal, v_comm, v_deptno  
      FROM emp WHERE empno = v_empno;
  END;
```
DECLARE 
  v_empno         NUMERIC(4);
  v_ename         VARCHAR(10);
  v_job           VARCHAR(9);
  v_mgr           NUMERIC(4);
  v_hiredate      DATE;
  v_sal           NUMERIC(7,2);
  v_comm          NUMERIC(7,2);
  v_deptno        NUMERIC(2);
BEGIN
  v_empno := new_empno();
  INSERT INTO emp VALUES (v_empno, p_ename, 'SALESMAN', 7698, CURRENT_DATE, p_sal, p_comm, 30);
  SELECT INTO v_empno, v_ename, v_job, v_mgr, v_hiredate, v_sal, v_comm, v_deptno empno, ename, job, mgr, hiredate, sal, comm, deptno FROM emp WHERE empno = v_empno;
  RAISE INFO 'Department : %', v_deptno;
  RAISE INFO 'Employee No: %', v_empno;
  RAISE INFO 'Name       : %', v_ename;
  RAISE INFO 'Job        : %', v_job;
  RAISE INFO 'Manager    : %', v_mgr;
  RAISE INFO 'Hire Date  : %', v_hiredate;
  RAISE INFO 'Salary     : %', v_sal;
  RAISE INFO 'Commission : %', v_comm;
  RETURN v_empno;
EXCEPTION
  WHEN OTHERS THEN
    RAISE INFO 'The following is SQLERRM: ';
    RAISE INFO '%', SQLERRM;
    RAISE INFO 'The following is SQLSTATE: ';
    RAISE INFO '%', SQLSTATE;
    RETURN -1;
END;
$$ LANGUAGE 'plpgsql';
-- Rule to INSERT into view 'salesemp'

CREATE OR REPLACE RULE salesemp_i AS ON INSERT TO salesemp
DO INSTEAD
    INSERT INTO emp VALUES (NEW.empno, NEW.ename, 'SALESMAN', 7698, NEW.hiredate, NEW.sal, NEW.comm, 30);

-- Rule to UPDATE view 'salesemp'

CREATE OR REPLACE RULE salesemp_u AS ON UPDATE TO salesemp
DO INSTEAD
    UPDATE emp SET empno = NEW.empno,
             ename = NEW.ename,
             hiredate = NEW.hiredate,
             sal = NEW.sal,
             comm = NEW.comm
    WHERE empno = OLD.empno;

-- Rule to DELETE from view 'salesemp'

CREATE OR REPLACE RULE salesemp_d AS ON DELETE TO salesemp
DO INSTEAD
    DELETE FROM emp WHERE empno = OLD.empno;

-- After statement-level trigger that displays a message after
-- an insert, update, or deletion to the 'emp' table. One message
-- per SQL command is displayed.

CREATE OR REPLACE TRIGGER user_audit_trig
    AFTER INSERT OR UPDATE OR DELETE ON emp
DECLARE
    v_action VARCHAR2(24);
BEGIN
    IF INSERTING THEN
        v_action := ' added employee(s) on ';
    ELSIF UPDATING THEN
        v_action := ' updated employee(s) on ';
    ELSIF DELETING THEN
        v_action := ' deleted employee(s) on ';
    END IF;
    DBMS_OUTPUT.PUT_LINE('User ' || USER || v_action ||
                TO_CHAR(SYSDATE,'YYYY-MM-DD'));
END;
/

-- Before row-level trigger that displays employee number and
-- salary of an employee that is about to be added, updated,
-- or deleted in the 'emp' table.

CREATE OR REPLACE TRIGGER emp_sal_trig
    BEFORE DELETE OR INSERT OR UPDATE ON emp
FOR EACH ROW
DECLARE
    sal_diff NUMBER;
BEGIN
    IF INSERTING THEN
        DBMS_OUTPUT.PUT_LINE('Inserting employee ' || :NEW.empno);
        DBMS_OUTPUT.PUT_LINE('..New salary: ' || :NEW.sal);
    END IF;
    IF UPDATING THEN
        sal_diff := :NEW.sal - :OLD.sal;
    END IF;
END;
DBMS_OUTPUT.PUT_LINE('Updating employee ' || :OLD.empno);
DBMS_OUTPUT.PUT_LINE('..Old salary: ' || :OLD.sal);
DBMS_OUTPUT.PUT_LINE('..New salary: ' || :NEW.sal);
DBMS_OUTPUT.PUT_LINE('..Raise     : ' || sal_diff);
END IF;
IF DELETING THEN
  DBMS_OUTPUT.PUT_LINE('Deleting employee ' || :OLD.empno);
  DBMS_OUTPUT.PUT_LINE('..Old salary: ' || :OLD.sal);
END IF;
END;
/
--
-- Package specification for the 'emp_admin' package.
--
CREATE OR REPLACE PACKAGE emp_admin
IS
  FUNCTION get_dept_name (p_deptno        NUMBER) RETURN VARCHAR2;
  FUNCTION update_emp_sal (p_empno         NUMBER,
                           p_raise         NUMBER) RETURN NUMBER;
  PROCEDURE hire_emp (p_empno NUMBER,
                      p_ename         VARCHAR2,
                      p_job           VARCHAR2,
                      p_sal           NUMBER,
                      p_hiredate      DATE,
                      p_comm          NUMBER,
                      p_mgr           NUMBER,
                      p_deptno        NUMBER);
  PROCEDURE fire_emp (p_empno NUMBER);
END emp_admin;
/
--
-- Package body for the 'emp_admin' package.
--
CREATE OR REPLACE PACKAGE BODY emp_admin
IS
  --
  -- Function that queries the 'dept' table based on the department
  -- number and returns the corresponding department name.
  --
  FUNCTION get_dept_name (p_deptno IN NUMBER)
  RETURN VARCHAR2
IS
    v_dname VARCHAR2(14);
BEGIN
  SELECT dname INTO v_dname FROM dept WHERE deptno = p_deptno;
END;
EXCEPTION
  WHEN NO_DATA_FOUND THEN
    DBMS_OUTPUT.PUT_LINE('Invalid department number ' || p_deptno);
    RETURN '';
END;
--
  -- Function that updates an employee's salary based on the
  -- employee number and salary increment/decrement passed
as IN parameters. Upon successful completion the function returns the new updated salary.

FUNCTION update_emp_sal (p_empno IN NUMBER, p_raise IN NUMBER)
RETURN NUMBER IS
v_sal NUMBER := 0;
BEGIN
SELECT sal INTO v_sal FROM emp WHERE empno = p_empno;
v_sal := v_sal + p_raise;
UPDATE emp SET sal = v_sal WHERE empno = p_empno;
RETURN v_sal;
EXCEPTION
WHEN NO_DATA_FOUND THEN
DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno || ' not found');
RETURN -1;
WHEN OTHERS THEN
DBMS_OUTPUT.PUT_LINE('The following is SQLERRM:');
DBMS_OUTPUT.PUT_LINE(SQLERRM);
DBMS_OUTPUT.PUT_LINE('The following is SQLCODE:');
DBMS_OUTPUT.PUT_LINE(SQLCODE);
RETURN -1;
END;

-- Procedure that inserts a new employee record into the 'emp' table.
PROCEDURE hire_emp (p_empno NUMBER, p_ename VARCHAR2, p_job VARCHAR2, p_sal NUMBER, p_hiredate DATE, p_comm NUMBER, p_mgr NUMBER, p_deptno NUMBER)
AS
BEGIN
INSERT INTO emp(empno, ename, job, sal, hiredate, comm, mgr, deptno)
VALUES(p_empno, p_ename, p_job, p_sal, p_hiredate, p_comm, p_mgr, p_deptno);
END;

-- Procedure that deletes an employee record from the 'emp' table based on the employee number.
PROCEDURE fire_emp (p_empno NUMBER)
AS
BEGIN
DELETE FROM emp WHERE empno = p_empno;
END;
END;
2.1.2 Creating a New Table

A new table is created by specifying the table name, along with all column names and their types. The following is a simplified version of the `emp` sample table with just the minimal information needed to define a table.

```
CREATE TABLE emp (
    empno           NUMBER(4),
    ename           VARCHAR2(10),
    job             VARCHAR2(9),
    mgr             NUMBER(4),
    hiredate        DATE,
    sal             NUMBER(7,2),
    comm            NUMBER(7,2),
    deptno          NUMBER(2)
);  
```

You can enter this into PSQL with line breaks. PSQL will recognize that the command is not terminated until the semicolon.

White space (i.e., spaces, tabs, and newlines) may be used freely in SQL commands. That means you can type the command aligned differently than the above, or even all on one line. Two dashes ("--") introduce comments. Whatever follows them is ignored up to the end of the line. SQL is case insensitive about key words and identifiers, except when identifiers are double-quoted to preserve the case (not done above).

`VARCHAR2(10)` specifies a data type that can store arbitrary character strings up to 10 characters in length. `NUMBER(7,2)` is a fixed point number with precision 7 and scale 2. `NUMBER(4)` is an integer number with precision 4 and scale 0.

Advanced Server supports the usual SQL data types `INTEGER, SMALLINT, NUMBER, REAL, DOUBLE PRECISION, CHAR, VARCHAR2, DATE, and TIMESTAMP` as well as various synonyms for these types.

If you don’t need a table any longer or want to recreate it differently you can remove it using the following command:

```
DROP TABLE tablename;
```
2.1.3 Populating a Table With Rows

The \texttt{INSERT} statement is used to populate a table with rows:

\begin{verbatim}
INSERT INTO emp VALUES (7369,'SMITH','CLERK',7902,'17-DEC-80',800,NULL,20);
\end{verbatim}

Note that all data types use rather obvious input formats. Constants that are not simple numeric values usually must be surrounded by single quotes ('), as in the example. The \texttt{DATE} type is actually quite flexible in what it accepts, but for this tutorial we will stick to the unambiguous format shown here.

The syntax used so far requires you to remember the order of the columns. An alternative syntax allows you to list the columns explicitly:

\begin{verbatim}
INSERT INTO emp(empno,ename,job,mgr,hiredate,sal,comm,deptno)
VALUES (7499,'ALLEN','SALESMAN',7698,'20-FEB-81',1600,300,30);
\end{verbatim}

You can list the columns in a different order if you wish or even omit some columns, e.g., if the commission is unknown:

\begin{verbatim}
INSERT INTO emp(empno,ename,job,mgr,hiredate,sal,deptno)
VALUES (7369,'SMITH','CLERK',7902,'17-DEC-80',800,20);
\end{verbatim}

Many developers consider explicitly listing the columns better style than relying on the order implicitly.
2.1.4 Querying a Table

To retrieve data from a table, the table is queried. An SQL SELECT statement is used to do this. The statement is divided into a select list (the part that lists the columns to be returned), a table list (the part that lists the tables from which to retrieve the data), and an optional qualification (the part that specifies any restrictions). The following query lists all columns of all employees in the table in no particular order.

```
SELECT * FROM emp;
```

Here, `*` in the select list means all columns. The following is the output from this query.

```
empno | ename  |    job    | mgr  |      hiredate      |   sal   |  comm   | deptno
-------+--------+-----------+------|-------------------+--------+--------+-------
7369   | SMITH  | CLERK     | 7902 | 17-DEC-80 00:00:00 | 800.00 |         |     20
7499   | ALLEN  | SALESMAN  | 7698 | 20-FEB-81 00:00:00 | 1600.00| 300.00  |     30
7521   | WARD   | SALESMAN  | 7698 | 22-FEB-81 00:00:00 | 1250.00| 500.00  |     30
7566   | JONES  | MANAGER   | 7839 | 02-APR-81 00:00:00 | 2975.00|         |     20
7654   | MARTIN | SALESMAN  | 7698 | 28-SEP-81 00:00:00 | 1250.00| 1400.00|     30
7698   | BLAKE  | MANAGER   | 7839 | 01-MAY-81 00:00:00 | 2850.00|         |     30
7782   | CLARK  | MANAGER   | 7839 | 09-JUN-81 00:00:00 | 2450.00|         |     10
7888   | SCOTT  | ANALYST   | 7566 | 19-APR-87 00:00:00 | 3000.00|         |     20
7839   | KING   | PRESIDENT | 7698 | 17-NOV-81 00:00:00 | 5000.00|         |     10
7844   | TURNER | SALESMAN  | 7698 | 08-SEP-81 00:00:00 | 1500.00| 0.00    |     30
7876   | ADAMS  | CLERK     | 7788 | 23-MAY-87 00:00:00 | 1100.00|         |     20
7900   | JAMES  | CLERK     | 7698 | 03-DEC-81 00:00:00 | 950.00 |         |     30
7902   | FORD   | ANALYST   | 7566 | 03-DEC-81 00:00:00 | 3000.00|         |     20
7934   | MILLER | CLERK     | 7788 | 23-JAN-82 00:00:00 | 1300.00|         |     10
(14 rows)
```

You may specify any arbitrary expression in the select list. For example, you can do:

```
SELECT ename, sal, sal * 24 AS yearly_salary, deptno FROM emp;
```

```
ename  |   sal   | yearly_salary | deptno
--------+---------+---------------+-------
SMITH   | 800.00  | 19200.00      |     20
ALLEN   | 1600.00 | 38400.00      |     30
WARD    | 1250.00 | 30000.00      |     30
JONES   | 2975.00 | 71400.00      |     20
MARTIN  | 1250.00 | 30000.00      |     30
BLAKE   | 2850.00 | 68400.00      |     30
CLARK   | 2450.00 | 58800.00      |     10
SCOTT   | 3000.00 | 72000.00      |     20
KING    | 5000.00 | 120000.00     |     10
TURNER | 1500.00 | 36000.00      |     30
ADAMS   | 1100.00 | 26400.00      |     20
JAMES   | 950.00  | 22800.00      |     30
FORD    | 3000.00 | 72000.00      |     20
MILLER  | 1300.00 | 31200.00      |     10
(14 rows)
```

Notice how the AS clause is used to re-label the output column. (The AS clause is optional.)
A query can be qualified by adding a `WHERE` clause that specifies which rows are wanted. The `WHERE` clause contains a Boolean (truth value) expression, and only rows for which the Boolean expression is true are returned. The usual Boolean operators (AND, OR, and NOT) are allowed in the qualification. For example, the following retrieves the employees in department 20 with salaries over $1000.00:

```sql
SELECT ename, sal, deptno FROM emp WHERE deptno = 20 AND sal > 1000;
```

You can request that the results of a query be returned in sorted order:

```sql
SELECT ename, sal, deptno FROM emp ORDER BY ename;
```

You can request that duplicate rows be removed from the result of a query:

```sql
SELECT DISTINCT job FROM emp;
```

The following section shows how to obtain rows from more than one table in a single query.
2.1.5 Joins Between Tables

Thus far, our queries have only accessed one table at a time. Queries can access multiple tables at once, or access the same table in such a way that multiple rows of the table are being processed at the same time. A query that accesses multiple rows of the same or different tables at one time is called a join query. For example, say you wish to list all the employee records together with the name and location of the associated department. To do that, we need to compare the deptno column of each row of the emp table with the deptno column of all rows in the dept table, and select the pairs of rows where these values match. This would be accomplished by the following query:

```
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM emp, dept
WHERE emp.deptno = dept.deptno;
```

```
<table>
<thead>
<tr>
<th>ename</th>
<th>sal</th>
<th>deptno</th>
<th>dname</th>
<th>loc</th>
</tr>
</thead>
<tbody>
<tr>
<td>MILLER</td>
<td>1300.00</td>
<td>10</td>
<td>ACCOUNTING</td>
<td>NEW YORK</td>
</tr>
<tr>
<td>CLARK</td>
<td>2450.00</td>
<td>10</td>
<td>ACCOUNTING</td>
<td>NEW YORK</td>
</tr>
<tr>
<td>KING</td>
<td>5000.00</td>
<td>10</td>
<td>ACCOUNTING</td>
<td>NEW YORK</td>
</tr>
<tr>
<td>SCOTT</td>
<td>3000.00</td>
<td>20</td>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>JONES</td>
<td>2975.00</td>
<td>20</td>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>SMITH</td>
<td>800.00</td>
<td>20</td>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>ADAMS</td>
<td>1100.00</td>
<td>20</td>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>FORD</td>
<td>3000.00</td>
<td>20</td>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>WARD</td>
<td>1250.00</td>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
<tr>
<td>TURNER</td>
<td>1500.00</td>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
<tr>
<td>ALLEN</td>
<td>1600.00</td>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
<tr>
<td>BLAKE</td>
<td>2850.00</td>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
<tr>
<td>MARTIN</td>
<td>1250.00</td>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
<tr>
<td>JAMES</td>
<td>950.00</td>
<td>30</td>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
</tbody>
</table>
```

(14 rows)

Observe two things about the result set:

- There is no result row for department 40. This is because there is no matching entry in the emp table for department 40, so the join ignores the unmatched rows in the dept table. Shortly we will see how this can be fixed.
- It is more desirable to list the output columns qualified by table name rather than using * or leaving out the qualification as follows:

```
SELECT ename, sal, dept.deptno, dname, loc FROM emp, dept
WHERE emp.deptno = dept.deptno;
```

Since all the columns had different names (except for deptno which therefore must be qualified), the parser automatically found out which table they belong to, but it is good style to fully qualify column names in join queries:

Join queries of the kind seen thus far can also be written in this alternative form:
This syntax is not as commonly used as the one above, but we show it here to help you understand the following topics.

You will notice that in all the above results for joins no employees were returned that belonged to department 40 and as a consequence, the record for department 40 never appears. Now we will figure out how we can get the department 40 record in the results despite the fact that there are no matching employees. What we want the query to do is to scan the \texttt{dept} table and for each row to find the matching \texttt{emp} row. If no matching row is found we want some “empty” values to be substituted for the \texttt{emp} table’s columns. This kind of query is called an \textit{outer join}. (The joins we have seen so far are \textit{inner joins}.) The command looks like this:

```sql
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM dept LEFT OUTER JOIN emp ON emp.deptno = dept.deptno;
```

This query is called a \textit{left outer join} because the table mentioned on the left of the join operator will have each of its rows in the output at least once, whereas the table on the right will only have those rows output that match some row of the left table. When a left-table row is selected for which there is no right-table match, empty (\texttt{NULL}) values are substituted for the right-table columns.

An alternative syntax for an outer join is to use the outer join operator, “(+),” in the join condition within the \texttt{WHERE} clause. The outer join operator is placed after the column name of the table for which null values should be substituted for unmatched rows. So for all the rows in the \texttt{dept} table that have no matching rows in the \texttt{emp} table, Advanced Server returns null for any select list expressions containing columns of \texttt{emp}. Hence the above example could be rewritten as:

```sql
SELECT emp.ename, emp.sal, dept.deptno, dept.dname, dept.loc FROM dept, emp
WHERE emp.deptno(+)= dept.deptno;
```
We can also join a table against itself. This is called a selfjoin. As an example, suppose we wish to find the name of each employee along with the name of that employee's manager. So we need to compare the mgr column of each emp row to the empno column of all other emp rows.

```
SELECT e1.ename || ' works for ' || e2.ename AS "Employees and their Managers" FROM emp e1, emp e2 WHERE e1.mgr = e2.empno;
```

```
Employees and their Managers
-------------------------------
FORD works for JONES
SCOTT works for JONES
WARD works for BLAKE
TURNER works for BLAKE
MARTIN works for BLAKE
JAMES works for BLAKE
MILLER works for CLARK
ADAMS works for SCOTT
CLARK works for KING
BLAKE works for KING
JONES works for KING
SMITH works for FORD
```

Here, the emp table has been re-labeled as e1 to represent the employee row in the select list and in the join condition, and also as e2 to represent the matching employee row acting as manager in the select list and in the join condition. These kinds of aliases can be used in other queries to save some typing, for example:

```
SELECT e.ename, e.mgr, d.deptno, d.dname, d.loc FROM emp e, dept d WHERE e.deptno = d.deptno;
```

```
ename | mgr  | deptno |   dname    |   loc
--------+-------+--------+------------+----------
MILLER | 7782  |   10   | ACCOUNTING | NEW YORK
CLARK  | 7839  |   10   | ACCOUNTING | NEW YORK
KING   | 7566  |  20    | RESEARCH   | DALLAS
SCOTT  | 7566  |  20    | RESEARCH   | DALLAS
```
This style of abbreviating will be encountered quite frequently.
2.1.6 Aggregate Functions

Like most other relational database products, Advanced Server supports aggregate functions. An aggregate function computes a single result from multiple input rows. For example, there are aggregates to compute the \texttt{COUNT}, \texttt{SUM}, \texttt{AVG} (average), \texttt{MAX} (maximum), and \texttt{MIN} (minimum) over a set of rows.

As an example, the highest and lowest salaries can be found with the following query:

\begin{verbatim}
SELECT MAX(sal) highest_salary, MIN(sal) lowest_salary FROM emp;
\end{verbatim}

\begin{verbatim}
highest_salary | lowest_salary
---------------|--------------
5000.00        | 800.00
\end{verbatim}

If we wanted to find the employee with the largest salary, we may be tempted to try:

\begin{verbatim}
SELECT ename FROM emp WHERE sal = MAX(sal);
\end{verbatim}

\begin{verbatim}
ERROR: aggregates not allowed in WHERE clause
\end{verbatim}

This does not work because the aggregate function, \texttt{MAX}, cannot be used in the \texttt{WHERE} clause. This restriction exists because the \texttt{WHERE} clause determines the rows that will go into the aggregation stage so it has to be evaluated before aggregate functions are computed. However, the query can be restated to accomplish the intended result by using a subquery:

\begin{verbatim}
SELECT ename FROM emp WHERE sal = (SELECT MAX(sal) FROM emp);
\end{verbatim}

\begin{verbatim}
ename
-----
KING
\end{verbatim}

The subquery is an independent computation that obtains its own result separately from the outer query.

Aggregates are also very useful in combination with the \texttt{GROUP BY} clause. For example, the following query gets the highest salary in each department.

\begin{verbatim}
SELECT deptno, MAX(sal) FROM emp GROUP BY deptno;
\end{verbatim}

\begin{verbatim}
depthno | max
--------|-----
10      | 5000.00
20      | 3000.00
30      | 2850.00
\end{verbatim}

(3 rows)
This query produces one output row per department. Each aggregate result is computed over the rows matching that department. These grouped rows can be filtered using the HAVING clause.

```
SELECT deptno, MAX(sal) FROM emp GROUP BY deptno HAVING AVG(sal) > 2000;
```

```
<table>
<thead>
<tr>
<th>deptno</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>5000.00</td>
</tr>
<tr>
<td>20</td>
<td>3000.00</td>
</tr>
</tbody>
</table>
```

(2 rows)

This query gives the same results for only those departments that have an average salary greater than 2000.

Finally, the following query takes into account only the highest paid employees who are analysts in each department.

```
SELECT deptno, MAX(sal) FROM emp WHERE job = 'ANALYST' GROUP BY deptno HAVING AVG(sal) > 2000;
```

```
<table>
<thead>
<tr>
<th>deptno</th>
<th>max</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>3000.00</td>
</tr>
</tbody>
</table>
```

(1 row)

There is a subtle distinction between the WHERE and HAVING clauses. The WHERE clause filters out rows before grouping occurs and aggregate functions are applied. The HAVING clause applies filters on the results after rows have been grouped and aggregate functions have been computed for each group.

So in the previous example, only employees who are analysts are considered. From this subset, the employees are grouped by department and only those groups where the average salary of analysts in the group is greater than 2000 are in the final result. This is true of only the group for department 20 and the maximum analyst salary in department 20 is 3000.00.
2.1.7 Updates

The column values of existing rows can be changed using the `UPDATE` command. For example, the following sequence of commands shows the before and after results of giving everyone who is a manager a 10% raise:

```
SELECT ename, sal FROM emp WHERE job = 'MANAGER';

date | sal
-------+-----
JONES | 2975.00
BLAKE | 2850.00
CLARK | 2450.00
(3 rows)

UPDATE emp SET sal = sal * 1.1 WHERE job = 'MANAGER';

SELECT ename, sal FROM emp WHERE job = 'MANAGER';

date | sal
-------+-----
JONES | 3272.50
BLAKE | 3135.00
CLARK | 2695.00
(3 rows)
```
2.1.8 Deletions

Rows can be removed from a table using the `DELETE` command. For example, the following sequence of commands shows the before and after results of deleting all employees in department 20.

```
SELECT ename, deptno FROM emp;

ename     | deptno
----------|--------
SMITH     | 20
ALLEN     | 30
WARD      | 30
JONES     | 20
MARTIN    | 30
BLAKE     | 30
CLARK     | 10
SCOTT     | 20
KING      | 10
TURNER    | 30
ADAMS     | 20
JAMES     | 30
FORD      | 20
MILLER    | 10
```

(14 rows)

```
DELETE FROM emp WHERE deptno = 20;
```

```
SELECT ename, deptno FROM emp;

ename     | deptno
----------|--------
ALLEN     | 30
WARD      | 30
MARTIN    | 30
BLAKE     | 30
CLARK     | 10
KING      | 10
TURNER    | 30
JAMES     | 30
MILLER    | 10
```

(9 rows)

Be extremely careful of giving a `DELETE` command without a `WHERE` clause such as the following:

```
DELETE FROM tablename;
```

This statement will remove all rows from the given table, leaving it completely empty. The system will not request confirmation before doing this.
2.1.9 The SQL Language

Advanced Server supports SQL language that is compatible with Oracle syntax as well as syntax and commands for extended functionality (functionality that does not provide database compatibility for Oracle or support Oracle-styled applications).

The Reference Guide that supports the Database Compatibility for Oracle Developer's Guide provides detailed information about:

- Compatible SQL syntax and language elements
- Data types
- Supported SQL command syntax

To review a copy of the Reference Guide, visit the Advanced Server website at:

http://www.enterprisedb.com/products-services-training/products/documentation
2.2 Advanced Concepts

The previous section discussed the basics of using SQL to store and access your data in Advanced Server. This section discusses more advanced SQL features that may simplify management and prevent loss or corruption of your data.

2.2.1 Views

Consider the following SELECT command.

```
SELECT ename, sal, sal * 24 AS yearly_salary, deptno FROM emp;
```

<table>
<thead>
<tr>
<th>ename</th>
<th>sal</th>
<th>yearly_salary</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMITH</td>
<td>800.00</td>
<td>19200.00</td>
<td>20</td>
</tr>
<tr>
<td>ALLEN</td>
<td>1600.00</td>
<td>38400.00</td>
<td>30</td>
</tr>
<tr>
<td>WARD</td>
<td>1250.00</td>
<td>30000.00</td>
<td>30</td>
</tr>
<tr>
<td>JONES</td>
<td>2975.00</td>
<td>71400.00</td>
<td>20</td>
</tr>
<tr>
<td>MARTIN</td>
<td>1250.00</td>
<td>30000.00</td>
<td>30</td>
</tr>
<tr>
<td>BLAKE</td>
<td>2850.00</td>
<td>68400.00</td>
<td>30</td>
</tr>
<tr>
<td>CLARK</td>
<td>2450.00</td>
<td>58800.00</td>
<td>10</td>
</tr>
<tr>
<td>SCOTT</td>
<td>3000.00</td>
<td>72000.00</td>
<td>20</td>
</tr>
<tr>
<td>KING</td>
<td>5000.00</td>
<td>120000.00</td>
<td>10</td>
</tr>
<tr>
<td>TURNER</td>
<td>1500.00</td>
<td>36000.00</td>
<td>30</td>
</tr>
<tr>
<td>ADAMS</td>
<td>1100.00</td>
<td>26400.00</td>
<td>20</td>
</tr>
<tr>
<td>JAMES</td>
<td>950.00</td>
<td>22800.00</td>
<td>30</td>
</tr>
<tr>
<td>MILLER</td>
<td>1300.00</td>
<td>31200.00</td>
<td>10</td>
</tr>
</tbody>
</table>
(14 rows)

If this is a query that is used repeatedly, a shorthand method of reusing this query without re-typing the entire SELECT command each time is to create a view as shown below.

```
CREATE VIEW employee_pay AS SELECT ename, sal, sal * 24 AS yearly_salary, deptno FROM emp;
```

The view name, employee_pay, can now be used like an ordinary table name to perform the query.

```
SELECT * FROM employee_pay;
```

<table>
<thead>
<tr>
<th>ename</th>
<th>sal</th>
<th>yearly_salary</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMITH</td>
<td>800.00</td>
<td>19200.00</td>
<td>20</td>
</tr>
<tr>
<td>ALLEN</td>
<td>1600.00</td>
<td>38400.00</td>
<td>30</td>
</tr>
<tr>
<td>WARD</td>
<td>1250.00</td>
<td>30000.00</td>
<td>30</td>
</tr>
<tr>
<td>JONES</td>
<td>2975.00</td>
<td>71400.00</td>
<td>20</td>
</tr>
<tr>
<td>MARTIN</td>
<td>1250.00</td>
<td>30000.00</td>
<td>30</td>
</tr>
<tr>
<td>BLAKE</td>
<td>2850.00</td>
<td>68400.00</td>
<td>30</td>
</tr>
<tr>
<td>CLARK</td>
<td>2450.00</td>
<td>58800.00</td>
<td>10</td>
</tr>
<tr>
<td>SCOTT</td>
<td>3000.00</td>
<td>72000.00</td>
<td>20</td>
</tr>
<tr>
<td>KING</td>
<td>5000.00</td>
<td>120000.00</td>
<td>10</td>
</tr>
<tr>
<td>TURNER</td>
<td>1500.00</td>
<td>36000.00</td>
<td>30</td>
</tr>
<tr>
<td>ADAMS</td>
<td>1100.00</td>
<td>26400.00</td>
<td>20</td>
</tr>
<tr>
<td>JAMES</td>
<td>950.00</td>
<td>22800.00</td>
<td>30</td>
</tr>
<tr>
<td>MILLER</td>
<td>1300.00</td>
<td>31200.00</td>
<td>10</td>
</tr>
</tbody>
</table>
Making liberal use of views is a key aspect of good SQL database design. Views provide a consistent interface that encapsulate details of the structure of your tables which may change as your application evolves.

Views can be used in almost any place a real table can be used. Building views upon other views is not uncommon.
2.2.2 Foreign Keys

Suppose you want to make sure all employees belong to a valid department. This is called maintaining the referential integrity of your data. In simplistic database systems this would be implemented (if at all) by first looking at the dept table to check if a matching record exists, and then inserting or rejecting the new employee record. This approach has a number of problems and is very inconvenient. Advanced Server can make it easier for you.

A modified version of the emp table presented in Section 2.1.2 is shown in this section with the addition of a foreign key constraint. The modified emp table looks like the following:

```sql
CREATE TABLE emp (  
    empno           NUMBER(4) NOT NULL CONSTRAINT emp_pk PRIMARY KEY,  
    ename           VARCHAR2(10),  
    job             VARCHAR2(9),  
    mgr             NUMBER(4),  
    hiredate        DATE,  
    sal             NUMBER(7,2),  
    comm            NUMBER(7,2),  
    deptno          NUMBER(2) CONSTRAINT emp_ref_dept_fk  
                    REFERENCES dept(deptno)  
);
```

If an attempt is made to issue the following INSERT command in the sample emp table, the foreign key constraint, emp_ref_dept_fk, ensures that department 50 exists in the dept table. Since it does not, the command is rejected.

```sql
INSERT INTO emp VALUES (8000,'JONES','CLERK',7902,'17-AUG-07',1200,NULL,50);
```

ERROR: insert or update on table "emp" violates foreign key constraint "emp_ref_dept_fk"

DETAIL: Key (deptno)=(50) is not present in table "dept".

The behavior of foreign keys can be finely tuned to your application. Making correct use of foreign keys will definitely improve the quality of your database applications, so you are strongly encouraged to learn more about them.
2.2.3 The ROWNUM Pseudo-Column

ROWNUM is a pseudo-column that is assigned an incremental, unique integer value for each row based on the order the rows were retrieved from a query. Therefore, the first row retrieved will have ROWNUM of 1; the second row will have ROWNUM of 2 and so on.

This feature can be used to limit the number of rows retrieved by a query. This is demonstrated in the following example:

```sql
SELECT empno, ename, job FROM emp WHERE ROWNUM < 5;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>job</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
</tr>
</tbody>
</table>

(4 rows)

The ROWNUM value is assigned to each row before any sorting of the result set takes place. Thus, the result set is returned in the order given by the ORDER BY clause, but the ROWNUM values may not necessarily be in ascending order as shown in the following example:

```sql
SELECT ROWNUM, empno, ename, job FROM emp WHERE ROWNUM < 5 ORDER BY ename;
```

<table>
<thead>
<tr>
<th>rownum</th>
<th>empno</th>
<th>ename</th>
<th>job</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>4</td>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
</tr>
<tr>
<td>1</td>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
</tr>
<tr>
<td>3</td>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
</tr>
</tbody>
</table>

(4 rows)

The following example shows how a sequence number can be added to every row in the jobhist table. First a new column named, seqno, is added to the table and then seqno is set to ROWNUM in the UPDATE command.

```sql
ALTER TABLE jobhist ADD seqno NUMBER(3);
UPDATE jobhist SET seqno = ROWNUM;
```

The following SELECT command shows the new seqno values.

```sql
SELECT seqno, empno, TO_CHAR(startdate,'DD-MON-YY') AS start, job FROM jobhist;
```

<table>
<thead>
<tr>
<th>seqno</th>
<th>empno</th>
<th>start</th>
<th>job</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7369</td>
<td>17-DEC-80</td>
<td>CLERK</td>
</tr>
<tr>
<td>2</td>
<td>7499</td>
<td>20-FEB-81</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>3</td>
<td>7521</td>
<td>22-FEB-81</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>4</td>
<td>7566</td>
<td>02-APR-81</td>
<td>MANAGER</td>
</tr>
<tr>
<td>ID</td>
<td>EMPLOYEE_ID</td>
<td>FROM_DATE</td>
<td>JOB_TITLE</td>
</tr>
<tr>
<td>----</td>
<td>-------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>5</td>
<td>7654</td>
<td>28-SEP-81</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>6</td>
<td>7698</td>
<td>01-MAY-81</td>
<td>MANAGER</td>
</tr>
<tr>
<td>7</td>
<td>7782</td>
<td>09-JUN-81</td>
<td>MANAGER</td>
</tr>
<tr>
<td>8</td>
<td>7788</td>
<td>19-APR-87</td>
<td>CLERK</td>
</tr>
<tr>
<td>9</td>
<td>7788</td>
<td>13-APR-88</td>
<td>CLERK</td>
</tr>
<tr>
<td>10</td>
<td>7788</td>
<td>05-MAY-90</td>
<td>ANALYST</td>
</tr>
<tr>
<td>11</td>
<td>7839</td>
<td>17-NOV-81</td>
<td>PRESIDENT</td>
</tr>
<tr>
<td>12</td>
<td>7844</td>
<td>08-SEP-81</td>
<td>SALESMAN</td>
</tr>
<tr>
<td>13</td>
<td>7876</td>
<td>23-MAY-87</td>
<td>CLERK</td>
</tr>
<tr>
<td>14</td>
<td>7900</td>
<td>03-DEC-81</td>
<td>CLERK</td>
</tr>
<tr>
<td>15</td>
<td>7900</td>
<td>15-JAN-83</td>
<td>CLERK</td>
</tr>
<tr>
<td>16</td>
<td>7902</td>
<td>03-DEC-81</td>
<td>ANALYST</td>
</tr>
<tr>
<td>17</td>
<td>7934</td>
<td>23-JAN-82</td>
<td>CLERK</td>
</tr>
</tbody>
</table>

(17 rows)
2.2.4 Synonyms

A synonym is an identifier that can be used to reference another database object in a SQL statement. A synonym is useful in cases where a database object would normally require full qualification by schema name to be properly referenced in a SQL statement. A synonym defined for that object simplifies the reference to a single, unqualified name.

Advanced Server supports synonyms for:

- tables
- views
- materialized views
- sequences
- procedures
- functions
- types
- objects that are accessible through a database link
- other synonyms

Neither the referenced schema or referenced object must exist at the time that you create the synonym; a synonym may refer to a non-existent object or schema. A synonym will become invalid if you drop the referenced object or schema. You must explicitly drop a synonym to remove it.

As with any other schema object, Advanced Server uses the search path to resolve unqualified synonym names. If you have two synonyms with the same name, an unqualified reference to a synonym will resolve to the first synonym with the given name in the search path. If public is in your search path, you can refer to a synonym in that schema without qualifying that name.

When Advanced Server executes an SQL command, the privileges of the current user are checked against the synonym’s underlying database object; if the user does not have the proper permissions for that object, the SQL command will fail.

Deleting a Synonym

To delete a synonym, use the command, DROP SYNONYM. The syntax is:

```
DROP [PUBLIC] SYNONYM [schema.] syn_name
```

Parameters:

`syn_name`
syn_name is the name of the synonym. A synonym name must be unique within a schema.

schema specifies the name of the schema in which the synonym resides.

Like any other object that can be schema-qualified, you may have two synonyms with the same name in your search path. To disambiguate the name of the synonym that you are dropping, include a schema name. Unless a synonym is schema qualified in the DROP SYNONYM command, Advanced Server deletes the first instance of the synonym it finds in your search path.

You can optionally include the PUBLIC clause to drop a synonym that resides in the public schema. Compatible with Oracle databases, the DROP PUBLIC SYNONYM command drops a synonym that resides in the public schema:

```
DROP PUBLIC SYNONYM syn_name;
```

The following example drops the synonym, personnel:

```
DROP SYNONYM personnel;
```
2.2.5 Hierarchical Queries

A hierarchical query is a type of query that returns the rows of the result set in a hierarchical order based upon data forming a parent-child relationship. A hierarchy is typically represented by an inverted tree structure. The tree is comprised of interconnected nodes. Each node may be connected to none, one, or multiple child nodes. Each node is connected to one parent node except for the top node which has no parent. This node is the root node. Each tree has exactly one root node. Nodes that don’t have any children are called leaf nodes. A tree always has at least one leaf node - e.g., the trivial case where the tree is comprised of a single node. In this case it is both the root and the leaf.

In a hierarchical query the rows of the result set represent the nodes of one or more trees.

Note: It is possible that a single, given row may appear in more than one tree and thus appear more than once in the result set.

The hierarchical relationship in a query is described by the `CONNECT BY` clause which forms the basis of the order in which rows are returned in the result set. The context of where the `CONNECT BY` clause and its associated optional clauses appear in the `SELECT` command is shown below.

```
SELECT select_list FROM table_expression [ WHERE ... ]
[ START WITH start_expression ]
CONNECT BY { PRIOR parent_expr = child_expr | child_expr = PRIOR parent_expr }
[ ORDER SIBLINGS BY column1 [ ASC | DESC ] [, column2 [ ASC | DESC ] ] ] ...
[ GROUP BY ...]
[ HAVING ...]
[ other ...]
```

`select_list` is one or more expressions that comprise the fields of the result set. `table_expression` is one or more tables or views from which the rows of the result set originate. `other` is any additional legal `SELECT` command clauses. The clauses pertinent to hierarchical queries, `START WITH`, `CONNECT BY`, and `ORDER SIBLINGS BY` are described in the following sections.

Note: At this time, Advanced Server does not support the use of AND (or other operators) in the `CONNECT BY` clause.
### 2.2.5.1 Defining the Parent/Child Relationship

For any given row, its parent and its children are determined by the `CONNECT BY` clause. The `CONNECT BY` clause must consist of two expressions compared with the equals (`=`) operator. In addition, one of these two expressions must be preceded by the keyword, `PRIOR`.

For any given row, to determine its children:

1. Evaluate `parent_expr` on the given row
2. Evaluate `child_expr` on any other row resulting from the evaluation of `table_expression`
3. If `parent_expr = child_expr`, then this row is a child node of the given parent row
4. Repeat the process for all remaining rows in `table_expression`. All rows that satisfy the equation in step 3 are the children nodes of the given parent row.

**Note:** The evaluation process to determine if a row is a child node occurs on every row returned by `table_expression` before the `WHERE` clause is applied to `table_expression`.

By iteratively repeating this process treating each child node found in the prior steps as a parent, an inverted tree of nodes is constructed. The process is complete when the final set of child nodes has no children of their own - these are the leaf nodes.

A `SELECT` command that includes a `CONNECT BY` clause typically includes the `START WITH` clause. The `START WITH` clause determines the rows that are to be the root nodes - i.e., the rows that are the initial parent nodes upon which the algorithm described previously is to be applied. This is further explained in the following section.

### 2.2.5.2 Selecting the Root Nodes

The `START WITH` clause is used to determine the row(s) selected by `table_expression` that are to be used as the root nodes. All rows selected by `table_expression` where `start_expression` evaluates to true become a root node of a tree. Thus, the number of potential trees in the result set is equal to the number of root nodes. As a consequence, if the `START WITH` clause is omitted, then every row returned by `table_expression` is a root of its own tree.

### 2.2.5.3 Organization Tree in the Sample Application

Consider the `emp` table of the sample application. The rows of the `emp` table form a hierarchy based upon the `mgr` column which contains the employee number of the employee’s manager. Each employee has at most, one manager. `KING` is the president of the company so he has no manager, therefore `KING`'s `mgr` column is null. Also, it is
possible for an employee to act as a manager for more than one employee. This relationship forms a typical, tree-structured, hierarchical organization chart as illustrated below.

To form a hierarchical query based upon this relationship, the `SELECT` command includes the clause, `CONNECT BY PRIOR empno = mgr`. For example, given the company president, KING, with employee number 7839, any employee whose `mgr` column is 7839 reports directly to KING which is true for JONES, BLAKE, and CLARK (these are the child nodes of KING). Similarly, for employee, JONES, any other employee with `mgr` column equal to 7566 is a child node of JONES - these are SCOTT and FORD in this example.

The top of the organization chart is KING so there is one root node in this tree. The `START WITH mgr IS NULL` clause selects only KING as the initial root node.

The complete `SELECT` command is shown below.

```sql
SELECT ename, empno, mgr
FROM emp
START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr;
```

The rows in the query output traverse each branch from the root to leaf moving in a top-to-bottom, left-to-right order. Below is the output from this query.

```
ename | empno | mgr
--------+-------+-------
KING   | 7839  |       
JONES  | 7566  | 7839  
SCOTT  | 7788  | 7566  
```

Figure 2 Employee Organization Hierarchy
2.2.5.4 Node Level

LEVEL is a pseudo-column that can be used wherever a column can appear in the SELECT command. For each row in the result set, LEVEL returns a non-zero integer value designating the depth in the hierarchy of the node represented by this row. The LEVEL for root nodes is 1. The LEVEL for direct children of root nodes is 2, and so on.

The following query is a modification of the previous query with the addition of the LEVEL pseudo-column. In addition, using the LEVEL value, the employee names are indented to further emphasize the depth in the hierarchy of each row.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr
FROM emp START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr;
```

The output from this query follows.

<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KING</td>
<td>7839</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
</tr>
<tr>
<td>3</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
</tr>
<tr>
<td>4</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
</tr>
<tr>
<td>3</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
</tr>
<tr>
<td>4</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
</tr>
<tr>
<td>2</td>
<td>BLAKE</td>
<td>7698</td>
<td>7566</td>
</tr>
<tr>
<td>3</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
</tr>
<tr>
<td>2</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
</tr>
<tr>
<td>3</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
</tr>
</tbody>
</table>

(14 rows)

Nodes that share a common parent and are at the same level are called siblings. For example in the above output, employees ALLEN, WARD, MARTIN, TURNER, and JAMES are siblings since they are all at level three with parent, BLAKE. JONES, BLAKE, and CLARK are siblings since they are at level two and KING is their common parent.
2.2.5.5 Ordering the Siblings

The result set can be ordered so the siblings appear in ascending or descending order by selected column value(s) using the ORDER SIBLINGS BY clause. This is a special case of the ORDER BY clause that can be used only with hierarchical queries.

The previous query is further modified with the addition of ORDER SIBLINGS BY ename ASC.

```sql
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr
FROM emp START WITH mgr IS NULL
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The output from the prior query is now modified so the siblings appear in ascending order by name. Siblings BLAKE, CLARK, and JONES are now alphabetically arranged under KING. Siblings ALLEN, JAMES, MARTIN, TURNER, and WARD are alphabetically arranged under BLAKE, and so on.

```plaintext
+-------+------------+-------+-------|
<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KING</td>
<td>7839</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
</tr>
<tr>
<td>3</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
</tr>
<tr>
<td>3</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
</tr>
<tr>
<td>2</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
</tr>
<tr>
<td>3</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
</tr>
<tr>
<td>2</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
</tr>
<tr>
<td>3</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
</tr>
<tr>
<td>4</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
</tr>
<tr>
<td>3</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
</tr>
<tr>
<td>4</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
</tr>
</tbody>
</table>
```

This final example adds the WHERE clause and starts with three root nodes. After the node tree is constructed, the WHERE clause filters out rows in the tree to form the result set.

```sql
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr
FROM emp WHERE mgr IN (7839, 7782, 7902, 7788)
START WITH ename IN ('BLAKE','CLARK','JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The output from the query shows three root nodes (level one) - BLAKE, CLARK, and JONES. In addition, rows that do not satisfy the WHERE clause have been eliminated from the output.

```plaintext
+-------+------------+-------+-------|
<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
</tr>
</tbody>
</table>
```

2.2.5.6 Retrieving the Root Node with CONNECT_BY_ROOT

CONNECT_BY_ROOT is a unary operator that can be used to qualify a column in order to return the column’s value of the row considered to be the root node in relation to the current row.

Note: A unary operator operates on a single operand, which in the case of CONNECT_BY_ROOT, is the column name following the CONNECT_BY_ROOT keyword.

In the context of the SELECT list, the CONNECT_BY_ROOT operator is shown by the following.

```
SELECT [... ,] CONNECT_BY_ROOT column [, ...]
FROM table_expression ...
```

The following are some points to note about the CONNECT_BY_ROOT operator.

- The CONNECT_BY_ROOT operator can be used in the SELECT list, the WHERE clause, the GROUP BY clause, the HAVING clause, the ORDER BY clause, and the ORDER SIBLINGS BY clause as long as the SELECT command is for a hierarchical query.
- The CONNECT_BY_ROOT operator cannot be used in the CONNECT BY clause or the START WITH clause of the hierarchical query.
- It is possible to apply CONNECT_BY_ROOT to an expression involving a column, but to do so, the expression must be enclosed within parentheses.

The following query shows the use of the CONNECT_BY_ROOT operator to return the employee number and employee name of the root node for each employee listed in the result set based on trees starting with employees BLAKE, CLARK, and JONES.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
       CONNECT_BY_ROOT empno "mgr empno",
       CONNECT_BY_ROOT ename "mgr ename"
FROM emp
START WITH ename IN ('BLAKE','CLARK','JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```
Note that the output from the query shows that all of the root nodes in columns `mgr empno` and `mgr ename` are one of the employees, BLAKE, CLARK, or JONES, listed in the `START WITH` clause.

```
<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
<th>mgr empno</th>
<th>mgr ename</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>1</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
<td>7782</td>
<td>CLARK</td>
</tr>
<tr>
<td>2</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
<td>7782</td>
<td>CLARK</td>
</tr>
<tr>
<td>1</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>2</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>3</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>2</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>3</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>7566</td>
<td>JONES</td>
</tr>
</tbody>
</table>
```

The following is a similar query, but producing only one tree starting with the single, top-level, employee where the `mgr` column is null.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
       CONNECT_BY_ROOT empno "mgr empno",
       CONNECT_BY_ROOT ename "mgr ename"
FROM emp START WITH mgr IS NULL
       CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

In the following output, all of the root nodes in columns `mgr empno` and `mgr ename` indicate KING as the root for this particular query.

```
<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
<th>mgr empno</th>
<th>mgr ename</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KING</td>
<td>7839</td>
<td></td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>2</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
<td>7698</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>7698</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>7698</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>7698</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>7698</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>7698</td>
<td>KING</td>
</tr>
<tr>
<td>2</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
<td>7782</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
<td>7782</td>
<td>KING</td>
</tr>
<tr>
<td>2</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
<td>7566</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>7566</td>
<td>KING</td>
</tr>
<tr>
<td>4</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>7566</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
<td>7566</td>
<td>KING</td>
</tr>
<tr>
<td>4</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>7839</td>
<td>KING</td>
</tr>
</tbody>
</table>
```

By contrast, the following example omits the `START WITH` clause thereby resulting in fourteen trees.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
       CONNECT_BY_ROOT empno "mgr empno",
       CONNECT_BY_ROOT ename "mgr ename"
FROM emp
ORDER SIBLINGS BY ename ASC;
```
CONNECT_BY_ROOT ename "mgr ename"
FROM emp
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;

The following is the output from the query. Each node appears at least once as a root node under the `mgr empno` and `mgr ename` columns since even the leaf nodes form the top of their own trees.

<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
<th>mgr empno</th>
<th>mgr ename</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>7876</td>
<td>ADAMS</td>
</tr>
<tr>
<td>1</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>7499</td>
<td>ALLEN</td>
</tr>
<tr>
<td>1</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>1</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
<td>7782</td>
<td>CLARK</td>
</tr>
<tr>
<td>2</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
<td>7782</td>
<td>CLARK</td>
</tr>
<tr>
<td>1</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>7902</td>
<td>FORD</td>
</tr>
<tr>
<td>2</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>7902</td>
<td>FORD</td>
</tr>
<tr>
<td>1</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>7900</td>
<td>JAMES</td>
</tr>
<tr>
<td>2</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>2</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>7902</td>
<td>JONES</td>
</tr>
<tr>
<td>3</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>2</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>3</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>1</td>
<td>KING</td>
<td>7839</td>
<td></td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>2</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>2</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>2</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>4</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>3</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>4</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>7566</td>
<td>KING</td>
</tr>
<tr>
<td>1</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>7654</td>
<td>MARTIN</td>
</tr>
<tr>
<td>1</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
<td>7934</td>
<td>MILLER</td>
</tr>
<tr>
<td>1</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
<td>7788</td>
<td>SCOTT</td>
</tr>
<tr>
<td>2</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>7788</td>
<td>SCOTT</td>
</tr>
<tr>
<td>1</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>7369</td>
<td>SMITH</td>
</tr>
<tr>
<td>1</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>7844</td>
<td>TURNER</td>
</tr>
<tr>
<td>1</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>7521</td>
<td>WARD</td>
</tr>
</tbody>
</table>

(39 rows)

The following illustrates the unary operator effect of `CONNECT_BY_ROOT`. As shown in this example, when applied to an expression that is not enclosed in parentheses, the `CONNECT_BY_ROOT` operator affects only the term, `ename`, immediately following it. The subsequent concatenation of `' manages ' || `ename` is not part of the `CONNECT_BY_ROOT` operation, hence the second occurrence of `ename` results in the
value of the currently processed row while the first occurrence of `ename` results in the value from the root node.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT ename || ' manages ' || ename "top mgr/employee"
FROM emp
START WITH ename IN ('BLAKE', 'CLARK', 'JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The following is the output from the query. Note the values produced under the `top mgr/employee` column.

<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
<th>top mgr/employee</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
<td>BLAKE manages BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>BLAKE manages ALLEN</td>
</tr>
<tr>
<td>2</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>BLAKE manages JAMES</td>
</tr>
<tr>
<td>2</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>BLAKE manages MARTIN</td>
</tr>
<tr>
<td>2</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>BLAKE manages TURNER</td>
</tr>
<tr>
<td>2</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>BLAKE manages WARD</td>
</tr>
<tr>
<td>1</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
<td>CLARK manages CLARK</td>
</tr>
<tr>
<td>2</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
<td>CLARK manages MILLER</td>
</tr>
<tr>
<td>1</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
<td>JONES manages JONES</td>
</tr>
<tr>
<td>2</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>JONES manages FORD</td>
</tr>
<tr>
<td>3</td>
<td>SMITH</td>
<td>7369</td>
<td>7902</td>
<td>JONES manages SMITH</td>
</tr>
<tr>
<td>2</td>
<td>SCOTT</td>
<td>7788</td>
<td>7566</td>
<td>JONES manages SCOTT</td>
</tr>
<tr>
<td>3</td>
<td>ADAMS</td>
<td>7876</td>
<td>7788</td>
<td>JONES manages ADAMS</td>
</tr>
</tbody>
</table>

(13 rows)

The following example uses the `CONNECT_BY_ROOT` operator on an expression enclosed in parentheses.

```
SELECT LEVEL, LPAD (' ', 2 * (LEVEL - 1)) || ename "employee", empno, mgr,
CONNECT_BY_ROOT ('Manager ' || ename || ' is emp # ' || empno)
"top mgr/empno"
FROM emp
START WITH ename IN ('BLAKE', 'CLARK', 'JONES')
CONNECT BY PRIOR empno = mgr
ORDER SIBLINGS BY ename ASC;
```

The following is the output of the query. Note that the values of both `ename` and `empno` are affected by the `CONNECT_BY_ROOT` operator and as a result, return the values from the root node as shown under the `top mgr/empno` column.

<table>
<thead>
<tr>
<th>level</th>
<th>employee</th>
<th>empno</th>
<th>mgr</th>
<th>top mgr/empno</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BLAKE</td>
<td>7698</td>
<td>7839</td>
<td>Manager BLAKE is emp # 7698</td>
</tr>
<tr>
<td>2</td>
<td>ALLEN</td>
<td>7499</td>
<td>7698</td>
<td>Manager BLAKE is emp # 7698</td>
</tr>
<tr>
<td>2</td>
<td>JAMES</td>
<td>7900</td>
<td>7698</td>
<td>Manager BLAKE is emp # 7698</td>
</tr>
<tr>
<td>2</td>
<td>MARTIN</td>
<td>7654</td>
<td>7698</td>
<td>Manager BLAKE is emp # 7698</td>
</tr>
<tr>
<td>2</td>
<td>TURNER</td>
<td>7844</td>
<td>7698</td>
<td>Manager BLAKE is emp # 7698</td>
</tr>
<tr>
<td>2</td>
<td>WARD</td>
<td>7521</td>
<td>7698</td>
<td>Manager BLAKE is emp # 7698</td>
</tr>
<tr>
<td>1</td>
<td>CLARK</td>
<td>7782</td>
<td>7839</td>
<td>Manager CLARK is emp # 7782</td>
</tr>
<tr>
<td>2</td>
<td>MILLER</td>
<td>7934</td>
<td>7782</td>
<td>Manager CLARK is emp # 7782</td>
</tr>
<tr>
<td>1</td>
<td>JONES</td>
<td>7566</td>
<td>7839</td>
<td>Manager JONES is emp # 7566</td>
</tr>
<tr>
<td>2</td>
<td>FORD</td>
<td>7902</td>
<td>7566</td>
<td>Manager JONES is emp # 7566</td>
</tr>
</tbody>
</table>

(13 rows)
2.2.5.7 Retrieving a Path with SYS_CONNECT_BY_PATH

SYS_CONNECT_BY_PATH is a function that works within a hierarchical query to retrieve the column values of a specified column that occur between the current node and the root node. The signature of the function is:

\[
\text{SYS_CONNECT_BY_PATH (column, delimiter)}
\]

The function takes two arguments:

- \textit{column} is the name of a column that resides within a table specified in the hierarchical query that is calling the function.
- \textit{delimiter} is the \texttt{varchar} value that separates each entry in the specified column.

The following example returns a list of employee names, and their managers; if the manager has a manager, that name is appended to the result:

```sql
edb=# SELECT level, ename, SYS_CONNECT_BY_PATH(ename, '/') as managers
FROM emp
CONNECT BY PRIOR empno = mgr
START WITH mgr IS NULL
ORDER BY level, ename, managers;
```

<table>
<thead>
<tr>
<th>level</th>
<th>ename</th>
<th>managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>KING</td>
<td>/KING</td>
</tr>
<tr>
<td>2</td>
<td>BLAKE</td>
<td>/KING/BLAKE</td>
</tr>
<tr>
<td>2</td>
<td>CLARK</td>
<td>/KING/CLARK</td>
</tr>
<tr>
<td>2</td>
<td>JONES</td>
<td>/KING/JONES</td>
</tr>
<tr>
<td>3</td>
<td>ALLEN</td>
<td>/KING/BLAKE/ALLEN</td>
</tr>
<tr>
<td>3</td>
<td>FORD</td>
<td>/KING/JONES/FORD</td>
</tr>
<tr>
<td>3</td>
<td>JAMES</td>
<td>/KING/BLAKE/JAMES</td>
</tr>
<tr>
<td>3</td>
<td>MARTIN</td>
<td>/KING/BLAKE/MARTIN</td>
</tr>
<tr>
<td>3</td>
<td>MILLER</td>
<td>/KING/CLARK/MILLER</td>
</tr>
<tr>
<td>3</td>
<td>SCOTT</td>
<td>/KING/JONES/SCOTT</td>
</tr>
<tr>
<td>3</td>
<td>TURNER</td>
<td>/KING/BLAKE/TURNER</td>
</tr>
<tr>
<td>3</td>
<td>WARD</td>
<td>/KING/BLAKE/WARD</td>
</tr>
<tr>
<td>4</td>
<td>ADAMS</td>
<td>/KING/JONES/SCOTT/ADAMS</td>
</tr>
<tr>
<td>4</td>
<td>SMITH</td>
<td>/KING/JONES/FORD/SMITH</td>
</tr>
</tbody>
</table>
```

(14 rows)
Within the result set:

- The **level** column displays the number of levels that the query returned.
- The **ename** column displays the employee name.
- The **managers** column contains the hierarchical list of managers.

The Advanced Server implementation of `SYS_CONNECT_BY_PATH` does not support use of:

- `SYS_CONNECT_BY_PATH` inside `CONNECT_BY_PATH`
- `SYS_CONNECT_BY_PATH` inside `SYS_CONNECT_BY_PATH`
2.2.6 Multidimensional Analysis

Multidimensional analysis refers to the process commonly used in data warehousing applications of examining data using various combinations of dimensions. *Dimensions* are categories used to classify data such as time, geography, a company’s departments, product lines, and so forth. The results associated with a particular set of dimensions are called *facts*. Facts are typically figures associated with product sales, profits, volumes, counts, etc.

In order to obtain these facts according to a set of dimensions in a relational database system, SQL aggregation is typically used. *SQL aggregation* basically means data is grouped according to certain criteria (dimensions) and the result set consists of aggregates of facts such as counts, sums, and averages of the data in each group.

The `GROUP BY` clause of the SQL `SELECT` command supports the following extensions that simplify the process of producing aggregate results.

- **ROLLUP extension**
- **CUBE extension**
- **GROUPING SETS extension**

In addition, the `GROUPING` function and the `GROUPING_ID` function can be used in the `SELECT` list or the `HAVING` clause to aid with the interpretation of the results when these extensions are used.

**Note:** The sample `dept` and `emp` tables are used extensively in this discussion to provide usage examples. The following changes were applied to these tables to provide more informative results.

```
UPDATE dept SET loc = 'BOSTON' WHERE deptno = 20;
INSERT INTO emp (empno,ename,job,deptno) VALUES (9001,'SMITH','CLERK',40);
INSERT INTO emp (empno,ename,job,deptno) VALUES (9002,'JONES','ANALYST',40);
INSERT INTO emp (empno,ename,job,deptno) VALUES (9003,'ROGERS','MANAGER',40);
```

The following rows from a join of the `emp` and `dept` tables are used:

```
SELECT loc, dname, job, empno FROM emp e, dept d
WHERE e.deptno = d.deptno
ORDER BY 1, 2, 3, 4;
```

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>empno</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>9002</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>9001</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>9003</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>7788</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>7369</td>
</tr>
</tbody>
</table>
The `loc`, `dname`, and `job` columns are used for the dimensions of the SQL aggregations used in the examples. The resulting facts of the aggregations are the number of employees obtained by using the `COUNT(*)` function.

A basic query grouping the `loc`, `dname`, and `job` columns is given by the following.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc, dname, job
ORDER BY 1, 2, 3;
```

The rows of this result set using the basic `GROUP BY` clause without extensions are referred to as the *base aggregate* rows.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
</tbody>
</table>

(12 rows)

The `ROLLUP` and `CUBE` extensions add to the base aggregate rows by providing additional levels of subtotals to the result set.

The `GROUPING SETS` extension provides the ability to combine different types of groupings into a single result set.

The `GROUPING` and `GROUPING_ID` functions aid in the interpretation of the result set.

The additions provided by these extensions are discussed in more detail in the subsequent sections.
2.2.6.1 ROLLUP Extension

The ROLLUP extension produces a hierarchical set of groups with subtotals for each hierarchical group as well as a grand total. The order of the hierarchy is determined by the order of the expressions given in the ROLLUP expression list. The top of the hierarchy is the leftmost item in the list. Each successive item proceeding to the right moves down the hierarchy with the rightmost item being the lowest level.

The syntax for a single ROLLUP is as follows:

```
ROLLUP ( { expr_1 | ( expr_1a [, expr_1b ] ...) } [, expr_2 | ( expr_2a [, expr_2b ] ...) ] ...) 
```

Each `expr` is an expression that determines the grouping of the result set. If enclosed within parenthesis as `(expr_1a, expr_1b, ...)` then the combination of values returned by `expr_1a` and `expr_1b` defines a single grouping level of the hierarchy.

The base level of aggregates returned in the result set is for each unique combination of values returned by the expression list.

In addition, a subtotal is returned for the first item in the list (`expr_1` or the combination of `(expr_1a, expr_1b, ...)`, whichever is specified) for each unique value. A subtotal is returned for the second item in the list (`expr_2` or the combination of `(expr_2a, expr_2b, ...)`, whichever is specified) for each unique value, within each grouping of the first item and so on. Finally a grand total is returned for the entire result set.

For the subtotal rows, null is returned for the items across which the subtotal is taken.

The ROLLUP extension specified within the context of the GROUP BY clause is shown by the following:

```
SELECT select_list FROM ... 
GROUP BY [...] ROLLUP ( expression_list ) [, ...] 
```

The items specified in `select_list` must also appear in the ROLLUP `expression_list`; or they must be aggregate functions such as `COUNT`, `SUM`, `AVG`, `MIN`, or `MAX`; or they must be constants or functions whose return values are independent of the individual rows in the group (for example, the `SYSDATE` function).

The GROUP BY clause may specify multiple ROLLUP extensions as well as multiple occurrences of other GROUP BY extensions and individual expressions.
The `ORDER BY` clause should be used if you want the output to display in a hierarchical or other meaningful structure. There is no guarantee on the order of the result set if no `ORDER BY` clause is specified.

The number of grouping levels or totals is \( n + 1 \) where \( n \) represents the number of items in the `ROLLUP` expression list. A parenthesized list counts as one item.

The following query produces a rollup based on a hierarchy of columns `loc, dname, then job`.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (loc, dname, job)
ORDER BY 1, 2, 3;
```

The following is the result of the query. There is a count of the number of employees for each unique combination of `loc, dname, and job`, as well as subtotals for each unique combination of `loc` and `dname`, for each unique value of `loc`, and a grand total displayed on the last line.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

(20 rows)

The following query shows the effect of combining items in the `ROLLUP` list within parenthesis.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (loc, (dname, job))
ORDER BY 1, 2, 3;
```

In the output, note that there are no subtotals for `loc` and `dname` combinations as in the prior example.
If the first two columns in the ROLLUP list are enclosed in parenthesis, the subtotal levels differ as well.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP ((loc, dname), job)
ORDER BY 1, 2, 3;
```

Now there is a subtotal for each unique loc and dname combination, but none for unique values of loc.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP ((loc, dname), job)
ORDER BY 1, 2, 3;
```
2.2.6.2 CUBE Extension

The CUBE extension is similar to the ROLLUP extension. However, unlike ROLLUP, which produces groupings and results in a hierarchy based on a left to right listing of items in the ROLLUP expression list, a CUBE produces groupings and subtotals based on every permutation of all items in the CUBE expression list. Thus, the result set contains more rows than a ROLLUP performed on the same expression list.

The syntax for a single CUBE is as follows:

```
CUBE ( { expr_1 | ( expr_1a [, expr_1b ] ...) } [, expr_2 | ( expr_2a [, expr_2b ] ...) ] ...)
```

Each expr is an expression that determines the grouping of the result set. If enclosed within parenthesis as ( expr_1a, expr_1b, ...) then the combination of values returned by expr_1a and expr_1b defines a single group.

The base level of aggregates returned in the result set is for each unique combination of values returned by the expression list.

In addition, a subtotal is returned for the first item in the list (expr_1 or the combination of ( expr_1a, expr_1b, ...), whichever is specified) for each unique value. A subtotal is returned for the second item in the list (expr_2 or the combination of ( expr_2a, expr_2b, ...), whichever is specified) for each unique value. A subtotal is also returned for each unique combination of the first item and the second item. Similarly, if there is a third item, a subtotal is returned for each unique value of the third item, each unique value of the third item and first item combination, each unique value of the third item and second item combination, and each unique value of the third item, second item, and first item combination. Finally a grand total is returned for the entire result set.

For the subtotal rows, null is returned for the items across which the subtotal is taken.

The CUBE extension specified within the context of the GROUP BY clause is shown by the following:

```
SELECT select_list FROM ...
GROUP BY [...] CUBE ( expression_list ) [, ...]
```

The items specified in select_list must also appear in the CUBE expression_list; or they must be aggregate functions such as COUNT, SUM, AVG, MIN, or MAX; or they must be constants or functions whose return values are independent of the individual rows in the group (for example, the SYSDATE function).
The `GROUP BY` clause may specify multiple `CUBE` extensions as well as multiple occurrences of other `GROUP BY` extensions and individual expressions.

The `ORDER BY` clause should be used if you want the output to display in a meaningful structure. There is no guarantee on the order of the result set if no `ORDER BY` clause is specified.

The number of grouping levels or totals is $2^n$ where $n$ represents the number of items in the `CUBE` expression list. A parenthesized list counts as one item.

The following query produces a cube based on permutations of columns `loc`, `dname`, and `job`.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, dname, job)
ORDER BY 1, 2, 3;
```

The following is the result of the query. There is a count of the number of employees for each combination of `loc`, `dname`, and `job`, as well as subtotals for each combination of `loc` and `dname`, for each combination of `loc` and `job`, for each combination of `dname` and `job`, for each unique value of `loc`, for each unique value of `dname`, for each unique value of `job`, and a grand total displayed on the last line.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>BOSTON</td>
<td>ANALYST</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>CLERK</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>MANAGER</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>CLERK</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>MANAGER</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALESMAN</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>CLERK</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>MANAGER</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>PRESIDENT</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
</tbody>
</table>
The following query shows the effect of combining items in the CUBE list within parenthesis.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, (dname, job))
ORDER BY 1, 2, 3;
```

In the output note that there are no subtotals for permutations involving loc and dname combinations, loc and job combinations, or for dname by itself, or for job by itself.
The following query shows another variation whereby the first expression is specified outside of the `CUBE` extension.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp, dept d
WHERE e.deptno = d.deptno
GROUP BY loc, CUBE (dname, job)
ORDER BY 1, 2, 3;
```

In this output, the permutations are performed for `dname` and `job` within each grouping of `loc`.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>BOSTON</td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>ANALYST</td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>CLERK</td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>MANAGER</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

(28 rows)
2.2.6.3 GROUPING SETS Extension

The use of the GROUPING SETS extension within the GROUP BY clause provides a means to produce one result set that is actually the concatenation of multiple result sets based upon different groupings. In other words, a UNION ALL operation is performed combining the result sets of multiple groupings into one result set.

Note that a UNION ALL operation, and therefore the GROUPING SETS extension, do not eliminate duplicate rows from the result sets that are being combined together.

The syntax for a single GROUPING SETS extension is as follows:

```
GROUPING SETS ( 
  { expr_1 | ( expr_1a [, expr_1b ] ...) | 
    ROLLUP ( expr_list ) | CUBE ( expr_list ) 
  } [, ... ] )
```

A GROUPING SETS extension can contain any combination of one or more comma-separated expressions, lists of expressions enclosed within parenthesis, ROLLUP extensions, and CUBE extensions.

The GROUPING SETS extension is specified within the context of the GROUP BY clause as shown by the following:

```
SELECT select_list FROM ...
GROUP BY [...] GROUPING SETS ( expression_list ) [, ...]
```

The items specified in select_list must also appear in the GROUPING SETS expression_list; or they must be aggregate functions such as COUNT, SUM, AVG, MIN, or MAX; or they must be constants or functions whose return values are independent of the individual rows in the group (for example, the SYSDATE function).

The GROUP BY clause may specify multiple GROUPING SETS extensions as well as multiple occurrences of other GROUP BY extensions and individual expressions.

The ORDER BY clause should be used if you want the output to display in a meaningful structure. There is no guarantee on the order of the result set if no ORDER BY clause is specified.

The following query produces a union of groups given by columns loc, dname, and job.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY GROUPING SETS (loc, dname, job)
ORDER BY 1, 2, 3;
```
The result is as follows:

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ANALYST</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CLERK</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>MANAGER</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PRESIDENT</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SALESMAN</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

(12 rows)

This is equivalent to the following query, which employs the use of the \textit{UNION ALL} operator.

```
SELECT loc AS "loc", NULL AS "dname", NULL AS "job", COUNT(*) AS "employees"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc
UNION ALL
SELECT NULL, dname, NULL, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY dname
UNION ALL
SELECT NULL, NULL, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY job
ORDER BY 1, 2, 3;
```

The output from the \textit{UNION ALL} query is the same as the \textit{GROUPING SETS} output.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>ANALYST</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>CLERK</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>MANAGER</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>PRESIDENT</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SALESMAN</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

(12 rows)

The following example shows how various types of \textit{GROUP BY} extensions can be used together within a \textit{GROUPING SETS} expression list.

```
SELECT loc, dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
```

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GROUP BY GROUPING SETS (loc, ROLLUP (dname, job), CUBE (job, loc))
ORDER BY 1, 2, 3;

The following is the output from this query.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td></td>
<td>ANALYST</td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>CLERK</td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>MANAGER</td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ANALYST</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CLERK</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MANAGER</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

(38 rows)

The output is basically a concatenation of the result sets that would be produced individually from GROUP BY loc, GROUP BY ROLLUP (dname, job), and GROUP BY CUBE (job, loc). These individual queries are shown by the following.

```sql
SELECT loc, NULL AS "dname", NULL AS "job", COUNT(*) AS "employees"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc
ORDER BY 1;
```
The following is the result set from the \texttt{GROUP BY loc} clause.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>NEW YORK</td>
<td></td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

(3 rows)

The following query uses the \texttt{GROUP BY ROLLUP (dname, job)} clause.

\begin{verbatim}
SELECT NULL AS "loc", dname, job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (dname, job)
ORDER BY 2, 3;
\end{verbatim}

The following is the result set from the \texttt{GROUP BY ROLLUP (dname, job)} clause.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>PRESIDENT</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>ANALYST</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>CLERK</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>CLERK</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>MANAGER</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>SALESMAN</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17</td>
</tr>
</tbody>
</table>

(17 rows)

The following query uses the \texttt{GROUP BY CUBE (job, loc)} clause.

\begin{verbatim}
SELECT loc, NULL AS "dname", job, COUNT(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (job, loc)
ORDER BY 1, 3;
\end{verbatim}

The following is the result set from the \texttt{GROUP BY CUBE (job, loc)} clause.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>ANALYST</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>CLERK</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>BOSTON</td>
<td>MANAGER</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>CLERK</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>MANAGER</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>CHICAGO</td>
<td>SALESMAN</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>CHICAGO</td>
<td></td>
<td></td>
<td>6</td>
</tr>
</tbody>
</table>
If the previous three queries are combined with the \texttt{UNION ALL} operator, a concatenation of the three results sets is produced.

\begin{verbatim}
SELECT loc AS "loc", NULL AS "dname", NULL AS "job", COUNT(*) AS "employees"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY loc
UNION ALL
SELECT NULL, dname, job, count(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (dname, job)
UNION ALL
SELECT loc, NULL, job, count(*) AS "employees" FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (job, loc)
ORDER BY 1, 2, 3;
\end{verbatim}

The following is the output, which is the same as when the \texttt{GROUP BY GROUPING SETS (loc, ROLLUP (dname, job), CUBE (job, loc))} clause is used.

\begin{verbatim}
loc | dname | job | employees
---+-------+-----+-------------
BOSTON | null | ANALYST | 3
BOSTON | null | CLERK | 3
BOSTON | null | MANAGER | 2
BOSTON | null | null | 8
BOSTON | null | null | 8
CHICAGO | null | CLERK | 1
CHICAGO | null | MANAGER | 1
CHICAGO | null | SALESMAN | 4
CHICAGO | null | null | 6
CHICAGO | null | null | 6
NEW YORK | null | CLERK | 1
NEW YORK | null | MANAGER | 1
NEW YORK | null | PRESIDENT | 1
NEW YORK | null | null | 3
NEW YORK | null | null | 3
ACCOUNTING | null | CLERK | 1
ACCOUNTING | null | MANAGER | 1
ACCOUNTING | null | PRESIDENT | 1
ACCOUNTING | null | null | 3
OPERATIONS | null | ANALYST | 1
OPERATIONS | null | CLERK | 1
OPERATIONS | null | MANAGER | 1
OPERATIONS | null | null | 3
RESEARCH | null | ANALYST | 2
RESEARCH | null | CLERK | 2
RESEARCH | null | MANAGER | 1
\end{verbatim}
| RESEARCH |     | 5  |
| SALES    | CLERK | 1  |
| SALES    | MANAGER | 1 |
| SALES    | SALESMAN | 4 |
| SALES    |     | 6  |
|          | ANALYST | 3  |
|          | CLERK   | 5  |
|          | MANAGER | 4  |
|          | PRESIDENT | 1 |
|          | SALESMAN | 4  |
|          |     | 17 |
|          |     | 17 |

(38 rows)
2.2.6.4 GROUPING Function

When using the ROLLUP, CUBE, or GROUPING SETS extensions to the GROUP BY clause, it may sometimes be difficult to differentiate between the various levels of subtotals generated by the extensions as well as the base aggregate rows in the result set. The GROUPING function provides a means of making this distinction.

The general syntax for use of the GROUPING function is shown by the following.

```
SELECT [ expr ...], GROUPING(col_expr) [, expr] ...
FROM ...
GROUP BY [ ... ]
{ ROLLUP | CUBE | GROUPING SETS } ( [ ... ] col_expr
[ , ... ] ) [ , ... ]
```

The GROUPING function takes a single parameter that must be an expression of a dimension column specified in the expression list of a ROLLUP, CUBE, or GROUPING SETS extension of the GROUP BY clause.

The return value of the GROUPING function is either a 0 or 1. In the result set of a query, if the column expression specified in the GROUPING function is null because the row represents a subtotal over multiple values of that column then the GROUPING function returns a value of 1. If the row returns results based on a particular value of the column specified in the GROUPING function, then the GROUPING function returns a value of 0. In the latter case, the column can be null as well as non-null, but in any case, it is for a particular value of that column, not a subtotal across multiple values.

The following query shows how the return values of the GROUPING function correspond to the subtotal lines.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees",
    GROUPING(loc) AS "gf_loc",
    GROUPING(dname) AS "gf_dname",
    GROUPING(job) AS "gf_job"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (loc, dname, job)
ORDER BY 1, 2, 3;
```

In the three right-most columns displaying the output of the GROUPING functions, a value of 1 appears on a subtotal line wherever a subtotal is taken across values of the corresponding columns.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>job</th>
<th>employees</th>
<th>gf_loc</th>
<th>gf_dname</th>
<th>gf_job</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>ANALYST</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>CLERK</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BOSTON</td>
<td>OPERATIONS</td>
<td>MANAGER</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
These indicators can be used as screening criteria for particular subtotals. For example, using the previous query, you can display only those subtotals for `loc` and `dname` combinations by using the `GROUPING` function in a `HAVING` clause.

```sql
SELECT loc, dname, job, COUNT(*) AS "employees",
       GROUPING(loc) AS "gf_loc",
       GROUPING(dname) AS "gf_dname",
       GROUPING(job) AS "gf_job"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY ROLLUP (loc, dname, job)
HAVING GROUPING(loc) = 0
     AND GROUPING(dname) = 0
     AND GROUPING(job) = 1
ORDER BY 1, 2;
```

This query produces the following result:

```
loc    |   dname    | job | employees | gf_loc | gf_dname | gf_job
----------+------------+-----+-----------+--------+----------+--------
BOSTON   | OPERATIONS |     |         3 |      0 |        0 |      1
BOSTON   | RESEARCH   |     |         5 |      0 |        0 |      1
CHICAGO  | SALES      |     |         6 |      0 |        0 |      1
NEW YORK | ACCOUNTING |     |         3 |      0 |        0 |      1
|           |           |     |         3 |      0 |        0 |      1
|           |           |     |         3 |      0 |        0 |      1
(4 rows)
```

The `GROUPING` function can be used to distinguish a subtotal row from a base aggregate row or from certain subtotal rows where one of the items in the expression list returns null as a result of the column on which the expression is based being null for one or more rows in the table, as opposed to representing a subtotal over the column.

To illustrate this point, the following row is added to the `emp` table. This provides a row with a null value for the `job` column.

```sql
INSERT INTO emp (empno, ename, deptno) VALUES (9004, 'PETERS', 40);
```
The following query is issued using a reduced number of rows for clarity.

```sql
SELECT loc, job, COUNT(*) AS "employees",
    GROUPING(loc) AS "gf_loc",
    GROUPING(job) AS "gf_job"
FROM emp e, dept d
WHERE e.deptno = d.deptno AND loc = 'BOSTON'
GROUP BY CUBE (loc, job)
ORDER BY 1, 2;
```

Note that the output contains two rows containing BOSTON in the `loc` column and spaces in the `job` column (fourth and fifth entries in the table).

<table>
<thead>
<tr>
<th>loc</th>
<th>job</th>
<th>employees</th>
<th>gf_loc</th>
<th>gf_job</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSTON</td>
<td>ANALYST</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BOSTON</td>
<td>CLERK</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BOSTON</td>
<td>MANAGER</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>BOSTON</td>
<td></td>
<td>9</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>ANALYST</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>CLERK</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>MANAGER</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

(10 rows)

The fifth row where the `GROUPING` function on the `job` column (`gf_job`) returns 1 indicates this is a subtotal over all jobs. Note that the row contains a subtotal value of 9 in the `employees` column.

The fourth row where the `GROUPING` function on the `job` column as well as on the `loc` column returns 0 indicates this is a base aggregate of all rows where `loc` is BOSTON and `job` is null, which is the row inserted for this example. The `employees` column contains 1, which is the count of the single such row inserted.

Also note that in the ninth row (next to last) the `GROUPING` function on the `job` column returns 0 while the `GROUPING` function on the `loc` column returns 1 indicating this is a subtotal over all locations where the `job` column is null, which again, is a count of the single row inserted for this example.
2.2.6.5 GROUPING_ID Function

The **GROUPING_ID** function provides a simplification of the **GROUPING** function in order to determine the subtotal level of a row in the result set from a **ROLLBACK**, **CUBE**, or **GROUPING SETS** extension.

The **GROUPING** function takes only one column expression and returns an indication of whether or not a row is a subtotal over all values of the given column. Thus, multiple **GROUPING** functions may be required to interpret the level of subtotals for queries with multiple grouping columns.

The **GROUPING_ID** function accepts one or more column expressions that have been used in the **ROLLBACK**, **CUBE**, or **GROUPING SETS** extensions and returns a single integer that can be used to determine over which of these columns a subtotal has been aggregated.

The general syntax for use of the **GROUPING_ID** function is shown by the following.

```sql
SELECT [ expr ...,
    GROUPING_ID( col_expr_1 [, col_expr_2 ] ... )
    [, expr ] ... 
FROM ...
GROUP BY [...,
    { ROLLUP | CUBE | GROUPING SETS }( [...,
        col_expr_1
        [, col_expr_2 ] [, ...] ) [, ...]
```

The **GROUPING_ID** function takes one or more parameters that must be expressions of dimension columns specified in the expression list of a **ROLLUP**, **CUBE**, or **GROUPING SETS** extension of the **GROUP BY** clause.

The **GROUPING_ID** function returns an integer value. This value corresponds to the base-10 interpretation of a bit vector consisting of the concatenated 1’s and 0’s that would be returned by a series of **GROUPING** functions specified in the same left-to-right order as the ordering of the parameters specified in the **GROUPING_ID** function.

The following query shows how the returned values of the **GROUPING_ID** function represented in column **gid** correspond to the values returned by two **GROUPING** functions on columns **loc** and **dname**.

```sql
SELECT loc, dname, COUNT(*) AS "employees",
    GROUPING(loc) AS "gf_loc", GROUPING(dname) AS "gf_dname",
    GROUPING_ID(loc, dname) AS "gid"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, dname)
ORDER BY 6, 1, 2;
```
In the following output, note the relationship between a bit vector consisting of the \textit{gf\_loc} value and \textit{gf\_dname} value compared to the integer given in \textit{gid}.

\begin{tabular}{|l|l|l|l|l|l|}
  \hline
  \textbf{loc} & \textbf{dname} & \textbf{employees} & \textbf{gf\_loc} & \textbf{gf\_dname} & \textbf{gid} \\
  \hline
  BOSTON & OPERATIONS & 3 & 0 & 0 & 0 \\
  BOSTON & RESEARCH & 5 & 0 & 0 & 0 \\
  CHICAGO & SALES & 6 & 0 & 0 & 0 \\
  NEW YORK & ACCOUNTING & 3 & 0 & 0 & 0 \\
  BOSTON & & 8 & 0 & 1 & 1 \\
  CHICAGO & & 6 & 0 & 1 & 1 \\
  NEW YORK & & 3 & 0 & 1 & 1 \\
  & ACCOUNTING & 3 & 1 & 0 & 2 \\
  & OPERATIONS & 3 & 1 & 0 & 2 \\
  & RESEARCH & 5 & 1 & 0 & 2 \\
  & SALES & 6 & 1 & 0 & 2 \\
  & & 17 & 1 & 1 & 3 \\
  \hline
\end{tabular}

(12 rows)

The following table provides specific examples of the \texttt{GROUPING\_ID} function calculations based on the \texttt{GROUPING} function return values for four rows of the output.

\begin{tabular}{|l|l|l|l|l|}
  \hline
  \textbf{loc} & \textbf{dname} & \textbf{Bit Vector} & \textbf{GROUPING\_ID} \\
  \hline
  BOSTON & OPERATIONS & \(0 \times 2^1 + 0 \times 2^2\) & 0 \\
  BOSTON & \textit{null} & \(0 \times 2^1 + 1 \times 2^0\) & 1 \\
  \textit{null} & ACCOUNTING & \(1 \times 2^1 + 0 \times 2^2\) & 2 \\
  \textit{null} & \textit{null} & \(1 \times 2^1 + 1 \times 2^0\) & 3 \\
  \hline
\end{tabular}

The following table summarizes how the \texttt{GROUPING\_ID} function return values correspond to the grouping columns over which aggregation occurs.

\begin{tabular}{|l|l|l|l|}
  \hline
  \textbf{Aggregation by Column} & \textbf{Bit Vector} & \textbf{GROUPING\_ID} \\
  \hline
  loc, dname & 0 0 & 0 \\
  loc & 0 1 & 1 \\
  dname & 1 0 & 2 \\
  Grand Total & 1 1 & 3 \\
  \hline
\end{tabular}

So to display only those subtotals by \textit{dname}, the following simplified query can be used with a \texttt{HAVING} clause based on the \texttt{GROUPING\_ID} function.

```sql
SELECT loc, dname, COUNT(*) AS "employees", GROUPING(loc) AS "gf\_loc", GROUPING(dname) AS "gf\_dname", GROUPING\_ID(loc, dname) AS "gid"
FROM emp e, dept d
WHERE e.deptno = d.deptno
GROUP BY CUBE (loc, dname)
HAVING GROUPING\_ID(loc, dname) = 2
ORDER BY 6, 1, 2;
```
The following is the result of the query.

<table>
<thead>
<tr>
<th>loc</th>
<th>dname</th>
<th>employees</th>
<th>gf_loc</th>
<th>gf_dname</th>
<th>gid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACCOUNTING</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>OPERATIONS</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>RESEARCH</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SALES</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

(4 rows)
### 2.3 Profile Management

Advanced Server allows a database superuser to create named profiles. Each profile defines rules for password management that augment password and md5 authentication. The rules in a profile can:

- count failed login attempts
- lock an account due to excessive failed login attempts
- mark a password for expiration
- define a grace period after a password expiration
- define rules for password complexity
- define rules that limit password re-use

A profile is a named set of password attributes that allow you to easily manage a group of roles that share comparable authentication requirements. If the password requirements change, you can modify the profile to have the new requirements applied to each user that is associated with that profile.

After creating the profile, you can associate the profile with one or more users. When a user connects to the server, the server enforces the profile that is associated with their login role. Profiles are shared by all databases within a cluster, but each cluster may have multiple profiles. A single user with access to multiple databases will use the same profile when connecting to each database within the cluster.

Advanced Server creates a profile named default that is associated with a new role when the role is created unless an alternate profile is specified. If you upgrade to Advanced Server from a previous server version, existing roles will automatically be assigned to the default profile. You cannot delete the default profile.

The default profile specifies the following attributes:

- `FAILED_LOGIN_ATTEMPTS` UNLIMITED
- `PASSWORD_LOCK_TIME` UNLIMITED
- `PASSWORD_LIFE_TIME` UNLIMITED
- `PASSWORD_GRACE_TIME` UNLIMITED
- `PASSWORD_REUSE_TIME` UNLIMITED
- `PASSWORD_REUSE_MAX` UNLIMITED
- `PASSWORD_VERIFY_FUNCTION` NULL

A database superuser can use the `ALTER PROFILE` command to modify the values specified by the default profile. For more information about modifying a profile, see Section 2.3.2.
2.3.1 Creating a New Profile

Use the CREATE PROFILE command to create a new profile. The syntax is:

```
CREATE PROFILE profile_name
    [LIMIT {parameter value} ... ];
```

Include the LIMIT clause and one or more space-delimited parameter/value pairs to specify the rules enforced by Advanced Server.

Parameters:

- `profile_name` specifies the name of the profile.
- `parameter` specifies the attribute limited by the profile.
- `value` specifies the parameter limit.

Advanced Server supports the `value` shown below for each `parameter`:

- `FAILED_LOGIN_ATTEMPTS` specifies the number of failed login attempts that a user may make before the server locks the user out of their account for the length of time specified by `PASSWORD_LOCK_TIME`. Supported values are:
  - An INTEGER value greater than 0.
  - DEFAULT - the value of `FAILED_LOGIN_ATTEMPTS` specified in the DEFAULT profile.
  - UNLIMITED – the connecting user may make an unlimited number of failed login attempts.

- `PASSWORD_LOCK_TIME` specifies the length of time that must pass before the server unlocks an account that has been locked because of `FAILED_LOGIN_ATTEMPTS`. Supported values are:
  - A NUMERIC value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value 4.5 to specify 4 days, 12 hours.
  - DEFAULT - the value of `PASSWORD_LOCK_TIME` specified in the DEFAULT profile.
  - UNLIMITED – the account is locked until it is manually unlocked by a database superuser.
**PASSWORD_LIFE_TIME** specifies the number of days that the current password may be used before the user is prompted to provide a new password. Include the **PASSWORD_GRACE_TIME** clause when using the **PASSWORD_LIFE_TIME** clause to specify the number of days that will pass after the password expires before connections by the role are rejected. If **PASSWORD_GRACE_TIME** is not specified, the password will expire on the day specified by the default value of **PASSWORD_GRACE_TIME**, and the user will not be allowed to execute any command until a new password is provided. Supported values are:

- A NUMERIC value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value 4.5 to specify 4 days, 12 hours.
- DEFAULT - the value of **PASSWORD_LIFE_TIME** specified in the DEFAULT profile.
- UNLIMITED - The password does not have an expiration date.

**PASSWORD_GRACE_TIME** specifies the length of the grace period after a password expires until the user is forced to change their password. When the grace period expires, a user will be allowed to connect, but will not be allowed to execute any command until they update their expired password. Supported values are:

- A NUMERIC value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value 4.5 to specify 4 days, 12 hours.
- DEFAULT - the value of **PASSWORD_GRACE_TIME** specified in the DEFAULT profile.
- UNLIMITED - The grace period is infinite.

**PASSWORD_REUSE_TIME** specifies the number of days a user must wait before reusing a password. The **PASSWORD_REUSE_TIME** and **PASSWORD_REUSE_MAX** parameters are intended to be used together. If you specify a finite value for one of these parameters while the other is UNLIMITED, old passwords can never be reused. If both parameters are set to UNLIMITED there are no restrictions on password reuse. Supported values are:

- A NUMERIC value greater than or equal to 0. To specify a fractional portion of a day, specify a decimal value. For example, use the value 4.5 to specify 4 days, 12 hours.
- DEFAULT - the value of **PASSWORD_REUSE_TIME** specified in the DEFAULT profile.
- UNLIMITED - The password can be re-used without restrictions.

**PASSWORD_REUSE_MAX** specifies the number of password changes that must occur before a password can be reused. The **PASSWORD_REUSE_TIME** and
PASSWORD_REUSE_MAX parameters are intended to be used together. If you specify a finite value for one of these parameters while the other is UNLIMITED, old passwords can never be reused. If both parameters are set to UNLIMITED there are no restrictions on password reuse. Supported values are:

- An integer value greater than or equal to 0.
- DEFAULT - the value of PASSWORD_REUSE_MAX specified in the DEFAULT profile.
- UNLIMITED - The password can be re-used without restrictions.

PASSWORD_VERIFY_FUNCTION specifies password complexity. Supported values are:

- The name of a PL/SQL function.
- DEFAULT - the value of PASSWORD_VERIFY_FUNCTION specified in the DEFAULT profile.
- NULL

Notes

Use DROP PROFILE command to remove the profile.

Examples

The following command creates a profile named acctg. The profile specifies that if a user has not authenticated with the correct password in five attempts, the account will be locked for one day:

```
CREATE PROFILE acctg LIMIT
   FAILED_LOGIN_ATTEMPTS 5
   PASSWORD_LOCK_TIME 1;
```

The following command creates a profile named sales. The profile specifies that a user must change their password every 90 days:

```
CREATE PROFILE sales LIMIT
   PASSWORD_LIFE_TIME 90
   PASSWORD_GRACE_TIME 3;
```

If the user has not changed their password before the 90 days specified in the profile has passed, they will be issued a warning at login. After a grace period of 3 days, their account will not be allowed to invoke any commands until they change their password.

The following command creates a profile named accts. The profile specifies that a user cannot re-use a password within 180 days of the last use of the password, and must change their password at least 5 times before re-using the password:
CREATE PROFILE accts LIMIT
   PASSWORD_REUSE_TIME 180
   PASSWORD_REUSE_MAX 5;

The following command creates a profile named resources; the profile calls a user-defined function named password_rules that will verify that the password provided meets their standards for complexity:

CREATE PROFILE resources LIMIT
   PASSWORD_VERIFY_FUNCTION password_rules;

### 2.3.1.1 Creating a Password Function

When specifying `PASSWORD_VERIFY_FUNCTION`, you can provide a customized function that specifies the security rules that will be applied when your users change their password. For example, you can specify rules that stipulate that the new password must be at least \( n \) characters long, and may not contain a specific value.

The password function has the following signature:

\[
\text{function\_name} \ (\text{user\_name} \ \text{VARCHAR2}, \newline \text{new\_password} \ \text{VARCHAR2}, \newline \text{old\_password} \ \text{VARCHAR2}) \ \text{RETURN boolean}
\]

**Where:**

- `user_name` is the name of the user.
- `new_password` is the new password.
- `old_password` is the user's previous password. If you reference this parameter within your function:

  **When a database superuser changes their password, the third parameter will always be NULL.**

  **When a user with the CREATEROLE attribute changes their password, the parameter will pass the previous password if the statement includes the REPLACE clause. Note that the REPLACE clause is optional syntax for a user with the CREATEROLE privilege.**

  **When a user that is not a database superuser and does not have the CREATEROLE attribute changes their password, the third parameter will contain the previous password for the role.**
The function returns a Boolean value. If the function returns true and does not raise an exception, the password is accepted; if the function returns false or raises an exception, the password is rejected. If the function raises an exception, the specified error message is displayed to the user. If the function does not raise an exception, but returns false, the following error message is displayed:

```
ERROR: password verification for the specified password failed
```

The function must be owned by a database superuser, and reside in the `sys` schema.

**Example:**

The following example creates a profile and a custom function; then, the function is associated with the profile. The following `CREATE PROFILE` command creates a profile named `acctg_pwd_profile`:

```
CREATE PROFILE acctg_pwd_profile;
```

The following commands create a (schema-qualified) function named `verify_password`:

```
CREATE OR REPLACE FUNCTION sys.verify_password(user_name varchar2,
new_password varchar2, old_password varchar2)
RETURN boolean IMMUTABLE
IS
BEGIN
  IF (length(new_password) < 5)
    THEN
      raise_application_error(-20001, 'too short');
    END IF;

  IF substring(new_password FROM old_password) IS NOT NULL
    THEN
      raise_application_error(-20002, 'includes old password');
    END IF;

  RETURN true;
END;
```

The function first ensures that the password is at least 5 characters long, and then compares the new password to the old password. If the new password contains fewer than 5 characters, or contains the old password, the function raises an error.

The following statement sets the ownership of the `verify_password` function to the `enterprisedb` database superuser:

```
ALTER FUNCTION verify_password(varchar2, varchar2, varchar2) OWNER TO enterprisedb;
```
Then, the `verify_password` function is associated with the profile:

```
ALTER PROFILE acctg_pwd_profile LIMIT PASSWORD_VERIFY_FUNCTION verify_password;
```

The following statements confirm that the function is working by first creating a test user (alice), and then attempting to associate invalid and valid passwords with her role:

```
CREATE ROLE alice WITH LOGIN PASSWORD 'temp_password' PROFILE acctg_pwd_profile;
```

Then, when alice connects to the database and attempts to change her password, she must adhere to the rules established by the profile function. A non-superuser without `CREATEROLE` must include the `REPLACE` clause when changing a password:

```
edb=> ALTER ROLE alice PASSWORD 'hey';
ERROR:  missing REPLACE clause
```

The new password must be at least 5 characters long:

```
edb=> ALTER USER alice PASSWORD 'hey' REPLACE 'temp_password';
ERROR:  EDB-20001: too short
CONTEXT:  edb-spl function verify_password(character varying,character varying,character varying) line 5 at procedure/function invocation statement
```

If the new password is acceptable, the command completes without error:

```
edb=> ALTER USER alice PASSWORD 'hello' REPLACE 'temp_password';
ALTER ROLE
```

If alice decides to change her password, the new password must not contain the old password:

```
edb=> ALTER USER alice PASSWORD 'helloworld' REPLACE 'hello';
ERROR:  EDB-20002: includes old password
CONTEXT:  edb-spl function verify_password(character varying,character varying,character varying) line 10 at procedure/function invocation statement
```

To remove the verify function, set `password_verify_function` to `NULL`:

```
ALTER PROFILE acctg_pwd_profile LIMIT password_verify_function NULL;
```

Then, all password constraints will be lifted:

```
edb=# ALTER ROLE alice PASSWORD 'hey';
ALTER ROLE
```
2.3.2 Altering a Profile

Use the ALTER PROFILE command to modify a user-defined profile; Advanced Server supports two forms of the command:

```
ALTER PROFILE profile_name RENAME TO new_name;
```

```
ALTER PROFILE profile_name
   LIMIT {parameter value}[...];
```

Include the LIMIT clause and one or more space-delimited parameter/value pairs to specify the rules enforced by Advanced Server, or use ALTER PROFILE...RENAME TO to change the name of a profile.

Parameters:

- `profile_name` specifies the name of the profile.
- `new_name` specifies the new name of the profile.
- `parameter` specifies the attribute limited by the profile.
- `value` specifies the parameter limit.

See the table in Section 2.3.1 for a complete list of accepted parameter/value pairs.

Examples

The following example modifies a profile named `acctg_profile`:

```
ALTER PROFILE acctg_profile
   LIMIT FAILED_LOGIN_ATTEMPTS 3 PASSWORD_LOCK_TIME 1;
```

`acctg_profile` will count failed connection attempts when a login role attempts to connect to the server. The profile specifies that if a user has not authenticated with the correct password in three attempts, the account will be locked for one day.

The following example changes the name of `acctg_profile` to `payables_profile`:

```
ALTER PROFILE acctg_profile RENAME TO payables_profile;
```
2.3.3 Dropping a Profile

Use the `DROP PROFILE` command to drop a profile. The syntax:

```
DROP PROFILE [IF EXISTS] profile_name [CASCADE|RESTRICT];
```

Include the `IF EXISTS` clause to instruct the server to not throw an error if the specified profile does not exist. The server will issue a notice if the profile does not exist.

Include the optional `CASCADE` clause to reassign any users that are currently associated with the profile to the default profile, and then drop the profile. Include the optional `RESTRICT` clause to instruct the server to not drop any profile that is associated with a role. This is the default behavior.

**Parameters**

`profile_name`

The name of the profile being dropped.

**Examples**

The following example drops a profile named `acctg_profile`:

```
DROP PROFILE acctg_profile CASCADE;
```

The command first re-associates any roles associated with the `acctg_profile` profile with the default profile, and then drops the `acctg_profile` profile.

The following example drops a profile named `acctg_profile`:

```
DROP PROFILE acctg_profile RESTRICT;
```

The `RESTRICT` clause in the command instructs the server to not drop `acctg_profile` if there are any roles associated with the profile.
2.3.4 Associating a Profile with an Existing Role

After creating a profile, you can use the `ALTER USER... PROFILE` or `ALTER ROLE... PROFILE` command to associate the profile with a role. The command syntax related to profile management functionality is:

```
ALTER USER|ROLE name [[WITH] option[...]]
```

where `option` can be the following compatible clauses:

```
PROFILE profile_name
| ACCOUNT {LOCK|UNLOCK}
| PASSWORD EXPIRE [AT 'timestamp']
```

or `option` can be the following non-compatible clauses:

```
| PASSWORD SET AT 'timestamp'
| LOCK TIME 'timestamp'
| STORE PRIOR PASSWORD{"password" 'timestamp'} [, ...]
```

For information about the administrative clauses of the `ALTER USER` or `ALTER ROLE` command that are supported by Advanced Server, please see the PostgreSQL core documentation available at:

```
https://www.postgresql.org/docs/10/static/sql-commands.html
```

Only a database superuser can use the `ALTER USER|ROLE` clauses that enforce profile management. The clauses enforce the following behaviors:

Include the `PROFILE` clause and a `profile_name` to associate a pre-defined profile with a role, or to change which pre-defined profile is associated with a user.

Include the `ACCOUNT` clause and the `LOCK` or `UNLOCK` keyword to specify that the user account should be placed in a locked or unlocked state.

Include the `LOCK TIME 'timestamp'` clause and a date/time value to lock the role at the specified time, and unlock the role at the time indicated by the `PASSWORD_LOCK_TIME` parameter of the profile assigned to this role. If `LOCK TIME` is used with the `ACCOUNT LOCK` clause, the role can only be unlocked by a database superuser with the `ACCOUNT UNLOCK` clause.
Include the `PASSWORD EXPIRE` clause with the `AT 'timestamp'` keywords to specify a date/time when the password associated with the role will expire. If you omit the `AT 'timestamp'` keywords, the password will expire immediately.

Include the `PASSWORD SET AT 'timestamp'` keywords to set the password modification date to the time specified.

Include the `STORE PRIOR PASSWORD { 'password' 'timestamp' } [, ...]` clause to modify the password history, adding the new password and the time the password was set.

Each login role may only have one profile. To discover the profile that is currently associated with a login role, query the `profile` column of the `DBA_USERS` view.

**Parameters**

`name`

The name of the role with which the specified profile will be associated.

`password`

The password associated with the role.

`profile_name`

The name of the profile that will be associated with the role.

`timestamp`

The date and time at which the clause will be enforced. When specifying a value for `timestamp`, enclose the value in single-quotes.

**Examples**

The following command uses the `ALTER USER... PROFILE` command to associate a profile named `acctg` with a user named `john`:

```sql
ALTER USER john PROFILE acctg_profile;
```

The following command uses the `ALTER ROLE... PROFILE` command to associate a profile named `acctg` with a user named `john`:

```sql
ALTER ROLE john PROFILE acctg_profile;
```
2.3.5 Unlocking a Locked Account

A database superuser can use clauses of the ALTER USER | ROLE... command to lock or unlock a role. The syntax is:

```
ALTER USER | ROLE name
    ACCOUNT {LOCK | UNLOCK}
    LOCK TIME 'timestamp'
```

Include the ACCOUNT LOCK clause to lock a role immediately; when locked, a role’s LOGIN functionality is disabled. When you specify the ACCOUNT LOCK clause without the LOCK TIME clause, the state of the role will not change until a superuser uses the ACCOUNT UNLOCK clause to unlock the role.

Use the ACCOUNT UNLOCK clause to unlock a role.

Use the LOCK TIME 'timestamp' clause to instruct the server to lock the account at the time specified by the given timestamp for the length of time specified by the PASSWORD_LOCK_TIME parameter of the profile associated with this role.

Combine the LOCK TIME 'timestamp' clause and the ACCOUNT LOCK clause to lock an account at a specified time until the account is unlocked by a superuser invoking the ACCOUNT UNLOCK clause.

Parameters

- **name**
  
  The name of the role that is being locked or unlocked.

- **timestamp**
  
  The date and time at which the role will be locked. When specifying a value for `timestamp`, enclose the value in single-quotes.

Note

This command (available only in Advanced Server) is implemented to support Oracle-styled profile management.
Examples

The following example uses the `ACCOUNT LOCK` clause to lock the role named `john`. The account will remain locked until the account is unlocked with the `ACCOUNT UNLOCK` clause:

```
ALTER ROLE john ACCOUNT LOCK;
```

The following example uses the `ACCOUNT UNLOCK` clause to unlock the role named `john`:

```
ALTER USER john ACCOUNT UNLOCK;
```

The following example uses the `LOCK TIME 'timestamp'` clause to lock the role named `john` on September 4, 2015:

```
ALTER ROLE john LOCK TIME 'September 4 12:00:00 2015';
```

The role will remain locked for the length of time specified by the `PASSWORD_LOCK_TIME` parameter.

The following example combines the `LOCK TIME 'timestamp'` clause and the `ACCOUNT LOCK` clause to lock the role named `john` on September 4, 2015:

```
ALTER ROLE john LOCK TIME 'September 4 12:00:00 2015' ACCOUNT LOCK;
```

The role will remain locked until a database superuser uses the `ACCOUNT UNLOCK` command to unlock the role.
2.3.6 Creating a New Role Associated with a Profile

A database superuser can use clauses of the `CREATE USER` or `CREATE ROLE` command to assign a named profile to a role when creating the role, or to specify profile management details for a role. The command syntax related to profile management functionality is:

```
CREATE USER | ROLE name [[WITH] option [...]]
```

where `option` can be the following compatible clauses:

- `PROFILE profile_name`
- `ACCOUNT {LOCK | UNLOCK}`
- `PASSWORD EXPIRE [AT 'timestamp']`

or `option` can be the following non-compatible clauses:

- `LOCK TIME 'timestamp'`

For information about the administrative clauses of the `CREATE USER` or `CREATE ROLE` command that are supported by Advanced Server, please see the PostgreSQL core documentation available at:

`https://www.postgresql.org/docs/10/static/sql-commands.html`

`CREATE ROLE | USER... PROFILE` adds a new role with an associated profile to an Advanced Server database cluster.

Roles created with the `CREATE USER` command are (by default) login roles. Roles created with the `CREATE ROLE` command are (by default) not login roles. To create a login account with the `CREATE ROLE` command, you must include the `LOGIN` keyword.

Only a database superuser can use the `CREATE USER | ROLE` clauses that enforce profile management; these clauses enforce the following behaviors:

- Include the `PROFILE` clause and a `profile_name` to associate a pre-defined profile with a role, or to change which pre-defined profile is associated with a user.

- Include the `ACCOUNT` clause and the `LOCK` or `UNLOCK` keyword to specify that the user account should be placed in a locked or unlocked state.

- Include the `LOCK TIME 'timestamp'` clause and a date/time value to lock the role at the specified time, and unlock the role at the time indicated by the `PASSWORD_LOCK_TIME` parameter of the profile assigned to this role. If `LOCK`
TIME is used with the ACCOUNT LOCK clause, the role can only be unlocked by a database superuser with the ACCOUNT UNLOCK clause.

Include the PASSWORD EXPIRE clause with the optional AT 'timestamp' keywords to specify a date/time when the password associated with the role will expire. If you omit the AT 'timestamp' keywords, the password will expire immediately.

Each login role may only have one profile. To discover the profile that is currently associated with a login role, query the profile column of the DBA_USERS view.

**Parameters**

*name*

The name of the role.

*profile_name*

The name of the profile associated with the role.

*timestamp*

The date and time at which the clause will be enforced. When specifying a value for *timestamp*, enclose the value in single-quotes.

**Examples**

The following example uses CREATE USER to create a login role named *john* who is associated with the acctg_profile profile:

```
CREATE USER john PROFILE acctg_profile IDENTIFIED BY "1safepwd";
```

*john* can log in to the server, using the password 1safepwd.

The following example uses CREATE ROLE to create a login role named *john* who is associated with the acctg_profile profile:

```
CREATE ROLE john PROFILE acctg_profile LOGIN PASSWORD "1safepwd";
```

*john* can log in to the server, using the password 1safepwd.
2.3.7 Backing up Profile Management Functions

A profile may include a PASSWORD_VERIFY_FUNCTION clause that refers to a user-defined function that specifies the behavior enforced by Advanced Server. Profiles are global objects; they are shared by all of the databases within a cluster. While profiles are global objects, user-defined functions are database objects.

Invoking pg_dumpall with the -g or -r option will create a script that recreates the definition of any existing profiles, but that does not recreate the user-defined functions that are referred to by the PASSWORD_VERIFY_FUNCTION clause. You should use the pg_dump utility to explicitly dump (and later restore) the database in which those functions reside.

The script created by pg_dump will contain a command that includes the clause and function name:

```
ALTER PROFILE… LIMIT PASSWORD_VERIFY_FUNCTION function_name
```

To associate the restored function with the profile with which it was previously associated.

If the PASSWORD_VERIFY_FUNCTION clause is set to DEFAULT or NULL, the behavior will be replicated by the script generated by the pg_dumpall -g or pg_dumpall -r command.
2.4 Optimizer Hints

When you invoke a `DELETE`, `INSERT`, `SELECT` or `UPDATE` command, the server generates a set of execution plans; after analyzing those execution plans, the server selects a plan that will (generally) return the result set in the least amount of time. The server's choice of plan is dependent upon several factors:

- The estimated execution cost of data handling operations.
- Parameter values assigned to parameters in the Query Tuning section of the `postgresql.conf` file.
- Column statistics that have been gathered by the `ANALYZE` command.

As a rule, the query planner will select the least expensive plan. You can use an optimizer hint to influence the server as it selects a query plan. An optimizer hint is a directive (or multiple directives) embedded in a comment-like syntax that immediately follows a `DELETE`, `INSERT`, `SELECT` or `UPDATE` command. Keywords in the comment instruct the server to employ or avoid a specific plan when producing the result set.

Synopsis

```
{ DELETE | INSERT | SELECT | UPDATE } /*+ { hint [ comment ] } */

statement_body
```

```
{ DELETE | INSERT | SELECT | UPDATE } --+ { hint [ comment ] }

statement_body
```

Optimizer hints may be included in either of the forms shown above. Note that in both forms, a plus sign (+) must immediately follow the /* or -- opening comment symbols, with no intervening space, or the server will not interpret the following tokens as hints.

If you are using the first form, the hint and optional comment may span multiple lines. The second form requires all hints and comments to occupy a single line; the remainder of the statement must start on a new line.

Description

Please Note:

- The database server will always try to use the specified hints if at all possible.
- If a planner method parameter is set so as to disable a certain plan type, then this plan will not be used even if it is specified in a hint, unless there are no other possible options for the planner. Examples of planner method parameters are
enable_indexscan, enable_seqscan, enable_hashjoin, enable_mergejoin, and enable_nestloop. These are all Boolean parameters.

- Remember that the hint is embedded within a comment. As a consequence, if the hint is misspelled or if any parameter to a hint such as view, table, or column name is misspelled, or non-existent in the SQL command, there will be no indication that any sort of error has occurred. No syntax error will be given and the entire hint is simply ignored.

- If an alias is used for a table or view name in the SQL command, then the alias name, not the original object name, must be used in the hint. For example, in the command, `SELECT /*+ FULL(acct) */ * FROM accounts acct`, `acct`, the alias for `accounts`, must be specified in the `FULL` hint, not the table name, `accounts`.

Use the `EXPLAIN` command to ensure that the hint is correctly formed and the planner is using the hint. See the Advanced Server documentation set for information on the `EXPLAIN` command.

In general, optimizer hints should not be used in production applications (where table data changes throughout the life of the application). By ensuring that dynamic columns are `ANALYZED` frequently, the column statistics will be updated to reflect value changes, and the planner will use such information to produce the least cost plan for any given command execution. Use of optimizer hints defeats the purpose of this process and will result in the same plan regardless of how the table data changes.

**Parameters**

`hint`

An optimizer hint directive.

`comment`

A string with additional information. Note that there are restrictions as to what characters may be included in the comment. Generally, `comment` may only consist of alphabetic, numeric, the underscore, dollar sign, number sign and space characters. These must also conform to the syntax of an identifier. Any subsequent hint will be ignored if the comment is not in this form.

`statement_body`

The remainder of the `DELETE`, `INSERT`, `SELECT`, or `UPDATE` command.

The following sections describe the optimizer hint directives in more detail.
2.4.1 Default Optimization Modes

There are a number of optimization modes that can be chosen as the default setting for an Advanced Server database cluster. This setting can also be changed on a per session basis by using the `ALTER SESSION` command as well as in individual `DELETE`, `SELECT`, and `UPDATE` commands within an optimizer hint. The configuration parameter that controls these default modes is named `OPTIMIZER_MODE`. The following table shows the possible values.

<table>
<thead>
<tr>
<th>Hint</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL_ROWS</td>
<td>Optimizes for retrieval of all rows of the result set.</td>
</tr>
<tr>
<td>CHOOSE</td>
<td>Does no default optimization based on assumed number of rows to be retrieved from the result set. This is the default.</td>
</tr>
<tr>
<td>FIRST_ROWS</td>
<td>Optimizes for retrieval of only the first row of the result set.</td>
</tr>
<tr>
<td>FIRST_ROWS_10</td>
<td>Optimizes for retrieval of the first 10 rows of the result set.</td>
</tr>
<tr>
<td>FIRST_ROWS_100</td>
<td>Optimizes for retrieval of the first 100 rows of the result set.</td>
</tr>
<tr>
<td>FIRST_ROWS_1000</td>
<td>Optimizes for retrieval of the first 1000 rows of the result set.</td>
</tr>
<tr>
<td>FIRST_ROWS(n)</td>
<td>Optimizes for retrieval of the first n rows of the result set. This form may not be used as the object of the <code>ALTER SESSION SET OPTIMIZER_MODE</code> command. It may only be used in the form of a hint in a SQL command.</td>
</tr>
</tbody>
</table>

These optimization modes are based upon the assumption that the client submitting the SQL command is interested in viewing only the first “n” rows of the result set and will then abandon the remainder of the result set. Resources allocated to the query are adjusted as such.

Examples

Alter the current session to optimize for retrieval of the first 10 rows of the result set.

```sql
ALTER SESSION SET OPTIMIZER_MODE = FIRST_ROWS_10;
```

The current value of the `OPTIMIZER_MODE` parameter can be shown by using the `SHOW` command. Note that this command is a utility dependent command. In PSQL, the `SHOW` command is used as follows:

```sql
SHOW OPTIMIZER_MODE;
optimizer_mode
-------------------
first_rows_10
(1 row)
```
The `SHOW` command, compatible with Oracle databases, has the following syntax:

```sql
SHOW PARAMETER OPTIMIZER_MODE;
```

<table>
<thead>
<tr>
<th>NAME</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>optimizer_mode</td>
<td>first_rows_10</td>
</tr>
</tbody>
</table>

The following example shows an optimization mode used in a `SELECT` command as a hint:

```sql
SELECT /*+ FIRST_ROWS(7) */ * FROM emp;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>job</th>
<th>mgr</th>
<th>hiredate</th>
<th>sal</th>
<th>comm</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
<td>7902</td>
<td>17-DEC-80 00:00:00</td>
<td>800.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
<td>7698</td>
<td>20-FEB-81 00:00:00</td>
<td>1600.00</td>
<td>300.00</td>
<td>30</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
<td>7698</td>
<td>22-FEB-81 00:00:00</td>
<td>1250.00</td>
<td>500.00</td>
<td>30</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
<td>7839</td>
<td>02-APR-81 00:00:00</td>
<td>2975.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>SALESMAN</td>
<td>7698</td>
<td>28-SEP-81 00:00:00</td>
<td>1250.00</td>
<td>1400.00</td>
<td>30</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>MANAGER</td>
<td>7839</td>
<td>01-MAY-81 00:00:00</td>
<td>2850.00</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>MANAGER</td>
<td>7839</td>
<td>09-JUN-81 00:00:00</td>
<td>2450.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>ANALYST</td>
<td>7566</td>
<td>19-APR-87 00:00:00</td>
<td>3000.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>PRESIDENT</td>
<td></td>
<td>17-NOV-81 00:00:00</td>
<td>5000.00</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>SALESMAN</td>
<td>7698</td>
<td>08-SEP-81 00:00:00</td>
<td>1500.00</td>
<td>0.00</td>
<td>30</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>CLERK</td>
<td>7788</td>
<td>23-MAY-87 00:00:00</td>
<td>1100.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>CLERK</td>
<td>7698</td>
<td>03-DEC-81 00:00:00</td>
<td>950.00</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>ANALYST</td>
<td>7566</td>
<td>03-DEC-81 00:00:00</td>
<td>3000.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>CLERK</td>
<td>7782</td>
<td>23-JAN-82 00:00:00</td>
<td>1300.00</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
```

(14 rows)
2.4.2 Access Method Hints

The following hints influence how the optimizer accesses relations to create the result set.

<table>
<thead>
<tr>
<th>Hint</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FULL(table)</td>
<td>Perform a full sequential scan on table.</td>
</tr>
<tr>
<td>INDEX(table [ index ] [ ...])</td>
<td>Use index on table to access the relation.</td>
</tr>
<tr>
<td>NO_INDEX(table [ index ] [ ...])</td>
<td>Do not use index on table to access the relation.</td>
</tr>
</tbody>
</table>

In addition, the ALL_ROWS, FIRST_ROWS, and FIRST_ROWS(n) hints of Table 2-1 can be used.

Examples

The sample application does not have sufficient data to illustrate the effects of optimizer hints so the remainder of the examples in this section will use a banking database created by the pgbench application located in the Advanced Server bin subdirectory.

The following steps create a database named, bank, populated by the tables, pgbench_accounts, pgbench_branches, pgbench_tellers, and pgbench_history. The -s 20 option specifies a scaling factor of twenty, which results in the creation of twenty branches, each with 100,000 accounts, resulting in a total of 2,000,000 rows in the pgbench_accounts table and twenty rows in the pgbench_branches table. Ten tellers are assigned to each branch resulting in a total of 200 rows in the pgbench_tellers table.

The following initializes the pgbench application in the bank database.

```bash
createdb -U enterprisedb bank
CREATE DATABASE
pgbench -i -s 20 -U enterprisedb bank
NOTICE: table "pgbench_history" does not exist, skipping
NOTICE: table "pgbench_tellers" does not exist, skipping
NOTICE: table "pgbench_accounts" does not exist, skipping
NOTICE: table "pgbench_branches" does not exist, skipping
creating tables...
100000 of 2000000 tuples (5%) done (elapsed 0.11 s, remaining 2.10 s)
200000 of 2000000 tuples (10%) done (elapsed 0.22 s, remaining 1.98 s)
300000 of 2000000 tuples (15%) done (elapsed 0.33 s, remaining 1.84 s)
400000 of 2000000 tuples (20%) done (elapsed 0.42 s, remaining 1.67 s)
500000 of 2000000 tuples (25%) done (elapsed 0.52 s, remaining 1.57 s)
600000 of 2000000 tuples (30%) done (elapsed 0.62 s, remaining 1.45 s)
700000 of 2000000 tuples (35%) done (elapsed 0.73 s, remaining 1.35 s)
800000 of 2000000 tuples (40%) done (elapsed 0.87 s, remaining 1.31 s)
900000 of 2000000 tuples (45%) done (elapsed 0.98 s, remaining 1.19 s)
1000000 of 2000000 tuples (50%) done (elapsed 1.09 s, remaining 1.09 s)
```
A total of 500,000 transactions are then processed. This will populate the pgbench_history table with 500,000 rows.

```
pgbench -U enterprisedb -t 500000 bank

starting vacuum...end.
transaction type: <builtin: TPC-B (sort of)>
scaling factor: 20
query mode: simple
number of clients: 1
number of threads: 1
number of transactions per client: 500000
number of transactions actually processed: 500000/500000
latency average: 0.000 ms
tps = 1464.338375 (including connections establishing)
tps = 1464.350357 (excluding connections establishing)
```

The table definitions are shown below:

```
\d pgbench_accounts

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>aid</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>bid</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>abalance</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>filler</td>
<td>character(84)</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "pgbench_accounts_pkey" PRIMARY KEY, btree (aid)

\d pgbench_branches

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>bid</td>
<td>integer</td>
<td>not null</td>
</tr>
<tr>
<td>bbalance</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>filler</td>
<td>character(88)</td>
<td></td>
</tr>
</tbody>
</table>

Indexes:
- "pgbench_branches_pkey" PRIMARY KEY, btree (bid)

\d pgbench_tellers

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
</table>

```
The `EXPLAIN` command shows the plan selected by the query planner. In the following example, `aid` is the primary key column, so an indexed search is used on index, `pgbench_accounts_pkey`.

```sql
EXPLAIN SELECT * FROM pgbench_accounts WHERE aid = 100;
```

```
<table>
<thead>
<tr>
<th>QUERY PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index Scan using pgbench_accounts_pkey on pgbench_accounts (cost=0.43..8.45 rows=1 width=97)</td>
</tr>
<tr>
<td>Index Cond: (aid = 100)</td>
</tr>
<tr>
<td>(2 rows)</td>
</tr>
</tbody>
</table>
```

The `FULL` hint is used to force a full sequential scan instead of using the indexes shown below:

```sql
EXPLAIN SELECT /*+ FULL(pgbench_accounts) */ * FROM pgbench_accounts WHERE aid = 100;
```

```
<table>
<thead>
<tr>
<th>QUERY PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seq Scan on pgbench_accounts (cost=0.00..58781.69 rows=1 width=97)</td>
</tr>
<tr>
<td>Filter: (aid = 100)</td>
</tr>
<tr>
<td>(2 rows)</td>
</tr>
</tbody>
</table>
```

The `NO_INDEX` hint forces a parallel sequential scan instead of use of the indexes shown below:

```sql
EXPLAIN SELECT /*+ NO_INDEX(pgbench_accounts pgbench_accounts_pkey) */ * FROM pgbench_accounts WHERE aid = 100;
```

```
<table>
<thead>
<tr>
<th>QUERY PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather (cost=1000.00..45094.80 rows=1 width=97)</td>
</tr>
<tr>
<td>Workers Planned: 2</td>
</tr>
</tbody>
</table>
```
In addition to using the **EXPLAIN** command as shown in the prior examples, more detailed information regarding whether or not a hint was used by the planner can be obtained by setting the **trace_hints** configuration parameter as follows:

```
SET trace_hints TO on;
```

The **SELECT** command with the **NO_INDEX** hint is repeated below to illustrate the additional information produced when the **trace_hints** configuration parameters is set.

```
EXPLAIN SELECT /*+ NO_INDEX(pgbench_accounts pgbench_accounts_pkey) */ * FROM pgbench_accounts WHERE aid = 100;
```

```
INFO: [HINTS] Index Scan of [pgbench_accounts].[pgbench_accounts_pkey] rejected due to NO_INDEX hint.
```

```
QUERY PLAN
------------------------------------------------------------------------------------
Gather (cost=1000.00..45094.80 rows=1 width=97)
  Workers Planned: 2
    -> Parallel Seq Scan on pgbench_accounts (cost=0.00..44094.70 rows=1 width=97)
      Filter: (aid = 100)
(4 rows)
```

Note that if a hint is ignored, the **INFO: [HINTS]** line will not appear. This may be an indication that there was a syntax error or some other misspelling in the hint as shown in the following example where the index name is misspelled.

```
EXPLAIN SELECT /*+ NO_INDEX(pgbench_accounts pgbench_accounts_xxx) */ * FROM pgbench_accounts WHERE aid = 100;
```

```
QUERY PLAN
------------------------------------------------------------------------------------
Index Scan using pgbench_accounts_pkey on pgbench_accounts (cost=0.43..8.45 rows=1 width=97)
  Index Cond: (aid = 100)
(2 rows)
```
2.4.3 Specifying a Join Order

Include the `ORDERED` directive to instruct the query optimizer to join tables in the order in which they are listed in the `FROM` clause. If you do not include the `ORDERED` keyword, the query optimizer will choose the order in which to join the tables.

For example, the following command allows the optimizer to choose the order in which to join the tables listed in the `FROM` clause:

```sql
SELECT e.ename, d.dname, h.startdate
FROM emp e, dept d, jobhist h
WHERE d.deptno = e.deptno
AND h.empno = e.empno;
```

The following command instructs the optimizer to join the tables in the ordered specified:

```sql
SELECT /*+ ORDERED */ e.ename, d.dname, h.startdate
FROM emp e, dept d, jobhist h
WHERE d.deptno = e.deptno
AND h.empno = e.empno;
```

In the `ORDERED` version of the command, Advanced Server will first join `emp e` with `dept d` before joining the results with `jobhist h`. Without the `ORDERED` directive, the join order is selected by the query optimizer.

Please note: the `ORDERED` directive does not work for Oracle-style outer joins (those joins that contain a `+` sign).
2.4.4 Joining Relations Hints

When two tables are to be joined, there are three possible plans that may be used to perform the join.

- **Nested Loop Join** – A table is scanned once for every row in the other joined table.
- **Merge Sort Join** – Each table is sorted on the join attributes before the join starts. The two tables are then scanned in parallel and the matching rows are combined to form the join rows.
- **Hash Join** – A table is scanned and its join attributes are loaded into a hash table using its join attributes as hash keys. The other joined table is then scanned and its join attributes are used as hash keys to locate the matching rows from the first table.

The following table lists the optimizer hints that can be used to influence the planner to use one type of join plan over another.

<table>
<thead>
<tr>
<th>Hint</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE_HASH(table [...])</td>
<td>Use a hash join for table.</td>
</tr>
<tr>
<td>NO_USE_HASH(table [...])</td>
<td>Do not use a hash join for table.</td>
</tr>
<tr>
<td>USE_MERGE(table [...])</td>
<td>Use a merge sort join for table.</td>
</tr>
<tr>
<td>NO_USE_MERGE(table [...])</td>
<td>Do not use a merge sort join for table.</td>
</tr>
<tr>
<td>USE_NL(table [...])</td>
<td>Use a nested loop join for table.</td>
</tr>
<tr>
<td>NO_USE_NL(table [...])</td>
<td>Do not use a nested loop join for table.</td>
</tr>
</tbody>
</table>

**Examples**

In the following example, the **USE_HASH** hint is used for a join on the `pgbench_branches` and `pgbench_accounts` tables. The query plan shows that a hash join is used by creating a hash table from the join attribute of the `pgbench_branches` table.

```
EXPLAIN SELECT /*+ USE_HASH(b) */ b.bid, a.aid, abalance FROM pgbench_branches b, pgbench_accounts a WHERE b.bid = a.bid;
```

```
QUERY PLAN

Hash Join  (cost=21.45..81463.06 rows=2014215 width=12)
  Hash Cond: (a.bid = b.bid)
  ->  Seq Scan on pgbench_accounts a  (cost=0.00..53746.15 rows=2014215 width=12)
  ->  Hash  (cost=21.20..21.20 rows=20 width=4)
    ->  Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20 width=4)
```

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Next, the `NO_USE_HASH(a b)` hint forces the planner to use an approach other than hash tables. The result is a merge join.

```
EXPLAIN SELECT /*+ NO_USE_HASH(a b) */ b.bid, a.aid, abalance FROM pgbench_branches b, pgbench_accounts a WHERE b.bid = a.bid;
```

```
QUERY PLAN
---------------------------------------------------------------------
Merge Join  (cost=333526.08..368774.94 rows=2014215 width=12)
  Merge Cond: (b.bid = a.bid)
    -> Sort  (cost=21.63..21.68 rows=20 width=4)
      Sort Key: b.bid
        -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20
          width=4)
    -> Materialize  (cost=333504.45..343575.53 rows=2014215 width=12)
      -> Sort  (cost=333504.45..338539.99 rows=2014215 width=12)
        Sort Key: a.bid
          -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15
            rows=2014215 width=12)
(9 rows)
```

Finally, the `USE_MERGE` hint forces the planner to use a merge join.

```
EXPLAIN SELECT /*+ USE_MERGE(a) */ b.bid, a.aid, abalance FROM pgbench_branches b, pgbench_accounts a WHERE b.bid = a.bid;
```

```
QUERY PLAN
---------------------------------------------------------------------
Merge Join  (cost=333526.08..368774.94 rows=2014215 width=12)
  Merge Cond: (b.bid = a.bid)
    -> Sort  (cost=21.63..21.68 rows=20 width=4)
      Sort Key: b.bid
        -> Seq Scan on pgbench_branches b  (cost=0.00..21.20 rows=20
          width=4)
    -> Materialize  (cost=333504.45..343575.53 rows=2014215 width=12)
      -> Sort  (cost=333504.45..338539.99 rows=2014215 width=12)
        Sort Key: a.bid
          -> Seq Scan on pgbench_accounts a  (cost=0.00..53746.15
            rows=2014215 width=12)
(9 rows)
```

In this three-table join example, the planner first performs a hash join on the `pgbench_branches` and `pgbench_history` tables, then finally performs a hash join of the result with the `pgbench_accounts` table.

```
EXPLAIN SELECT h.mtime, h.delta, b.bid, a.aid FROM pgbench_history h, pgbench_branches b, pgbench_accounts a WHERE h.bid = b.bid AND h.aid = a.aid;
```

```
QUERY PLAN
-----------------------------
Hash Join  (cost=86814.29..123103.29 rows=500000 width=20)
  Hash Cond: (h.aid = a.aid)
    -> Hash Join  (cost=21.45..15081.45 rows=500000 width=20)
      Hash Cond: (h.bid = b.bid)
        -> Seq Scan on pgbench_history h  (cost=0.00..8185.00 rows=500000 width=20)
(5 rows)
```
This plan is altered by using hints to force a combination of a merge sort join and a hash join.

```
EXPLAIN SELECT /*+ USE_MERGE(h b) USE_HASH(a) */ h.mtime, h.delta, b.bid, a.aid FROM pgbench_history h, pgbench_branches b, pgbench_accounts a WHERE h.bid = b.bid AND h.aid = a.aid;
```

```
QUERY PLAN
---------------------------------------------------------------------------------------
------------
Hash Join (cost=152583.39..182562.49 rows=500000 width=20)
  Hash Cond: (h.aid = a.aid)
  -> Merge Join (cost=65790.55..74540.65 rows=500000 width=20)
    Merge Cond: (b.bid = h.bid)
    -> Sort (cost=21.63..21.68 rows=20 width=4)
      Sort Key: b.bid
    -> Seq Scan on pgbench_branches b (cost=0.00..21.20 rows=20 width=4)
  -> Materialize (cost=65768.92..68268.92 rows=500000 width=20)
    -> Sort (cost=65768.92..67018.92 rows=500000 width=20)
      Sort Key: h.bid
    -> Seq Scan on pgbench_history h (cost=0.00..8185.00 rows=500000 width=20)
  -> Hash (cost=53746.15..53746.15 rows=2014215 width=4)
    -> Seq Scan on pgbench_accounts a (cost=0.00..53746.15 rows=2014215 width=4)
(13 rows)
```
2.4.5 Global Hints

Thus far, hints have been applied directly to tables that are referenced in the SQL command. It is also possible to apply hints to tables that appear in a view when the view is referenced in the SQL command. The hint does not appear in the view, itself, but rather in the SQL command that references the view.

When specifying a hint that is to apply to a table within a view, the view and table names are given in dot notation within the hint argument list.

Synopsis

\texttt{hint(view.table)}

Parameters

- \texttt{hint}
  - Any of the hints in Table 2-2 or Table 2-3.
- \texttt{view}
  - The name of the view containing \texttt{table}.
- \texttt{table}
  - The table on which the hint is to be applied.

Examples

A view named, \texttt{tx}, is created from the three-table join of \texttt{pgbench\_history}, \texttt{pgbench\_branches}, and \texttt{pgbench\_accounts} shown in the final example of Section 2.4.4.

```
CREATE VIEW tx AS SELECT h.mtime, h.delta, b.bid, a.aid FROM pgbench\_history h, pgbench\_branches b, pgbench\_accounts a WHERE h.bid = b.bid AND h.aid = a.aid;
```

The query plan produced by selecting from this view is show below:

```
EXPLAIN SELECT * FROM tx;
```

<table>
<thead>
<tr>
<th>QUERY PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hash Join (cost=86814.29..123103.29 rows=500000 width=20)</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>-&gt; Hash Join (cost=21.45..15081.45 rows=500000 width=20)</td>
</tr>
</tbody>
</table>

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The same hints that were applied to this join at the end of Section 2.4.4 can be applied to the view as follows:

```
EXPLAIN SELECT /*+ USE_MERGE(tx.h tx.b) USE_HASH(tx.a) */ * FROM tx;
```

<table>
<thead>
<tr>
<th>QUERY PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hash Join (cost=152583.39..182562.49 rows=500000 width=20)</td>
</tr>
<tr>
<td>Hash Cond: (h.aid = a.aid)</td>
</tr>
<tr>
<td>Merge Join (cost=65790.55..74540.65 rows=500000 width=20)</td>
</tr>
<tr>
<td>Merge Cond: (b.bid = h.bid)</td>
</tr>
<tr>
<td>-&gt; Sort (cost=21.63..21.68 rows=20 width=4)</td>
</tr>
<tr>
<td>Sort Key: b.bid</td>
</tr>
<tr>
<td>Materialize (cost=65768.92..68268.92 rows=500000 width=20)</td>
</tr>
<tr>
<td>Sort (cost=65768.92..67018.92 rows=500000 width=20)</td>
</tr>
<tr>
<td>Sort Key: h.bid</td>
</tr>
<tr>
<td>-&gt; Seq Scan on pgbench_history h (cost=0.00..8185.00 rows=500000 width=20)</td>
</tr>
<tr>
<td>-&gt; Seq Scan on pgbench_accounts a (cost=0.00..53746.15 rows=2014215 width=4)</td>
</tr>
</tbody>
</table>

In addition to applying hints to tables within stored views, hints can be applied to tables within subqueries as illustrated by the following example. In this query on the sample application `emp` table, employees and their managers are listed by joining the `emp` table with a subquery of the `emp` table identified by the alias, `b`.

```
SELECT a.empno, a.ename, b.empno "mgr empno", b.ename "mgr ename" FROM emp a, (SELECT * FROM emp) b WHERE a.mgr = b.empno;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>mgr empno</th>
<th>mgr ename</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>7902</td>
<td>FORD</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>7788</td>
<td>SCOTT</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>7782</td>
<td>CLARK</td>
</tr>
</tbody>
</table>

The plan chosen by the query planner is shown below:

```
EXPLAIN SELECT a.empno, a.ename, b.empno "mgr empno", b.ename "mgr ename" FROM emp a, (SELECT * FROM emp) b WHERE a.mgr = b.empno;
```
A hint can be applied to the `emp` table within the subquery to perform an index scan on `index, emp_p_k`, instead of a table scan. Note the difference in the query plans.

```sql
EXPLAIN SELECT /*+ INDEX(b.emp emp_pk) */ a.empno, a.ename, b.empno "mgr empno", b.ename "mgr ename" FROM emp a, (SELECT * FROM emp) b WHERE a.mgr = b.empno;

 QUERY PLAN
---------------------------------------------------------------
 Merge Join  (cost=4.17..13.11 rows=13 width=22)
  Merge Cond: (a.mgr = emp.empno)
    ->  Sort  (cost=1.41..1.44 rows=14 width=16)
      Sort Key: a.mgr
    ->  Seq Scan on emp a  (cost=0.00..1.14 rows=14 width=16)
  ->  Index Scan using emp_pk on emp  (cost=0.14..12.35 rows=14 width=11)
(6 rows)
```
2.4.6 Using the APPEND Optimizer Hint

By default, Advanced Server will add new data into the first available free-space in a table (vacated by vacuumed records). Include the `APPEND` directive after an `INSERT` or `SELECT` command to instruct the server to bypass mid-table free space, and affix new rows to the end of the table. This optimizer hint can be particularly useful when bulk loading data.

The syntax is:

```
/*+APPEND*/
```

For example, the following command, compatible with Oracle databases, instructs the server to append the data in the `INSERT` statement to the end of the `sales` table:

```
INSERT /*+APPEND*/ INTO sales VALUES (10, 10, '01-Mar-2011', 10, 'OR');
```

Note that Advanced Server supports the `APPEND` hint when adding multiple rows in a single `INSERT` statement:

```
INSERT /*+APPEND*/ INTO sales VALUES (20, 20, '01-Aug-2011', 20, 'NY'),
    (30, 30, '01-Feb-2011', 30, 'FL'),
    (40, 40, '01-Nov-2011', 40, 'TX');
```

The `APPEND` hint can also be included in the `SELECT` clause of an `INSERT INTO` statement:

```
INSERT INTO sales_history SELECT /*+APPEND*/ FROM sales;
```
2.4.7 Parallelism Hints

The **PARALLEL** optimizer hint is used to force parallel scanning.

The **NO_PARALLEL** optimizer hint prevents usage of a parallel scan.

**Synopsis**

```
PARALLEL (table [ parallel_degree | DEFAULT ])
NO_PARALLEL (table)
```

**Description**

*Parallel scanning* is the usage of multiple background workers to simultaneously perform a scan of a table (that is, in parallel) for a given query. This process provides performance improvement over other methods such as the sequential scan.

**Parameters**

*table*

The table to which the parallel hint is to be applied.

*parallel_degree | DEFAULT*

*parallel_degree* is a positive integer that specifies the desired number of workers to use for a parallel scan. If specified, the lesser of *parallel_degree* and configuration parameter max_parallel_workers_per_gather is used as the planned number of workers. For information on the max_parallel_workers_per_gather parameter, please see Section 19.4.6 Asynchronous Behavior located in Section 19.4 Resource Consumption in the PostgreSQL core documentation available at:

[https://www.postgresql.org/docs/10/static/runtime-config-resource.html](https://www.postgresql.org/docs/10/static/runtime-config-resource.html)

If **DEFAULT** is specified, then the maximum possible parallel degree is used.

If both *parallel_degree* and **DEFAULT** are omitted, then the query optimizer determines the parallel degree. In this case, if *table* has been set with the parallel_workers storage parameter, then this value is used as the parallel degree, otherwise the optimizer uses the maximum possible parallel degree as if **DEFAULT** was specified. For information on the parallel_workers storage
parameter, please see the Storage Parameters subsection located under CREATE TABLE in the PostgreSQL core documentation available at:

https://www.postgresql.org/docs/10/static/sql-createtable.html

Regardless of the circumstance, the parallel degree never exceeds the setting of configuration parameter `max_parallel_workers_per_gather`.

Examples

The following configuration parameter settings are in effect:

```sql
SHOW max_worker_processes;
max_worker_processes
----------------------
8
(1 row)
SHOW max_parallel_workers_per_gather;
max_parallel_workers_per_gather
---------------------------------
2
(1 row)
```

The following example shows the default scan on table `pgbench_accounts`. Note that a sequential scan is shown in the query plan.

```sql
SET trace_hints TO on;
EXPLAIN SELECT * FROM pgbench_accounts;
```

```sql
QUERY PLAN
-----------------------------------------
Seq Scan on pgbench_accounts  (cost=0.00..53746.15 rows=2014215 width=97)
(1 row)
```

The following example uses the PARALLEL hint. In the query plan, the Gather node, which launches the background workers, indicates that two workers are planned to be used.

**Note:** If `trace_hints` is set to on, the INFO: [HINTS] lines appear stating that PARALLEL has been accepted for `pgbench_accounts` as well as other hint information. For the remaining examples, these lines will not be displayed as they generally show the same output (that is, `trace_hints` has been reset to off).

```sql
EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;
```

```sql
INFO: [HINTS] SeqScan of [pgbench_accounts] rejected due to PARALLEL hint.
INFO: [HINTS] PARALLEL on [pgbench_accounts] accepted.
INFO: [HINTS] Index Scan of [pgbench_accounts].[pgbench_accounts_pkey] rejected due to PARALLEL hint.
```
Now, the `max_parallel_workers_per_gather` setting is increased:

```sql
SET max_parallel_workers_per_gather TO 6;
SHOW max_parallel_workers_per_gather;
```

The same query on `pgbench_accounts` is issued again with no parallel degree specification in the `PARALLEL` hint. Note that the number of planned workers has increased to 4 as determined by the optimizer.

```sql
EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;
```

Now, a value of 6 is specified for the parallel degree parameter of the `PARALLEL` hint. The planned number of workers is now returned as this specified value:

```sql
EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts 6) */ * FROM pgbench_accounts;
```

The same query is now issued with the `DEFAULT` setting for the parallel degree. The results indicate that the maximum allowable number of workers is planned.
Table `pgbench_accounts` is now altered so that the `parallel_workers` storage parameter is set to 3.

**Note:** This format of the `ALTER TABLE` command to set the `parallel_workers` parameter is not compatible with Oracle databases.

The `parallel_workers` setting is shown by the PSQL `\d+` command.

```sql
ALTER TABLE pgbench_accounts SET (parallel_workers=3);
\d+ pgbench_accounts
```

Now, when the `PARALLEL` hint is given with no parallel degree, the resulting number of planned workers is the value from the `parallel_workers` parameter:

```sql
EXPLAIN SELECT /*+ PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;
```

Specifying a parallel degree value or DEFAULT in the `PARALLEL` hint overrides the `parallel_workers` setting.

The following example shows the `NO_PARALLEL` hint. Note that with `trace_hints` set to on, the `INFO: [HINTS]` message states that the parallel scan was rejected due to the `NO_PARALLEL` hint.

```sql
EXPLAIN SELECT /*+ NO_PARALLEL(pgbench_accounts) */ * FROM pgbench_accounts;
INFO: [HINTS] Parallel SeqScan of [pgbench_accounts] rejected due to NO_PARALLEL hint.
```
<table>
<thead>
<tr>
<th>QUERY PLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seq Scan on pgbench_accounts</td>
</tr>
<tr>
<td>cost=0.00..53746.15 rows=2014215 width=97</td>
</tr>
<tr>
<td>(1 row)</td>
</tr>
</tbody>
</table>
2.4.8 Conflicting Hints

If a command includes two or more conflicting hints, the server will ignore the contradictory hints. The following table lists hints that are contradictory to each other.

Table 2-4 Conflicting Hints

<table>
<thead>
<tr>
<th>Hint</th>
<th>Conflicting Hint</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALL_ROWS</td>
<td>FIRST_ROWS - all formats</td>
</tr>
<tr>
<td><code>FULL(table)</code></td>
<td><code>INDEX(table [ index ])</code></td>
</tr>
<tr>
<td></td>
<td><code>PARALLEL(table [ degree ])</code></td>
</tr>
<tr>
<td><code>INDEX(table)</code></td>
<td><code>FULL(table)</code></td>
</tr>
<tr>
<td></td>
<td><code>NO_INDEX(table)</code></td>
</tr>
<tr>
<td></td>
<td><code>PARALLEL(table [ degree ])</code></td>
</tr>
<tr>
<td><code>INDEX(table index)</code></td>
<td><code>FULL(table)</code></td>
</tr>
<tr>
<td></td>
<td><code>NO_INDEX(table index)</code></td>
</tr>
<tr>
<td></td>
<td><code>PARALLEL(table [ degree ])</code></td>
</tr>
<tr>
<td><code>PARALLEL(table [ degree ])</code></td>
<td><code>FULL(table)</code></td>
</tr>
<tr>
<td></td>
<td><code>INDEX(table)</code></td>
</tr>
<tr>
<td></td>
<td><code>NO_PARALLEL(table)</code></td>
</tr>
<tr>
<td><code>USE_HASH(table)</code></td>
<td><code>NO_USE_HASH(table)</code></td>
</tr>
<tr>
<td><code>USE_MERGE(table)</code></td>
<td><code>NO_USE_MERGE(table)</code></td>
</tr>
<tr>
<td><code>USE_NL(table)</code></td>
<td><code>NO_USE_NL(table)</code></td>
</tr>
</tbody>
</table>
3 Stored Procedure Language

This chapter describes the Stored Procedure Language (SPL). SPL is a highly productive, procedural programming language for writing custom procedures, functions, triggers, and packages for Advanced Server that provides:

- full procedural programming functionality to complement the SQL language
- a single, common language to create stored procedures, functions, triggers, and packages for the Advanced Server database
- a seamless development and testing environment
- the use of reusable code
- ease of use

This chapter describes the basic elements of an SPL program, before providing an overview of the organization of an SPL program and how it is used to create a procedure or a function. Triggers, while still utilizing SPL, are sufficiently different to warrant a separate discussion (see Section 4 for information about triggers). Packages are discussed in the Database Compatibility for Oracle Developers Built-in Package Guide available at:

http://www.enterprisedb.com/products-services-training/products/documentation

The remaining sections of this chapter delve into the details of the SPL language and provide examples of its application.

3.1 Basic SPL Elements

This section discusses the basic programming elements of an SPL program.

3.1.1 Character Set

SPL programs are written using the following set of characters:

- Uppercase letters A thru Z and lowercase letters a thru z
- Digits 0 thru 9
- Symbols ( ) + - * / < > = ! ~ ^ : . ' @ % , " # $ & _ | { } [ ]
- White space characters tabs, spaces, and carriage returns

Identifiers, expressions, statements, control structures, etc. that comprise the SPL language are written using these characters.
Note: The data that can be manipulated by an SPL program is determined by the character set supported by the database encoding.

3.1.2 Case Sensitivity

Keywords and user-defined identifiers that are used in an SPL program are case insensitive. So for example, the statement `DBMS_OUTPUT.PUT_LINE('Hello World');` is interpreted to mean the same thing as `DBMS_OUTPUT.PUT_LINE('Hello World');` or `DBMS_OUTPUT.PUT_LINE('Hello World');`.

Character and string constants, however, are case sensitive as well as any data retrieved from the Advanced Server database or data obtained from other external sources. The statement `DBMS_OUTPUT.PUT_LINE('Hello World!');` produces the following output:

```
Hello World!
```

However the statement `DBMS_OUTPUT.PUT_LINE('HELLO WORLD!');` produces the output:

```
HELLO WORLD!
```

3.1.3 Identifiers

Identifiers are user-defined names that are used to identify various elements of an SPL program including variables, cursors, labels, programs, and parameters. The syntax rules for valid identifiers are the same as for identifiers in the SQL language.

An identifier must not be the same as an SPL keyword or a keyword of the SQL language. The following are some examples of valid identifiers:

```
x
last__name
a_$_Sign
Many$$$$$$signs---
THIS_IS_AN_EXTREMELY_LONG_NAME
A1
```

3.1.4 Qualifiers

A qualifier is a name that specifies the owner or context of an entity that is the object of the qualification. A qualified object is specified as the qualifier name followed by a dot with no intervening white space, followed by the name of the object being qualified with no intervening white space. This syntax is called *dot notation*.

The following is the syntax of a qualified object.
qualifier. [ qualifier. ]... object

qualifier is the name of the owner of the object. object is the name of the entity belonging to qualifier. It is possible to have a chain of qualifications where the preceding qualifier owns the entity identified by the subsequent qualifier(s) and object.

Almost any identifier can be qualified. What an identifier is qualified by depends upon what the identifier represents and the context of its usage.

Some examples of qualification follow:

- Procedure and function names qualified by the schema to which they belong - e.g., `schema_name.procedure_name(...)`
- Trigger names qualified by the schema to which they belong - e.g., `schema_name.trigger_name`
- Column names qualified by the table to which they belong - e.g., `emp.empno`
- Table names qualified by the schema to which they belong - e.g., `public.emp`
- Column names qualified by table and schema - e.g., `public.emp.empno`

As a general rule, wherever a name appears in the syntax of an SPL statement, its qualified name can be used as well. Typically a qualified name would only be used if there is some ambiguity associated with the name. For example, if two procedures with the same name belonging to two different schemas are invoked from within a program or if the same name is used for a table column and SPL variable within the same program.

You should avoid using qualified names if at all possible. In this chapter, the following conventions are adopted to avoid naming conflicts:

- All variables declared in the declaration section of an SPL program are prefixed by `v_`. E.g., `v_empno`
- All formal parameters declared in a procedure or function definition are prefixed by `p_`. E.g., `p_empno`
- Column names and table names do not have any special prefix conventions. E.g., `column empno in table emp`

### 3.1.5 Constants

Constants or literals are fixed values that can be used in SPL programs to represent values of various types - e.g., numbers, strings, dates, etc. Constants come in the following types:

- Numeric (Integer and Real)
- Character and String
- Date/time
3.1.6 User-Defined PL/SQL Subtypes

Advanced Server supports user-defined PL/SQL subtypes and (subtype) aliases. A subtype is a data type with an optional set of constraints that restrict the values that can be stored in a column of that type. The rules that apply to the type on which the subtype is based are still enforced, but you can use additional constraints to place limits on the precision or scale of values stored in the type.

You can define a subtype in the declaration of a PL function, procedure, anonymous block or package. The syntax is:

```
SUBTYPE subtype_name IS type_name[(constraint)] [NOT NULL]
```

Where `constraint` is:

```
{precision [, scale]} | length
```

Where:

- `subtype_name` specifies the name of the subtype.
- `type_name` specifies the name of the original type on which the subtype is based.

`type_name` may be:

- The name of any of the type supported by Advanced Server.
- The name of any composite type.
- A column anchored by a `%TYPE operator.
- The name of another subtype.

Include the `constraint` clause to define restrictions for types that support precision or scale.

- `precision` specifies the total number of digits permitted in a value of the subtype.
scale

scale specifies the number of fractional digits permitted in a value of the subtype.

length

length specifies the total length permitted in a value of CHARACTER, VARCHAR, or TEXT base types

Include the NOT NULL clause to specify that NULL values may not be stored in a column of the specified subtype.

Note that a subtype that is based on a column will inherit the column size constraints, but the subtype will not inherit NOT NULL or CHECK constraints.

Unconstrained Subtypes

To create an unconstrained subtype, use the SUBTYPE command to specify the new subtype name and the name of the type on which the subtype is based. For example, the following command creates a subtype named address that has all of the attributes of the type, CHAR:

    SUBTYPE address IS CHAR;

You can also create a subtype (constrained or unconstrained) that is a subtype of another subtype:

    SUBTYPE cust_address IS address NOT NULL;

This command creates a subtype named cust_address that shares all of the attributes of the address subtype. Include the NOT NULL clause to specify that a value of the cust_address may not be NULL.

Constrained Subtypes

Include a length value when creating a subtype that is based on a character type to define the maximum length of the subtype. For example:

    SUBTYPE acct_name IS VARCHAR (15);

This example creates a subtype named acct_name that is based on a VARCHAR data type, but is limited to 15 characters in length.
Include values for `precision` (to specify the maximum number of digits in a value of the subtype) and optionally, `scale` (to specify the number of digits to the right of the decimal point) when constraining a numeric base type. For example:

```sql
SUBTYPE acct_balance IS NUMBER (5, 2);
```

This example creates a subtype named `acct_balance` that shares all of the attributes of a `NUMBER` type, but that may not exceed 3 digits to the left of the decimal point and 2 digits to the right of the decimal.

An argument declaration (in a function or procedure header) is a *formal argument*. The value passed to a function or procedure is an *actual argument*. When invoking a function or procedure, the caller provides (0 or more) actual arguments. Each actual argument is assigned to a formal argument that holds the value within the body of the function or procedure.

If a formal argument is declared as a constrained subtype:

- Advanced Server does not enforce subtype constraints when assigning an actual argument to a formal argument when invoking a function.
- Advanced Server enforces subtype constraints when assigning an actual argument to a formal argument when invoking a procedure.

### Using the % TYPE Operator

You can use `%TYPE` notation to declare a subtype anchored to a column. For example:

```sql
SUBTYPE emp_type IS emp.empno%TYPE
```

This command creates a subtype named `emp_type` whose base type matches the type of the `empno` column in the `emp` table. A subtype that is based on a column will share the column size constraints; `NOT NULL` and `CHECK` constraints are not inherited.

### Subtype Conversion

Unconstrained subtypes are aliases for the type on which they are based. Any variable of type subtype (unconstrained) is interchangeable with a variable of the base type without conversion, and vice versa.

A variable of a constrained subtype may be interchanged with a variable of the base type without conversion, but a variable of the base type may only be interchanged with a constrained subtype if it complies with the constraints of the subtype. A variable of a constrained subtype may be implicitly converted to another subtype if it is based on the same subtype, and the constraint values are within the values of the subtype to which it is being converted.
3.2 SPL Programs

SPL is a procedural, block-structured language. There are four different types of programs that can be created using SPL, namely procedures, functions, triggers, and packages.

In addition, SPL is used to create subprograms. A subprogram refers to a subprocedure or a subfunction, which are nearly identical in appearance to procedures and functions, but differ in that procedures and functions are standalone programs, which are individually stored in the database and can be invoked by other SPL programs or from PSQL. Subprograms can only be invoked from within the standalone program within which they have been created.
3.2.1 SPL Block Structure

Regardless of whether the program is a procedure, function, subprogram, or trigger, an SPL program has the same block structure. A block consists of up to three sections - an optional declaration section, a mandatory executable section, and an optional exception section. Minimally, a block has an executable section that consists of one or more SPL statements within the keywords, BEGIN and END.

The optional declaration section is used to declare variables, cursors, types, and subprograms that are used by the statements within the executable and exception sections. Declarations appear just prior to the BEGIN keyword of the executable section. Depending upon the context of where the block is used, the declaration section may begin with the keyword DECLARE.

You can include an exception section within the BEGIN-END block. The exception section begins with the keyword, EXCEPTION, and continues until the end of the block in which it appears. If an exception is thrown by a statement within the block, program control goes to the exception section where the thrown exception may or may not be handled depending upon the exception and the contents of the exception section.

The following is the general structure of a block:

```
[ [ DECLARE ]
  declarations ]
BEGIN
  statements
[ EXCEPTION
  WHEN exception_condition THEN
    statements [, ...] ]
END;
```

declarations are one or more variable, cursor, type, or subprogram declarations that are local to the block. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations. Each declaration must be terminated by a semicolon. The use of the keyword DECLARE depends upon the context in which the block appears.

statements are one or more SPL statements. Each statement must be terminated by a semicolon. The end of the block denoted by the keyword END must also be terminated by a semicolon.

If present, the keyword EXCEPTION marks the beginning of the exception section. exception_condition is a conditional expression testing for one or more types of exceptions. If a thrown exception matches one of the exceptions in exception_condition, the statements following the WHEN
exception_condition clause are executed. There may be one or more WHEN exception_condition clauses, each followed by statements. Note: A BEGIN/END block in itself, is considered a statement; thus, blocks may be nested. The exception section may also contain nested blocks.

The following is the simplest possible block consisting of the NULL statement within the executable section. The NULL statement is an executable statement that does nothing.

```sql
BEGIN
    NULL;
END;
```

The following block contains a declaration section as well as the executable section.

```sql
DECLARE
    v_numerator     NUMBER(2);
    v_denominator   NUMBER(2);
    v_result        NUMBER(5,2);
BEGIN
    v_numerator := 75;
    v_denominator := 14;
    v_result := v_numerator / v_denominator;
    DBMS_OUTPUT.PUT_LINE(v_numerator || ' divided by ' || v_denominator || ' is ' || v_result);
END;
```

In this example, three numeric variables are declared of data type NUMBER. Values are assigned to two of the variables, and one number is divided by the other, storing the results in a third variable which is then displayed. If executed, the output would be:

```
75 divided by 14 is 5.36
```

The following block consists of a declaration, an executable, and an exception:

```sql
DECLARE
    v_numerator     NUMBER(2);
    v_denominator   NUMBER(2);
    v_result        NUMBER(5,2);
BEGIN
    v_numerator := 75;
    v_denominator := 0;
    v_result := v_numerator / v_denominator;
    DBMS_OUTPUT.PUT_LINE(v_numerator || ' divided by ' || v_denominator || ' is ' || v_result);
EXCEPTION
    WHEN OTHERS THEN
        DBMS_OUTPUT.PUT_LINE('An exception occurred');
END;
```

The following output shows that the statement within the exception section is executed as a result of the division by zero.

```
An exception occurred
```
3.2.2 Anonymous Blocks

Blocks are typically written as part of a procedure, function, subprogram, or trigger. Procedure, function, and trigger programs are named and stored in the database for re-use. For quick (one-time) execution (such as testing), you can simply enter the block without providing a name or storing it in the database.

A block of this type is called an *anonymous block*. An anonymous block is unnamed and is not stored in the database. Once the block has been executed and erased from the application buffer, it cannot be re-executed unless the block code is re-entered into the application.

Typically, the same block of code will be re-executed many times. In order to run a block of code repeatedly without the necessity of re-entering the code each time, with some simple modifications, an anonymous block can be turned into a procedure or function. The following sections discuss how to create a procedure or function that can be stored in the database and invoked repeatedly by another procedure, function, or application program.
3.2.3 Procedures Overview

Procedures are standalone SPL programs that are invoked or called as an individual SPL program statement. When called, procedures may optionally receive values from the caller in the form of input parameters and optionally return values to the caller in the form of output parameters.

3.2.3.1 Creating a Procedure

The `CREATE PROCEDURE` command defines and names a standalone procedure that will be stored in the database.

```
CREATE [ OR REPLACE ] PROCEDURE name [ (parameters) ]

[ IMMUTABLE
  | STABLE
  | VOLATILE
  | DETERMINISTIC
  | [ NOT ] LEAKPROOF
  | CALLED ON NULL INPUT
  | RETURNS NULL ON NULL INPUT
  | STRICT
  | [ EXTERNAL ] SECURITY INVOKER
  | [ EXTERNAL ] SECURITY DEFINER
  | AUTHID DEFINER
  | AUTHID CURRENT_USER
  | PARALLEL { UNSAFE | RESTRICTED | SAFE }
  | COST execution_cost
  | ROWS result_rows
  | SET configuration_parameter
    { TO value | = value | FROM CURRENT }

  ...]
  { IS | AS }
  [ declarations ]
BEGIN
  statements
END [ name ];
```

Where:

- `name` is the identifier of the procedure. If you specify the `[ OR REPLACE ]` clause and a procedure with the same name already exists in the schema, the new procedure will replace the existing one. If you do not specify `[ OR REPLACE ]`, the new procedure will not replace the existing procedure with the same name in the same schema.
parameters

parameters is a list of formal parameters.

declarations

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statements

statements are SPL program statements (the BEGIN-END block may contain an EXCEPTION section).

IMMUTABLE
STABLE
VOLATILE

These attributes inform the query optimizer about the behavior of the procedure; you can specify only one choice. VOLATILE is the default behavior.

IMMUTABLE indicates that the procedure cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the procedure with all-constant arguments can be immediately replaced with the procedure value.

STABLE indicates that the procedure cannot modify the database, and that within a single table scan, it will consistently return the same result for the same argument values, but that its result could change across SQL statements. This is the appropriate selection for procedures that depend on database lookups, parameter variables (such as the current time zone), etc.

VOLATILE indicates that the procedure value can change even within a single table scan, so no optimizations can be made. Please note that any function that has side-effects must be classified volatile, even if its result is quite predictable, to prevent calls from being optimized away.

DETERMINISTIC

DETERMINISTIC is a synonym for IMMUTABLE. A DETERMINISTIC procedure cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the procedure with all-constant arguments can be immediately replaced with the procedure value.
[ NOT ] LEAKPROOF

A LEAKPROOF procedure has no side effects, and reveals no information about the values used to call the procedure.

CALLED ON NULL INPUT
RETURNS NULL ON NULL INPUT
STRICT

CALLED ON NULL INPUT (the default) indicates that the procedure will be called normally when some of its arguments are NULL. It is the author's responsibility to check for NULL values if necessary and respond appropriately.

RETURNS NULL ON NULL INPUT or STRICT indicates that the procedure always returns NULL whenever any of its arguments are NULL. If these clauses are specified, the procedure is not executed when there are NULL arguments; instead a NULL result is assumed automatically.

[ EXTERNAL ] SECURITY DEFINER

SECURITY DEFINER specifies that the procedure will execute with the privileges of the user that created it; this is the default. The key word EXTERNAL is allowed for SQL conformance, but is optional.

[ EXTERNAL ] SECURITY INVOKER

The SECURITY INVOKER clause indicates that the procedure will execute with the privileges of the user that calls it. The key word EXTERNAL is allowed for SQL conformance, but is optional.

AUTHID DEFINER
AUTHID CURRENT_USER

The AUTHID DEFINER clause is a synonym for [EXTERNAL] SECURITY DEFINER. If the AUTHID clause is omitted or if AUTHID DEFINER is specified, the rights of the procedure owner are used to determine access privileges to database objects.

The AUTHID CURRENT_USER clause is a synonym for [EXTERNAL] SECURITY INVOKER. If AUTHID CURRENT_USER is specified, the rights of the current user executing the procedure are used to determine access privileges.

PARALLEL { UNSAFE | RESTRICTED | SAFE }
The `PARALLEL` clause enables the use of parallel sequential scans (parallel mode). A parallel sequential scan uses multiple workers to scan a relation in parallel during a query in contrast to a serial sequential scan.

When set to `UNSAFE`, the procedure cannot be executed in parallel mode. The presence of such a procedure forces a serial execution plan. This is the default setting if the `PARALLEL` clause is omitted.

When set to `RESTRICTED`, the procedure can be executed in parallel mode, but the execution is restricted to the parallel group leader. If the qualification for any particular relation has anything that is parallel restricted, that relation won't be chosen for parallelism.

When set to `SAFE`, the procedure can be executed in parallel mode with no restriction.

**COST** `execution_cost`

`execution_cost` is a positive number giving the estimated execution cost for the procedure, in units of `cpu_operator_cost`. If the procedure returns a set, this is the cost per returned row. Larger values cause the planner to try to avoid evaluating the function more often than necessary.

**ROWS** `result_rows`

`result_rows` is a positive number giving the estimated number of rows that the planner should expect the procedure to return. This is only allowed when the procedure is declared to return a set. The default assumption is 1000 rows.

**SET** `configuration_parameter` { TO value | = value | FROM CURRENT }

The `SET` clause causes the specified configuration parameter to be set to the specified value when the procedure is entered, and then restored to its prior value when the procedure exits. `SET FROM CURRENT` saves the session's current value of the parameter as the value to be applied when the procedure is entered.

If a `SET` clause is attached to a procedure, then the effects of a `SET LOCAL` command executed inside the procedure for the same variable are restricted to the procedure; the configuration parameter's prior value is restored at procedure exit. An ordinary `SET` command (without `LOCAL`) overrides the `SET` clause, much as it would do for a previous `SET LOCAL` command, with the effects of such a command persisting after procedure exit, unless the current transaction is rolled back.

**Please Note:** The `STRICT`, `LEAKPROOF`, `PARALLEL`, `COST`, `ROWS` and `SET` keywords provide extended functionality for Advanced Server and are not supported by Oracle.
Example

The following is an example of a simple procedure that takes no parameters.

```sql
CREATE OR REPLACE PROCEDURE simple_procedure
IS
BEGIN
    DBMS_OUTPUT.PUT_LINE('That''s all folks!');
END simple_procedure;
```

The procedure is stored in the database by entering the procedure code in Advanced Server.

The following example demonstrates using the `AUTHID DEFINER` and `SET` clauses in a procedure declaration. The `update_salary` procedure conveys the privileges of the role that defined the procedure to the role that is calling the procedure (while the procedure executes):

```sql
CREATE OR REPLACE PROCEDURE update_salary(id INT, new_salary NUMBER)
SET SEARCH_PATH = 'public' SET WORK_MEM = '1MB'
AUTHID DEFINER IS
BEGIN
    UPDATE emp SET salary = new_salary WHERE emp_id = id;
END;
```

Include the `SET` clause to set the procedure's search path to `public` and the work memory to `1MB`. Other procedures, functions and objects will not be affected by these settings.

In this example, the `AUTHID DEFINER` clause temporarily grants privileges to a role that might otherwise not be allowed to execute the statements within the procedure. To instruct the server to use the privileges associated with the role invoking the procedure, replace the `AUTHID DEFINER` clause with the `AUTHID CURRENT_USER` clause.

### 3.2.3.2 Calling a Procedure

A procedure can be invoked from another SPL program by simply specifying the procedure name followed by its parameters, if any, followed by a semicolon.

```
name [ ([ parameters ]) ];
```

Where:

- `name` is the identifier of the procedure.
- `parameters` is a list of actual parameters.

**Note:** If there are no actual parameters to be passed, the procedure may be called with an empty parameter list, or the opening and closing parenthesis may be omitted entirely.
**Note:** The syntax for calling a procedure is the same as in the preceding syntax diagram when executing it with the `EXEC` command in PSQL or EDB*Plus. See the *Database Compatibility for Oracle Developers Tools and Utilities Guide* for information about the `EXEC` command.

The following is an example of calling the procedure from an anonymous block:

```sql
BEGIN
  simple_procedure;
END;
That's all folks!
```

**Note:** Each application has its own unique way to call a procedure. For example, in a Java application, the application programming interface, JDBC, is used.

### 3.2.3.3 Deleting a Procedure

A procedure can be deleted from the database using the `DROP PROCEDURE` command.

```sql
DROP PROCEDURE name;
```

Where `name` is the name of the procedure to be dropped.

The previously created procedure is dropped in this example:

```sql
DROP PROCEDURE simple_procedure;
```
3.2.4 Functions Overview

Functions are standalone SPL programs that are invoked as expressions. When evaluated, a function returns a value that is substituted in the expression in which the function is embedded. Functions may optionally take values from the calling program in the form of input parameters. In addition to the fact that the function, itself, returns a value, a function may optionally return additional values to the caller in the form of output parameters. The use of output parameters in functions, however, is not an encouraged programming practice.

3.2.4.1 Creating a Function

The CREATE FUNCTION command defines and names a standalone function that will be stored in the database.

```
CREATE [ OR REPLACE ] FUNCTION name [ (parameters) ]
    RETURN data_type
    [ IMMTABLE | STABLE | VOLATILE | DETERMINISTIC | [ NOT ] LEAKPROOF | CALLED ON NULL INPUT | RETURNS NULL ON NULL INPUT | STRICT | [ EXTERNAL ] SECURITY INVOKER | [ EXTERNAL ] SECURITY DEFINER | AUTHID DEFINER | AUTHID CURRENT_USER | PARALLEL { UNSAFE | RESTRICTED | SAFE } | COST execution_cost | ROWS result_rows | SET configuration_parameter
    { TO value | = value | FROM CURRENT }

...]
{ IS | AS }
    [ declarations ]
BEGIN
    statements
END [ name ];
```

Where:

name
name is the identifier of the function. If you specify the [OR REPLACE] clause and a function with the same name already exists in the schema, the new function will replace the existing one. If you do not specify [OR REPLACE], the new function will not replace the existing function with the same name in the same schema.

parameters

parameters is a list of formal parameters.

data_type

data_type is the data type of the value returned by the function’s RETURN statement.

declarations

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statements

statements are SPL program statements (the BEGIN-END block may contain an EXCEPTION section).

IMMUTABLE
STABLE
VOLATILE

These attributes inform the query optimizer about the behavior of the function; you can specify only one choice. VOLATILE is the default behavior.

IMMUTABLE indicates that the function cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the function with all-constant arguments can be immediately replaced with the function value.

STABLE indicates that the function cannot modify the database, and that within a single table scan, it will consistently return the same result for the same argument values, but that its result could change across SQL statements. This is the appropriate selection for function that depend on database lookups, parameter variables (such as the current time zone), etc.
VOLATILE indicates that the function value can change even within a single table scan, so no optimizations can be made. Please note that any function that has side-effects must be classified volatile, even if its result is quite predictable, to prevent calls from being optimized away.

DETERMINISTIC

DETERMINISTIC is a synonym for IMMUTABLE. A DETERMINISTIC function cannot modify the database and always reaches the same result when given the same argument values; it does not do database lookups or otherwise use information not directly present in its argument list. If you include this clause, any call of the function with all-constant arguments can be immediately replaced with the function value.

[ NOT ] LEAKPROOF

A LEAKPROOF function has no side effects, and reveals no information about the values used to call the function.

CALLED ON NULL INPUT
RETURNS NULL ON NULL INPUT
STRICT

CALLED ON NULL INPUT (the default) indicates that the procedure will be called normally when some of its arguments are NULL. It is the author's responsibility to check for NULL values if necessary and respond appropriately.

RETURNS NULL ON NULL INPUT or STRICT indicates that the procedure always returns NULL whenever any of its arguments are NULL. If these clauses are specified, the procedure is not executed when there are NULL arguments; instead a NULL result is assumed automatically.

[ EXTERNAL ] SECURITY DEFINER

SECURITY DEFINER specifies that the function will execute with the privileges of the user that created it; this is the default. The key word EXTERNAL is allowed for SQL conformance, but is optional.

[ EXTERNAL ] SECURITY INVOKER

The SECURITY INVOKER clause indicates that the function will execute with the privileges of the user that calls it. The key word EXTERNAL is allowed for SQL conformance, but is optional.

AUTHID DEFINER
AUTHID CURRENT_USER
The **AUTHID DEFINER** clause is a synonym for **[EXTERNAL] SECURITY DEFINER**. If the **AUTHID** clause is omitted or if **AUTHID DEFINER** is specified, the rights of the function owner are used to determine access privileges to database objects.

The **AUTHID CURRENT_USER** clause is a synonym for **[EXTERNAL] SECURITY INVOKER**. If **AUTHID CURRENT_USER** is specified, the rights of the current user executing the function are used to determine access privileges.

**PARALLEL { UNSAFE | RESTRICTED | SAFE }**

The **PARALLEL** clause enables the use of parallel sequential scans (parallel mode). A parallel sequential scan uses multiple workers to scan a relation in parallel during a query in contrast to a serial sequential scan.

When set to **UNSAFE**, the function cannot be executed in parallel mode. The presence of such a function in a SQL statement forces a serial execution plan. This is the default setting if the **PARALLEL** clause is omitted.

When set to **RESTRICTED**, the function can be executed in parallel mode, but the execution is restricted to the parallel group leader. If the qualification for any particular relation has anything that is parallel restricted, that relation won't be chosen for parallelism.

When set to **SAFE**, the function can be executed in parallel mode with no restriction.

**COST execution_cost**

**execution_cost** is a positive number giving the estimated execution cost for the function, in units of **cpu_operator_cost**. If the function returns a set, this is the cost per returned row. Larger values cause the planner to try to avoid evaluating the function more often than necessary.

**ROWS result_rows**

**result_rows** is a positive number giving the estimated number of rows that the planner should expect the function to return. This is only allowed when the function is declared to return a set. The default assumption is 1000 rows.

**SET configuration_parameter { TO value | = value | FROM CURRENT }**

The **SET** clause causes the specified configuration parameter to be set to the specified value when the function is entered, and then restored to its prior value when the function exits. **SET FROM CURRENT** saves the session's current value of the parameter as the value to be applied when the function is entered.
If a `SET` clause is attached to a function, then the effects of a `SET LOCAL` command executed inside the function for the same variable are restricted to the function; the configuration parameter's prior value is restored at function exit. An ordinary `SET` command (without `LOCAL`) overrides the `SET` clause, much as it would do for a previous `SET LOCAL` command, with the effects of such a command persisting after procedure exit, unless the current transaction is rolled back.

Please Note: The `STRICT`, `LEAKPROOF`, `PARALLEL`, `COST`, `ROWS` and `SET` keywords provide extended functionality for Advanced Server and are not supported by Oracle.

**Examples**

The following is an example of a simple function that takes no parameters.

```sql
CREATE OR REPLACE FUNCTION simple_function
  RETURN VARCHAR2
IS
  BEGIN
    RETURN 'That''s All Folks!';
  END simple_function;
```

The following function takes two input parameters. Parameters are discussed in more detail in subsequent sections.

```sql
CREATE OR REPLACE FUNCTION emp_comp (p_sal NUMBER, p_comm NUMBER) RETURN NUMBER
IS
    BEGIN
    RETURN (p_sal + NVL(p_comm, 0)) * 24;
END emp_comp;
```

The following example demonstrates using the `AUTHID CURRENT_USER` clause and `STRICT` keyword in a function declaration:

```sql
CREATE OR REPLACE FUNCTION dept_salaries(dept_id int) RETURN NUMBER
STRICT
AUTHID CURRENT_USER
BEGIN
    RETURN QUERY (SELECT sum(salary) FROM emp WHERE deptno = id);
END;
```

Include the `STRICT` keyword to instruct the server to return `NULL` if any input parameter passed is `NULL`; if a `NULL` value is passed, the function will not execute.

The `dept_salaries` function executes with the privileges of the role that is calling the function. If the current user does not have sufficient privileges to perform the `SELECT` statement querying the `emp` table (to display employee salaries), the function will report an error. To instruct the server to use the privileges associated with the role that defined
3.2.4.2 Calling a Function

A function can be used anywhere an expression can appear within an SPL statement. A function is invoked by simply specifying its name followed by its parameters enclosed in parenthesis, if any.

\[
name \ [ ( [ \ parameters \ ] ) ]
\]

\textit{name} is the name of the function. \textit{parameters} is a list of actual parameters.

\textbf{Note:} If there are no actual parameters to be passed, the function may be called with an empty parameter list, or the opening and closing parenthesis may be omitted entirely.

The following shows how the function can be called from another SPL program.

```
BEGIN
   DBMS_OUTPUT.PUT_LINE(simple_function);
END;
```

That's All Folks!

A function is typically used within a SQL statement as shown in the following.

```
SELECT empno "EMPNO", ename "ENAME", sal "SAL", comm "COMM",
       emp_comp(sal, comm) "YEARLY COMPENSATION" FROM emp;
```

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>SAL</th>
<th>COMM</th>
<th>YEARLY COMPENSATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>800.00</td>
<td></td>
<td>19200.00</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>1600.00</td>
<td>300.00</td>
<td>45600.00</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>1250.00</td>
<td>500.00</td>
<td>42000.00</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>2975.00</td>
<td></td>
<td>71400.00</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>1250.00</td>
<td>1400.00</td>
<td>63600.00</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>2850.00</td>
<td></td>
<td>68400.00</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>2450.00</td>
<td></td>
<td>58800.00</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>3000.00</td>
<td></td>
<td>72000.00</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>5000.00</td>
<td></td>
<td>120000.00</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>1500.00</td>
<td>0.00</td>
<td>36000.00</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>1100.00</td>
<td></td>
<td>26400.00</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>950.00</td>
<td></td>
<td>22800.00</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>3000.00</td>
<td></td>
<td>72000.00</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>1300.00</td>
<td></td>
<td>31200.00</td>
</tr>
</tbody>
</table>

(14 rows)
3.2.4.3 Deleting a Function

A function can be deleted from the database using the `DROP FUNCTION` command.

```
DROP FUNCTION name [ (parameters) ];
```

Where `name` is the name of the function to be dropped.

**Note:** The specification of the parameter list is required in Advanced Server under certain circumstances. Oracle requires that the parameter list always be omitted.

The previously created function is dropped in this example:

```
DROP FUNCTION simple_function;
```
3.2.5 Procedure and Function Parameters

An important aspect of using procedures and functions is the capability to pass data from the calling program to the procedure or function and to receive data back from the procedure or function. This is accomplished by using parameters.

Parameters are declared in the procedure or function definition, enclosed within parenthesis following the procedure or function name. Parameters declared in the procedure or function definition are known as formal parameters. When the procedure or function is invoked, the calling programs supplies the actual data that is to be used in the called program’s processing as well as the variables that are to receive the results of the called program’s processing. The data and variables supplied by the calling program when the procedure or function is called are referred to as the actual parameters.

The following is the general format of a formal parameter declaration.

```
(name [ IN | OUT | IN OUT ] data_type [ DEFAULT value ])
```

`name` is an identifier assigned to the formal parameter. If specified, `IN` defines the parameter for receiving input data into the procedure or function. An `IN` parameter can also be initialized to a default value. If specified, `OUT` defines the parameter for returning data from the procedure or function. If specified, `IN OUT` allows the parameter to be used for both input and output. If all of `IN`, `OUT`, and `IN OUT` are omitted, then the parameter acts as if it were defined as `IN` by default. Whether a parameter is `IN`, `OUT`, or `IN OUT` is referred to as the parameter’s mode. `data_type` defines the data type of the parameter. `value` is a default value assigned to an `IN` parameter in the called program if an actual parameter is not specified in the call.

The following is an example of a procedure that takes parameters:

```
CREATE OR REPLACE PROCEDURE emp_query ( 
    p_deptno        IN     NUMBER, 
    p_empno         IN OUT NUMBER, 
    p_ename         IN OUT VARCHAR2, 
    p_job           OUT    VARCHAR2, 
    p_hiredate      OUT    DATE, 
    p_sal           OUT    NUMBER 
) 
IS 
BEGIN 
    SELECT empno, ename, job, hiredate, sal 
    INTO p_empno, p_ename, p_job, p_hiredate, p_sal 
    FROM emp 
    WHERE deptno = p_deptno 
    AND (empno = p_empno 
    OR ename = UPPER(p_ename)); 
END;
```
In this example, \texttt{p_deptno} is an \texttt{IN} formal parameter, \texttt{p_empno} and \texttt{p_ename} are \texttt{IN OUT} formal parameters, and \texttt{p_job}, \texttt{p_hiredate}, and \texttt{p_sal} are \texttt{OUT} formal parameters.

\textbf{Note:} In the previous example, no maximum length was specified on the \texttt{VARCHAR2} parameters and no precision and scale were specified on the \texttt{NUMBER} parameters. It is illegal to specify a length, precision, scale or other constraints on parameter declarations. These constraints are automatically inherited from the actual parameters that are used when the procedure or function is called.

The \texttt{emp_query} procedure can be called by another program, passing it the actual parameters. The following is an example of another SPL program that calls \texttt{emp_query}.

```sql
DECLARE
  v_deptno        NUMBER(2);
  v_empno         NUMBER(4);
  v_ename         VARCHAR2(10);
  v_job           VARCHAR2(9);
  v_hiredate      DATE;
  v_sal           NUMBER;
BEGIN
  v_deptno := 30;
  v_empno  := 7900;
  v_ename  := 'JAMES';
  emp_query(v_deptno, v_empno, v_ename, v_job, v_hiredate, v_sal);
  DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);
  DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);
  DBMS_OUTPUT.PUT_LINE('Name       : ' || v_ename);
  DBMS_OUTPUT.PUT_LINE('Job        : ' || v_job);
  DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || v_hiredate);
  DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);
END;
```

In this example, \texttt{v_deptno}, \texttt{v_empno}, \texttt{v_ename}, \texttt{v_job}, \texttt{v_hiredate}, and \texttt{v_sal} are the actual parameters.

The output from the preceding example is shown as follows:

```
Department : 30
Employee No: 7900
Name       : JAMES
Job        : CLERK
Hire Date  : 03-DEC-81
Salary     : 950
```

\subsection*{3.2.5.1 Positional vs. Named Parameter Notation}

You can use either \textit{positional} or \textit{named} parameter notation when passing parameters to a function or procedure. If you specify parameters using positional notation, you must list the parameters in the order that they are declared; if you specify parameters with named notation, the order of the parameters is not significant.
To specify parameters using named notation, list the name of each parameter followed by an arrow (=>) and the parameter value. Named notation is more verbose, but makes your code easier to read and maintain.

A simple example that demonstrates using positional and named parameter notation follows:

```sql
CREATE OR REPLACE PROCEDURE emp_info (  
p_deptno IN NUMBER,  
p_empno IN OUT NUMBER,  
p_ename IN OUT VARCHAR2,  
)  
IS  
BEGIN  
dbms_output.put_line('Department Number = ' || p_deptno);  
dbms_output.put_line('Employee Number = ' || p_empno);  
dbms_output.put_line('Employee Name = ' || p_ename);  
END;
```

To call the procedure using positional notation, pass the following:

```sql
emp_info(30, 7455, 'Clark');
```

To call the procedure using named notation, pass the following:

```sql
emp_info(p_ename =>'Clark', p_empno=>7455, p_deptno=>30);
```

Using named notation can alleviate the need to re-arrange a procedure’s parameter list if the parameter list changes, if the parameters are reordered or if a new optional parameter is added.

In a case where you have a default value for an argument and the argument is not a trailing argument, you must use named notation to call the procedure or function. The following case demonstrates a procedure with two, leading, default arguments.

```sql
CREATE OR REPLACE PROCEDURE check_balance (  
p_customerID IN NUMBER DEFAULT NULL,  
p_balance IN NUMBER DEFAULT NULL,  
p_amount IN NUMBER  
)  
IS  
DECLARE  
    balance NUMBER;  
BEGIN  
    IF (p_balance IS NULL AND p_customerID IS NULL) THEN  
        RAISE_APPLICATION_ERROR  
            (-20010, 'Must provide balance or customer');  
    ELSEIF (p_balance IS NOT NULL AND p_customerID IS NOT NULL) THEN  
        RAISE_APPLICATION_ERROR  
            (-20020, 'Must provide balance or customer, not both');  
    ELSEIF (p_balance IS NULL) THEN  
        RAISE_APPLICATION_ERROR  
            (-20030, 'Must provide customer');  
    END IF;
```
balance := getCustomerBalance(p_customerID);
ELSE
    balance := p_balance;
END IF;

IF (amount > balance) THEN
    RAISE APPLICATION_ERROR
      (-20030, 'Balance insufficient');
END IF;
END;

You can only omit non-trailing argument values (when you call this procedure) by using named notation; when using positional notation, only trailing arguments are allowed to default. You can call this procedure with the following arguments:

    check_balance(p_customerID => 10, p_amount = 500.00)
    check_balance(p_balance => 1000.00, p_amount = 500.00)

You can use a combination of positional and named notation (mixed notation) to specify parameters. A simple example that demonstrates using mixed parameter notation follows:

    CREATE OR REPLACE PROCEDURE emp_info (  
        p_deptno        IN     NUMBER,  
        p_empno         IN OUT NUMBER,  
        p_ename         IN OUT VARCHAR2,  
    ) IS
    BEGIN
        dbms_output.put_line('Department Number = ' || p_deptno);
        dbms_output.put_line('Employee Number = ' || p_empno);
        dbms_output.put_line('Employee Name = ' || p_ename);
    END;

You can call the procedure using mixed notation:

    emp_info(30, p_ename =>'Clark', p_empno=>7455);

If you do use mixed notation, remember that named arguments cannot precede positional arguments.

3.2.5.2 Parameter Modes

As previously discussed, a parameter has one of three possible modes - IN, OUT, or IN OUT. The following characteristics of a formal parameter are dependent upon its mode:

- Its initial value when the procedure or function is called.
- Whether or not the called procedure or function can modify the formal parameter.
• How the actual parameter value is passed from the calling program to the called program.
• What happens to the formal parameter value when an unhandled exception occurs in the called program.

The following table summarizes the behavior of parameters according to their mode.

**Table 3-1 Parameter Modes**

<table>
<thead>
<tr>
<th>Mode Property</th>
<th>IN</th>
<th>IN OUT</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Formal parameter initialized to:</td>
<td>Actual parameter value</td>
<td>Actual parameter value</td>
<td>Actual parameter value</td>
</tr>
<tr>
<td>Formal parameter modifiable by the called program?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Actual parameter contains: (after normal called program termination)</td>
<td>Original actual parameter value prior to the call</td>
<td>Last value of the formal parameter</td>
<td>Last value of the formal parameter</td>
</tr>
<tr>
<td>Actual parameter contains: (after a handled exception in the called program)</td>
<td>Original actual parameter value prior to the call</td>
<td>Last value of the formal parameter</td>
<td>Last value of the formal parameter</td>
</tr>
<tr>
<td>Actual parameter contains: (after an unhandled exception in the called program)</td>
<td>Original actual parameter value prior to the call</td>
<td>Original actual parameter value prior to the call</td>
<td>Original actual parameter value prior to the call</td>
</tr>
</tbody>
</table>

As shown by the table, an **IN** formal parameter is initialized to the actual parameter with which it is called unless it was explicitly initialized with a default value. The **IN** parameter may be referenced within the called program, however, the called program may not assign a new value to the **IN** parameter. After control returns to the calling program, the actual parameter always contains the same value as it was set to prior to the call.

The **OUT** formal parameter is initialized to the actual parameter with which it is called. The called program may reference and assign new values to the formal parameter. If the called program terminates without an exception, the actual parameter takes on the value last set in the formal parameter. If a handled exception occurs, the value of the actual parameter takes on the last value assigned to the formal parameter. If an unhandled exception occurs, the value of the actual parameter remains as it was prior to the call.

Like an **IN** parameter, an **IN OUT** formal parameter is initialized to the actual parameter with which it is called. Like an **OUT** parameter, an **IN OUT** formal parameter is modifiable by the called program and the last value in the formal parameter is passed to the calling program’s actual parameter if the called program terminates without an exception. If a handled exception occurs, the value of the actual parameter takes on the last value assigned to the formal parameter. If an unhandled exception occurs, the value of the actual parameter remains as it was prior to the call.
3.2.5.3 Using Default Values in Parameters

You can set a default value of a formal parameter by including the DEFAULT clause or using the assignment operator (:=) in the CREATE PROCEDURE or CREATE FUNCTION statement.

The general form of a formal parameter declaration is:

\[
(name \ [ \ IN|OUT|IN\ OUT \ ] \ data\_type \ [{\{DEFAULT \ | \ := \ } \ expr \ ])
\]

- **name** is an identifier assigned to the parameter.
- **IN|OUT|IN\ OUT** specifies the parameter mode.
- **data\_type** is the data type assigned to the variable.
- **expr** is the default value assigned to the parameter. If you do not include a DEFAULT clause, the caller must provide a value for the parameter.

The default value is evaluated every time the function or procedure is invoked. For example, assigning SYSDATE to a parameter of type DATE causes the parameter to have the time of the current invocation, not the time when the procedure or function was created.

The following simple procedure demonstrates using the assignment operator to set a default value of SYSDATE into the parameter, hiredate:

```sql
CREATE OR REPLACE PROCEDURE hire_emp ( 
  p_empno NUMBER, 
  p_ename VARCHAR2, 
  p_hiredate DATE := SYSDATE 
) 
IS 
BEGIN 
  INSERT INTO emp(empno, ename, hiredate) 
  VALUES(p_empno, p_ename, p_hiredate); 
  DBMS_OUTPUT.PUT_LINE('Hired!'); 
END hire_emp;
```

If the parameter declaration includes a default value, you can omit the parameter from the actual parameter list when you call the procedure. Calls to the sample procedure (hire_emp) must include two arguments: the employee number (p_empno) and employee name (p_ename). The third parameter (p_hiredate) defaults to the value of SYSDATE:

```sql
hire_emp (7575, Clark)
```
If you do include a value for the actual parameter when you call the procedure, that value takes precedence over the default value:

```sql
hire_emp (7575, Clark, 15-FEB-2010)
```

Adds a new employee with a hiredate of February 15, 2010, regardless of the current value of SYSDATE.

You can write the same procedure by substituting the `DEFAULT` keyword for the assignment operator:

```sql
CREATE OR REPLACE PROCEDURE hire_emp (
  p_empno         NUMBER,
  p_ename         VARCHAR2,
  p_hiredate      DATE DEFAULT SYSDATE
) IS
BEGIN
  INSERT INTO emp(empno, ename, hiredate)
  VALUES(p_empno, p_ename, p_hiredate);
  DBMS_OUTPUT.PUT_LINE('Hired!');
END hire_emp;
```

### 3.2.6 Subprograms – Subprocedures and Subfunctions

The capability and functionality of SPL procedure and function programs can be used in an advantageous manner to build well-structured and maintainable programs by organizing the SPL code into subprocedures and subfunctions.

The same SPL code can be invoked multiple times from different locations within a relatively large SPL program by declaring subprocedures and subfunctions within the SPL program.

Subprocedures and subfunctions have the following characteristics:

- The syntax, structure, and functionality of subprocedures and subfunctions are practically identical to standalone procedures and functions. The major difference is the use of the keyword `PROCEDURE` or `FUNCTION` instead of `CREATE PROCEDURE` or `CREATE FUNCTION` to declare the subprogram.
- Subprocedures and subfunctions provide isolation for the identifiers (that is, variables, cursors, types, and other subprograms) declared within itself. That is, these identifiers cannot be accessed or altered from the upper, parent level SPL programs or subprograms outside of the subprocedure or subfunction. This ensures that the subprocedure and subfunction results are reliable and predictable.
- The declaration section of subprocedures and subfunctions can include its own subprocedures and subfunctions. Thus, a multi-level hierarchy of subprograms...
can exist in the standalone program. Within the hierarchy, a subprogram can access the identifiers of upper level parent subprograms and also invoke upper level parent subprograms. However, the same access to identifiers and invocation cannot be done for lower level child subprograms in the hierarchy.

Subprocedures and subfunctions can be declared and invoked from within any of the following types of SPL programs:

- Standalone procedures and functions
- Anonymous blocks
- Triggers
- Packages
- Procedure and function methods of an object type body
- Subprocedures and subfunctions declared within any of the preceding programs

The rules regarding subprocedure and subfunction structure and access are discussed in more detail in the next sections.

### 3.2.6.1 Creating a Subprocedure

The `PROCEDURE` clause specified in the declaration section defines and names a subprocedure local to that block.

The term *block* refers to the SPL block structure consisting of an optional declaration section, a mandatory executable section, and an optional exception section. Blocks are the structures for standalone procedures and functions, anonymous blocks, subprograms, triggers, packages, and object type methods.

The phrase *the identifier is local to the block* means that the identifier (that is, a variable, cursor, type, or subprogram) is declared within the declaration section of that block and is therefore accessible by the SPL code within the executable section and optional exception section of that block.

Subprocedures can only be declared after all other variable, cursor, and type declarations included in the declaration section. (That is, subprograms must be the last set of declarations.)

```sql
PROCEDURE name [ (parameters) ]
{ IS | AS }
  [ declarations ]
BEGIN
  statements
END [ name ];
```

Where:
name

name is the identifier of the subprocedure.

parameters

parameters is a list of formal parameters.

declarations

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statements

statements are SPL program statements (the BEGIN-END block may contain an EXCEPTION section).

Examples

The following example is a subprocedure within an anonymous block.

```sql
DECLARE
    PROCEDURE list_emp IS
        v_empno NUMBER(4);
        v_ename VARCHAR2(10);
        CURSOR emp_cur IS
            SELECT empno, ename FROM emp ORDER BY empno;
        BEGIN
            OPEN emp_cur;
            DBMS_OUTPUT.PUT_LINE('Subprocedure list_emp:');
            DBMS_OUTPUT.PUT_LINE('EMPNO   ENAME');
            DBMS_OUTPUT.PUT_LINE('-----   ------');
            LOOP
                FETCH emp_cur INTO v_empno, v_ename;
                EXIT WHEN emp_cur%NOTFOUND;
                DBMS_OUTPUT.PUT_LINE(v_empno || ' ' || v_ename);
            END LOOP;
            CLOSE emp_cur;
        END;
    BEGIN
        list_emp;
    END;
```

Invoking this anonymous block produces the following output:

```
Subprocedure list_emp:
EMPNO   ENAME
-----   ------
7369    SMITH
7499    ALLEN
7521    WARD
```
The following example is a subprocedure within a trigger.

```sql
CREATE OR REPLACE TRIGGER dept_audit_trig
    AFTER INSERT OR UPDATE OR DELETE ON dept
DECLARE
    v_action VARCHAR2(24);
    PROCEDURE display_action (p_action IN VARCHAR2)
    IS
    BEGIN
        DBMS_OUTPUT.PUT_LINE('User ' || USER || ' ' || p_action || ' dept on ' || TO_CHAR(SYSDATE,'YYYY-MM-DD'));
    END display_action;
BEGIN
    IF INSERTING THEN
        v_action := 'added';
    ELSIF UPDATING THEN
        v_action := 'updated';
    ELSIF DELETING THEN
        v_action := 'deleted';
    END IF;
    display_action(v_action);
END;
```

Invoking this trigger produces the following output:

```sql
INSERT INTO dept VALUES (50,'HR','DENVER');
User enterprisedb added dept on 2016-07-26
```

### 3.2.6.2 Creating a Subfunction

The `FUNCTION` clause specified in the declaration section defines and names a subfunction local to that block.

The term *block* refers to the SPL block structure consisting of an optional declaration section, a mandatory executable section, and an optional exception section. Blocks are the structures for standalone procedures and functions, anonymous blocks, subprograms, triggers, packages, and object type methods.
The phrase *the identifier is local to the block* means that the identifier (that is, a variable, cursor, type, or subprogram) is declared within the declaration section of that block and is therefore accessible by the SPL code within the executable section and optional exception section of that block.

```pl
FUNCTION name [ (parameters) ]
RETURN data_type
{ IS | AS }
[ declarations ]
BEGIN
  statements
END [ name ];
```

**Where:**

- `name` is the identifier of the subfunction.
- `parameters` is a list of formal parameters.
- `data_type` is the data type of the value returned by the function’s `RETURN` statement.
- `declarations` are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.
- `statements` are SPL program statements (the `BEGIN-END` block may contain an `EXCEPTION` section).

**Examples**

The following example shows the use of a recursive subfunction:

```pl
DECLARE
  FUNCTION factorial (n BINARY_INTEGER)
  RETURN BINARY_INTEGER
IS
BEGIN
```
IF n = 1 THEN
RETURN n;
ELSE
RETURN n * factorial(n-1);
END IF;
END factorial;
BEGIN
FOR i IN 1..5 LOOP
   DBMS_OUTPUT.PUT_LINE(i || '!' = ' || factorial(i));
END LOOP;
END;

The output from the example is the following:

1! = 1
2! = 2
3! = 6
4! = 24
5! = 120

3.2.6.3 Block Relationships

This section describes the terminology of the relationship between blocks that can be declared in an SPL program. The ability to invoke subprograms and access identifiers declared within a block depends upon this relationship.

The following are the basic terms:

- A block is the basic SPL structure consisting of an optional declaration section, a mandatory executable section, and an optional exception section. Blocks implement standalone procedure and function programs, anonymous blocks, triggers, packages, and subprocedures and subfunctions.
- An identifier (variable, cursor, type, or subprogram) local to a block means that it is declared within the declaration section of the given block. Such local identifiers are accessible from the executable section and optional exception section of the block.
- The parent block contains the declaration of another block (the child block). Descendent blocks are the set of blocks forming the child relationship starting from a given parent block.
- Ancestor blocks are the set of blocks forming the parental relationship starting from a given child block.
- The set of descendent (or ancestor) blocks form a hierarchy.
- The level is an ordinal number of a given block from the highest, ancestor block. For example, given a standalone procedure, the subprograms declared within the declaration section of this procedure are all at the same level, for example call it level 1. Additional subprograms within the declaration section of the subprograms declared in the standalone procedure are at the next level, which is level 2.
• The sibling blocks are the set of blocks that have the same parent block (that is, they are all locally declared in the same block). Sibling blocks are also always at the same level relative to each other.

The following schematic of a set of procedure declaration sections provides an example of a set of blocks and their relationships to their surrounding blocks.

The two vertical lines on the left-hand side of the blocks indicate there are two pairs of sibling blocks. block_1a and block_1b is one pair, and block_2a and block_2b is the second pair.

The relationship of each block with its ancestors is shown on the right-hand side of the blocks. There are three hierarchical paths formed when progressing up the hierarchy from the lowest level child blocks. The first consists of block_0, block_1a, block_2a, and block_3. The second is block_0, block_1a, and block_2b. The third is block_0, block_1b, and block_2b.
CREATE PROCEDURE block_0
IS
  .
  +---- PROCEDURE block_1a  +---- Local to block_0
    IS
      .
      .
      .
      +---- PROCEDURE block_2a  +---- Local to block_1a and descendant
      IS
        .
        .
        .
        .
        +---- PROCEDURE block_3  +---- Local to block_2a and descendant
        IS
          .
          .
          .
          .
          Siblings
          |    .
          |    .
          |    .
          |    .
          |    END block_3;
          |    END block_2a;
          +---- PROCEDURE block_2b  +---- Local to block_1a and descendant
          IS
            .
            .
            .
            Siblings
            |    .
            |    .
            |    .
            |    .
            |    END block_2b;
            |    END block_1a;
            +---- PROCEDURE block_1b  +---- Local to block_0
            IS
              .
              .
              .
              .
              PROCEDURE block_2b  +---- Local to block_1b and descendant
              IS
                .
                .
                .
                END block_2b;
                +---- END block_1b;
BEGIN
  .
  .
END block_0;

The rules for invoking subprograms based upon block location is described starting with Section 3.2.6.4. The rules for accessing variables based upon block location is described in Section 3.2.6.7.

3.2.6.4 Invoking Subprograms

A subprogram is invoked in the same manner as a standalone procedure or function by specifying its name and any actual parameters.

The subprogram may be invoked with none, one, or more qualifiers, which are the names of the parent subprograms or labeled anonymous blocks forming the ancestor hierarchy from where the subprogram has been declared.
The invocation is specified as a dot-separated list of qualifiers ending with the subprogram name and any of its arguments as shown by the following:

```
[[qualifier_1.] [... ] qualifier_n.] subprog [(arguments)]
```

If specified, qualifier_n is the subprogram in which subprog has been declared in its declaration section. The preceding list of qualifiers must reside in a continuous path up the hierarchy from qualifier_n to qualifier_1. qualifier_1 may be any ancestor subprogram in the path as well as any of the following:

- Standalone procedure name containing the subprogram
- Standalone function name containing subprogram
- Package name containing the subprogram
- Object type name containing the subprogram within an object type method
- An anonymous block label included prior to the DECLARE keyword if a declaration section exists, or prior to the BEGIN keyword if there is no declaration section.

**Note:** qualifier_1 may not be a schema name, otherwise an error is thrown upon invocation of the subprogram. This Advanced Server restriction is not compatible with Oracle databases, which allow use of the schema name as a qualifier.

arguments is the list of actual parameters to be passed to the subprocedure or subfunction.

Upon invocation, the search for the subprogram occurs as follows:

- The invoked subprogram name of its type (that is, subprocedure or subfunction) along with any qualifiers in the specified order, (referred to as the invocation list) is used to find a matching set of blocks residing in the same hierarchical order. The search begins in the block hierarchy where the lowest level is the block from where the subprogram is invoked. The declaration of the subprogram must be in the SPL code prior to the code line where it is invoked when the code is observed from top to bottom. (An exception to this requirement can be accomplished using a forward declaration. See Section 3.2.6.5 for information on forward declarations.)
- If the invocation list does not match the hierarchy of blocks starting from the block where the subprogram is invoked, a comparison is made by matching the invocation list starting with the parent of the previous starting block. In other words, the comparison progresses up the hierarchy.
- If there are sibling blocks of the ancestors, the invocation list comparison also includes the hierarchy of the sibling blocks, but always comparing in an upward level, never comparing the descendants of the sibling blocks.
- This comparison process continues up the hierarchies until the first complete match is found in which case the located subprogram is invoked. Note that the formal parameter list of the matched subprogram must comply with the actual
parameter list specified for the invoked subprogram, otherwise an error occurs
upon invocation of the subprogram.

- If no match is found after searching up to the standalone program, then an error is
  thrown upon invocation of the subprogram.

**Note:** The Advanced Server search algorithm for subprogram invocation is not quite
compatible with Oracle databases. For Oracle, the search looks for the first match of the
first qualifier (that is `qualifier_1`). When such a match is found, all remaining
qualifiers, the subprogram name, subprogram type, and arguments of the invocation must
match the hierarchy content where the matching first qualifier is found, otherwise an
error is thrown. For Advanced Server, a match is not found unless all qualifiers, the
subprogram name, and the subprogram type of the invocation match the hierarchy
content. If such an exact match is not initially found, Advanced Server continues the
search progressing up the hierarchy.

The location of subprograms relative to the block from where the invocation is made can
be accessed as follows:

- Subprograms declared in the local block can be invoked from the executable
  section or the exception section of the same block.
- Subprograms declared in the parent or other ancestor blocks can be invoked from
  the child block of the parent or other ancestors.
- Subprograms declared in sibling blocks can be called from a sibling block or from
  any descendent block of the sibling.

However, the following location of subprograms cannot be accessed relative to the block
from where the invocation is made:

- Subprograms declared in blocks that are descendants of the block from where the
  invocation is attempted.
- Subprograms declared in blocks that are descendants of a sibling block from
  where the invocation is attempted.

The following examples illustrate the various conditions previously described.

**Invoking Locally Declared Subprograms**

The following example contains a single hierarchy of blocks contained within standalone
procedure `level_0`. Within the executable section of procedure `level_1a`, the means
of invoking the local procedure `level_2a` are shown, both with and without qualifiers.

Also note that access to the descendant of local procedure `level_2a`, which is procedure
`level_3a`, is not permitted, with or without qualifiers. These calls are commented out in
the example.
IS
PROCEDURE level_1a
IS
PROCEDURE level_2a
IS
PROCEDURE level_3a
IS
BEGIN
DBMS_OUTPUT.PUT_LINE('........ BLOCK level_3a');
DBMS_OUTPUT.PUT_LINE('........ END BLOCK level_3a');
END level_3a;
BEGIN
DBMS_OUTPUT.PUT_LINE('...... BLOCK level_2a');
DBMS_OUTPUT.PUT_LINE('...... END BLOCK level_2a');
END level_2a;
BEGIN
DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
level_2a;
-- Local block called
level_1a.level_2a;
-- Qualified local block called
level_0.level_1a.level_2a;
-- Double qualified local block called
-- level_3a;
-- Error - Descendant of local block
-- level_2a.level_3a;
-- Error - Descendant of local block
DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
END level_1a;
BEGIN
DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
level_1a;
DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;

When the standalone procedure is invoked, the output is the following, which indicates that procedure level_2a is successfully invoked from the calls in the executable section of procedure level_1a.

BEGIN
level_0;
END;

BLOCK level_0
.. BLOCK level_1a
...... BLOCK level_2a
...... END BLOCK level_2a
...... BLOCK level_2a
...... END BLOCK level_2a
...... BLOCK level_2a
...... END BLOCK level_2a
.. END BLOCK level_1a
END BLOCK level_0

If you were to attempt to run procedure level_0 with any of the calls to the descendent block uncommented, then an error occurs.

Invoking Subprograms Declared in Ancestor Blocks

The following example shows how subprograms can be invoked that are declared in parent and other ancestor blocks relative to the block where the invocation is made.

In this example, the executable section of procedure level_3a invokes procedure level_2a, which is its parent block. (Note that v_cnt is used to avoid an infinite loop.)
v_cnt NUMBER(2) := 0;
PROCEDURE level_1a
IS
  PROCEDURE level_2a
  IS
    PROCEDURE level_3a
    IS
      BEGIN
        DBMS_OUTPUT.PUT_LINE('........ BLOCK level_3a');
        v_cnt := v_cnt + 1;
        IF v_cnt < 2 THEN
          level_2a; -- Parent block called
        END IF;
        DBMS_OUTPUT.PUT_LINE('........ END BLOCK level_3a');
      END level_3a;
  BEGIN
    BEGIN
      DBMS_OUTPUT.PUT_LINE('...... BLOCK level_2a');
      level_3a; -- Local block called
      DBMS_OUTPUT.PUT_LINE('...... END BLOCK level_2a');
    END level_2a;
  BEGIN
    BEGIN
      DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
      level_2a; -- Local block called
      DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
    END level_1a;
  BEGIN
    BEGIN
      DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
      level_1a;
      DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
    END level_0;
  The following is the resulting output:

  BEGIN
    level_0;
  END;

  BLOCK level_0
  .. BLOCK level_1a
     .... BLOCK level_2a
     ....... BLOCK level_3a
     ....... END BLOCK level_3a
  .... END BLOCK level_2a
  .... END BLOCK level_3a
  .... END BLOCK level_2a
  .. END BLOCK level_1a
  END BLOCK level_0

  In a similar example, the executable section of procedure level_3a invokes procedure level_1a, which is further up the ancestor hierarchy. (Note that v_cnt is used to avoid an infinite loop.)

  CREATE OR REPLACE PROCEDURE level_0
  IS
    v_cnt NUMBER(2) := 0;
    PROCEDURE level_1a
    IS
      PROCEDURE level_2a
      IS
        PROCEDURE level_3a
        IS
          BEGIN
            DBMS_OUTPUT.PUT_LINE('........ BLOCK level_3a');
            v_cnt := v_cnt + 1;
            IF v_cnt < 2 THEN
            END level_3a;
        BEGIN
          BEGIN
            DBMS_OUTPUT.PUT_LINE('...... BLOCK level_2a');
            level_3a;
            -- Local block called
            DBMS_OUTPUT.PUT_LINE('...... END BLOCK level_2a');
          END level_2a;
        BEGIN
          BEGIN
            DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
            level_2a; -- Local block called
            DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
          END level_1a;
        BEGIN
          BEGIN
            DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
            level_1a;
            DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
          END level_0;
The following is the resulting output:

```
BEGIN
  level_0;
END;

BLOCK level_0
 .. BLOCK level_1a
    .... BLOCK level_2a
    ....... BLOCK level_3a
   .. BLOCK level_1a
    .... BLOCK level_2a
    ....... BLOCK level_3a
   .... END BLOCK level_3a
   .... END BLOCK level_2a
  .. END BLOCK level_1a
 .. END BLOCK level_0
END BLOCK level_0
```

**Invoking Subprograms Declared in Sibling Blocks**

The following examples show how subprograms can be invoked that are declared in a sibling block relative to the local, parent, or other ancestor blocks from where the invocation of the subprogram is made.

In this example, the executable section of procedure `level_1b` invokes procedure `level_1a`, which is its sibling block. Both are local to standalone procedure `level_0`.

Note that invocation of `level_2a` or equivalently, `level_1a.level_2a` from within procedure `level_1b` is commented out as this call would result in an error. Invoking a descendent subprogram (`level_2a`) of sibling block (`level_1a`) is not permitted.
The following is the resulting output:

```
BEGIN
    level_0;
END;
```

```
BLOCK level_0
.. BLOCK level_1b
.. BLOCK level_1a
.. END BLOCK level_1a
.. END BLOCK level_1b
END BLOCK level_0
```

In the following example, procedure `level_1a`, which is the sibling of procedure `level_1b`, which is an ancestor of procedure `level_3b` is successfully invoked.

```
CREATE OR REPLACE PROCEDURE level_0
IS
    PROCEDURE level_1a
    IS
        BEGIN
            DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
            DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
            END level_1a;
        PROCEDURE level_1b
        IS
            BEGIN
                DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
                level_1a;
                -- Sibling block called
                level_1a.level_2a;
                -- Error - Descendant of sibling block
                DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
            END level_1b;
            BEGIN
                DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
                level_1b;
                DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
            END level_0;
```

```
BEGIN
    level_0;
END;
```

```
.. BLOCK level_1b
.. BLOCK level_1a
.. END BLOCK level_1a
.. END BLOCK level_1b
END BLOCK level_0
```

```
CREATE OR REPLACE PROCEDURE level_0
IS
    PROCEDURE level_1a
    IS
        BEGIN
            DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
            DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
        END level_1a;
        PROCEDURE level_1b
        IS
            BEGIN
                DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
                level_1a;
                -- Sibling block called
                level_1a.level_2a;
                -- Error - Descendant of sibling block
                DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
            END level_1b;
            BEGIN
                DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
                level_1b;
                DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
            END level_0;
```

```
BEGIN
    level_0;
END;
```

```
.. BLOCK level_1b
.. BLOCK level_1a
.. END BLOCK level_1a
.. END BLOCK level_1b
END BLOCK level_0
```

```
CREATE OR REPLACE PROCEDURE level_0
IS
    PROCEDURE level_1a
    IS
        BEGIN
            DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
            DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1a');
        END level_1a;
        PROCEDURE level_1b
        IS
            BEGIN
                DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1b');
                level_1a;
                -- Sibling block called
                level_1a.level_2a;
                -- Error - Descendant of sibling block
                DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
            END level_1b;
            BEGIN
                DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
                level_1b;
                DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
            END level_0;
```

```
BEGIN
    level_0;
END;
```

```
.. BLOCK level_1b
.. BLOCK level_1a
.. END BLOCK level_1a
.. END BLOCK level_1b
END BLOCK level_0
```
The following is the resulting output:

```
BEGIN
  level_0;
END;

BLOCK level_0
  .  BLOCK level_1b
  ....  BLOCK level_2b
  .......  BLOCK level_3b
  .  BLOCK level_1a
  .  END BLOCK level_1a
  .  BLOCK level_1a
  .  END BLOCK level_1a
  ....  END BLOCK level_3b
  ....  END BLOCK level_2b
  .  END BLOCK level_1b
  END BLOCK level_0
```

### 3.2.6.5 Using Forward Declarations

As discussed so far, when a subprogram is to be invoked, it must have been declared somewhere in the hierarchy of blocks within the standalone program, but prior to where it is invoked. In other words, when scanning the SPL code from beginning to end, the subprogram declaration must be found before its invocation.

However, there is a method of constructing the SPL code so that the full declaration of the subprogram (that is, its optional declaration section, its mandatory executable section, and optional exception section) appears in the SPL code after the point in the code where it is invoked.

This is accomplished by inserting a **forward declaration** in the SPL code prior to its invocation. The forward declaration is the specification of a subprocedure or subfunction name, formal parameters, and return type if it is a subfunction.

The full subprogram specification consisting of the optional declaration section, the executable section, and the optional exception section must be specified in the same declaration section as the forward declaration, but may appear following other subprogram declarations that invoke this subprogram with the forward declaration.

Typical usage of a forward declaration is when two subprograms invoke each other as shown by the following:

```
DECLARE
  FUNCTION add_one (p_add IN NUMBER)
  RETURN NUMBER;
  FUNCTION test_max (p_max IN NUMBER)
  RETURN NUMBER;
BEGIN
  DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
  level_1b;
  DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
  END level_0;
END level_1b;
BEGIN
  DBMS_OUTPUT.PUT_LINE('BLOCK level_0');
  level_1b;
  DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
  END level_0;
```
Subfunction \texttt{test\_max} invokes subfunction \texttt{add\_one}, which also invokes subfunction \texttt{test\_max}, so a forward declaration is required for one of the subprograms, which is implemented for \texttt{add\_one} at the beginning of the anonymous block declaration section.

The resulting output from the anonymous block is as follows:

\begin{verbatim}
Increase by 1
Increase by 1
Final value is 5
\end{verbatim}

### 3.2.6.6 Overloading Subprograms

Generally, subprograms of the same type (subprocedure or subfunction) with the same name, and same formal parameter specification can appear multiple times within the same standalone program as long as they are not sibling blocks (that is, the subprograms are not declared in the same local block).

Each subprogram can be individually invoked depending upon the use of qualifiers and the location where the subprogram invocation is made as discussed in the previous sections.

It is however possible to declare subprograms, even as siblings, that are of the same subprogram type and name as long as certain aspects of the formal parameters differ. These characteristics (subprogram type, name, and formal parameter specification) is generally known as a program’s \textit{signature}.

The declaration of multiple subprograms where the signatures are identical except for certain aspects of the formal parameter specification is referred to as \textit{subprogram overloading}. 

Thus, the determination of which particular overloaded subprogram is to be invoked is determined by a match of the actual parameters specified by the subprogram invocation and the formal parameter lists of the overloaded subprograms.

Any of the following differences permit overloaded subprograms:

- The number of formal parameters are different.
- At least one pair of data types of the corresponding formal parameters (that is, compared according to the same order of appearance in the formal parameter list) are different, but are not aliases. Data type aliases are discussed later in this section.

Note that the following differences alone do not permit overloaded subprograms:

- Different formal parameter names
- Different parameter modes (IN, IN OUT, OUT) for the corresponding formal parameters
- For subfunctions, different data types in the RETURN clause

As previously indicated, one of the differences allowing overloaded subprograms are different data types.

However, certain data types have alternative names referred to as *aliases*, which can be used for the table definition.

For example, there are fixed length character data types that can be specified as `CHAR` or `CHARACTER`. There are variable length character data types that can be specified as `CHAR VARYING`, `CHARACTER VARYING`, `VARCHAR`, or `VARCHAR2`. For integers, there are `BINARY_INTEGER`, `PLS_INTEGER`, and `INTEGER` data types. For numbers, there are `NUMBER`, `NUMERIC`, `DEC`, and `DECIMAL` data types.

For detailed information about the data types supported by Advanced Server, please see the Database Compatibility for Oracle Developers Reference Guide, available from EnterpriseDB at:


Thus, when attempting to create overloaded subprograms, the formal parameter data types are not considered different if the specified data types are aliases of each other.

It can be determined if certain data types are aliases of other types by displaying the table definition containing the data types in question.

For example, the following table definition contains some data types and their aliases.

```
CREATE TABLE data_type_aliases (  
```
Using the PSQL \d command to display the table definition, the Type column displays the data type internally assigned to each column based upon its data type in the table definition:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Modifiers</th>
</tr>
</thead>
<tbody>
<tr>
<td>dt_blob</td>
<td>bytea</td>
<td></td>
</tr>
<tr>
<td>dt_long_raw</td>
<td>bytea</td>
<td></td>
</tr>
<tr>
<td>dt_raw</td>
<td>bytea(4)</td>
<td></td>
</tr>
<tr>
<td>dt_bytea</td>
<td>bytea</td>
<td></td>
</tr>
<tr>
<td>dt_integer</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>dt_binary_integer</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>dt_pls_integer</td>
<td>integer</td>
<td></td>
</tr>
<tr>
<td>dt_real</td>
<td>real</td>
<td></td>
</tr>
<tr>
<td>dt_double_precision</td>
<td>double precision</td>
<td></td>
</tr>
<tr>
<td>dt_float</td>
<td>double precision</td>
<td></td>
</tr>
<tr>
<td>dt_number</td>
<td>numeric</td>
<td></td>
</tr>
<tr>
<td>dt_decimal</td>
<td>numeric</td>
<td></td>
</tr>
<tr>
<td>dt_numeric</td>
<td>numeric</td>
<td></td>
</tr>
<tr>
<td>dt_char</td>
<td>character(1)</td>
<td></td>
</tr>
<tr>
<td>dt_character</td>
<td>character</td>
<td></td>
</tr>
<tr>
<td>dt_varchar2</td>
<td>character varying(4)</td>
<td></td>
</tr>
<tr>
<td>dt_char_varying</td>
<td>character varying(4)</td>
<td></td>
</tr>
<tr>
<td>dt_vchar</td>
<td>character varying(4)</td>
<td></td>
</tr>
</tbody>
</table>

In the example, the base set of data types are bytea, integer, real, double precision, numeric, character, and character varying.

When attempting to declare overloaded subprograms, a pair of formal parameter data types that are aliases would not be sufficient to allow subprogram overloading. Thus, parameters with data types integer and pls_integer cannot overload a pair of subprograms, but data types integer and real, or integer and float, or integer and number can overload the subprograms.

Note: The overloading rules based upon formal parameter data types are not compatible with Oracle databases. Generally, the Advanced Server rules are more flexible, and
certain combinations are allowed in Advanced Server that would result in an error when attempting to create the procedure or function in Oracle databases.

For certain pairs of data types used for overloading, casting of the arguments specified by the subprogram invocation may be required to avoid an error encountered during runtime of the subprogram. Invocation of a subprogram must include the actual parameter list that can specifically identify the data types. Certain pairs of overloaded data types may require the `CAST` function to explicitly identify data types. For example, pairs of overloaded data types that may require casting during the invocation are `CHAR` and `VARCHAR2`, or `NUMBER` and `REAL`.

The following example shows a group of overloaded subfunctions invoked from within an anonymous block. The executable section of the anonymous block contains the use of the `CAST` function to invoke overloaded functions with certain data types.

```sql
DECLARE
    FUNCTION add_it (  
        p_add_1     IN BINARY_INTEGER,  
        p_add_2     IN BINARY_INTEGER  
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it BINARY_INTEGER: ' || TO_CHAR(p_add_1 + p_add_2,9999.9999);
    END add_it;
    FUNCTION add_it (  
        p_add_1     IN NUMBER,  
        p_add_2     IN NUMBER  
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it NUMBER: ' || TO_CHAR(p_add_1 + p_add_2,999.9999);
    END add_it;
    FUNCTION add_it (  
        p_add_1     IN REAL,  
        p_add_2     IN REAL  
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it REAL: ' || TO_CHAR(p_add_1 + p_add_2,9999.9999);
    END add_it;
    FUNCTION add_it (  
        p_add_1     IN DOUBLE PRECISION,  
        p_add_2     IN DOUBLE PRECISION  
    ) RETURN VARCHAR2
    IS
    BEGIN
        RETURN 'add_it DOUBLE PRECISION: ' || TO_CHAR(p_add_1 + p_add_2,9999.9999);
    END add_it;
BEGIN
    DBMS_OUTPUT.PUT_LINE(add_it (25, 50));
    DBMS_OUTPUT.PUT_LINE(add_it (25.0000, 50.0000));
    DBMS_OUTPUT.PUT_LINE(add_it (TO_NUMBER(25.3333), TO_NUMBER(50.3333)));  
    DBMS_OUTPUT.PUT_LINE(add_it (CAST('25.3333' AS REAL), CAST('50.3333' AS REAL)));
    DBMS_OUTPUT.PUT_LINE(add_it (CAST('25.3333' AS DOUBLE PRECISION),  
        CAST('50.3333' AS DOUBLE PRECISION)));
END;
```

The following is the output displayed from the anonymous block:

```
add_it BINARY_INTEGER:   75.0000
add_it NUMBER:   75.6666
```
3.2.6.7 Accessing Subprogram Variables

Variable declared in blocks such as subprograms or anonymous blocks can be accessed from the executable section or the exception section of other blocks depending upon their relative location.

Accessing a variable means being able to reference it within a SQL statement or an SPL statement as is done with any local variable.

**Note:** If the subprograms signature contains formal parameters, these may be accessed in the same manner as local variables of the subprogram. In this section, all discussion related to variables of a subprogram also applies to formal parameters of the subprogram.

Access of variables not only includes those defined as a data type, but also includes others such as record types, collection types, and cursors.

The variable may be accessed by at most one qualifier, which is the name of the subprogram or labeled anonymous block in which the variable has been locally declared.

The syntax to reference a variable is shown by the following:

```
[qualifier.]variable
```

If specified, *qualifier* is the subprogram or labeled anonymous block in which *variable* has been declared in its declaration section (that is, it is a local variable).

**Note:** In Advanced Server, there is only one circumstance where two qualifiers are permitted. This scenario is for accessing public variables of packages where the reference can be specified in the following format:

```
schema_name.package_name.public_variable_name
```

For more information about supported package syntax, please see the Database Compatibility for Oracle Developers Built-In Packages Guide.

The following summarizes how variables can be accessed:

- Variables can be accessed as long as the block in which the variable has been locally declared is within the ancestor hierarchical path starting from the block containing the reference to the variable. Such variables declared in ancestor blocks are referred to as *global variables*.
- If a reference to an unqualified variable is made, the first attempt is to locate a local variable of that name. If such a local variable does not exist, then the search
for the variable is made in the parent of the current block, and so forth, proceeding up the ancestor hierarchy. If such a variable is not found, then an error occurs upon invocation of the subprogram.

- If a reference to a qualified variable is made, the same search process is performed as described in the previous bullet point, but searching for the first match of the subprogram or labeled anonymous block that contains the local variable. The search proceeds up the ancestor hierarchy until a match is found. If such a match is not found, then an error occurs upon invocation of the subprogram.

The following location of variables cannot be accessed relative to the block from where the reference to the variable is made:

- Variables declared in a descendent block cannot be accessed,
- Variables declared in a sibling block, a sibling block of an ancestor block, or any descendants within the sibling block cannot be accessed.

**Note:** The Advanced Server process for accessing variables is not compatible with Oracle databases. For Oracle, any number of qualifiers can be specified and the search is based upon the first match of the first qualifier in a similar manner to the Oracle matching algorithm for invoking subprograms.

The following example displays how variables in various blocks are accessed, with and without qualifiers. The lines that are commented out illustrate attempts to access variables that would result in an error.

```sql
CREATE OR REPLACE PROCEDURE level_0
IS
  v_level_0 VARCHAR2(20) := 'Value from level_0';
PROCEDURE level_1a
IS
  v_level_1a VARCHAR2(20) := 'Value from level_1a';
PROCEDURE level_2a
IS
  v_level_2a VARCHAR2(20) := 'Value from level_2a';
BEGIN
  DBMS_OUTPUT.PUT_LINE('...... BLOCK level_2a');
  DBMS_OUTPUT.PUT_LINE('....... v_level_2a: ' || v_level_2a);  
  DBMS_OUTPUT.PUT_LINE('....... v_level_1a: ' || v_level_1a);  
  DBMS_OUTPUT.PUT_LINE('....... level_1a.v_level_1a: ' || level_1a.v_level_1a);  
  DBMS_OUTPUT.PUT_LINE('........ v_level_0: ' || v_level_0);  
  DBMS_OUTPUT.PUT_LINE('........ level_0.v_level_0: ' || level_0.v_level_0);  
  DBMS_OUTPUT.PUT_LINE('........ END BLOCK level_2a');
END level_2a;
BEGIN
  DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
  level_2a;
  DBMS_OUTPUT.PUT_LINE('.... v_level_2a: ' || v_level_2a);
  DBMS_OUTPUT.PUT_LINE('.... level_2a.v_level_2a: ' || level_2a.v_level_2a);
  DBMS_OUTPUT.PUT_LINE('.... END BLOCK level_2a');
END level_1a;
PROCEDURE level_1b
IS
  v_level_1b VARCHAR2(20) := 'Value from level_1b';
```
BEGIN
  DBMS_OUTPUT.PUT_LINE('BEGIN BLOCK level_1b');
  DBMS_OUTPUT.PUT_LINE('.... v_level_1b: ' || v_level_1b);
  DBMS_OUTPUT.PUT_LINE('.... v_level_0 : ' || v_level_0);
  -- DBMS_OUTPUT.PUT_LINE('.... level_1a.v_level_1a: ' || level_1a.v_level_1a);
  -- Error - Sibling block ---------------
  -- DBMS_OUTPUT.PUT_LINE('.... level_2a.v_level_2a: ' || level_2a.v_level_2a);
  -- Error - Sibling block descendant -------
  DBMS_OUTPUT.PUT_LINE('.. END BLOCK level_1b');
END level_1b;
BEGIN
  DBMS_OUTPUT.PUT_LINE('BEGIN BLOCK level_0');
  DBMS_OUTPUT.PUT_LINE('.. v_level_0: ' || v_level_0);
  level_1a;
  level_1b;
  DBMS_OUTPUT.PUT_LINE('END BLOCK level_0');
END level_0;
BEGIN
  BEGIN BLOCK level_0
  .. v_level_0: Value from level_0
  .. BLOCK level_1a
  .... v_level_1a: Value from level_1a
  .... BLOCK level_2a
  ........ v_level_2a: Value from level_2a
  ........ v_level_1a: Value from level_1a
  ........ level_1a.v_level_1a: Value from level_1a
  ........ v_level_0: Value from level_0
  ........ level_0.v_level_0: Value from level_0
  .... END BLOCK level_2a
  .. END BLOCK level_1a
  .. BLOCK level_1b
  .... v_level_1b: Value from level_1b
  .... v_level_0 : Value from level_0
  .. END BLOCK level_1b
END BLOCK level_0
The following is the output showing the content of each variable when the procedure is invoked:

BEGIN
  level_0;
END;
BLOCK level_0
.. v_level_0: Value from level_0
.. BLOCK level_1a
.... v_level_1a: Value from level_1a
.... BLOCK level_2a
     .... v_level_2a: Value from level_2a
     .... v_level_1a: Value from level_1a
     .... level_1a.v_level_1a: Value from level_1a
     .... v_level_0: Value from level_0
     .... level_0.v_level_0: Value from level_0
     .... END BLOCK level_2a
.. END BLOCK level_1a
.. BLOCK level_1b
.... v_level_1b: Value from level_1b
.... v_level_0 : Value from level_0
.. END BLOCK level_1b
END BLOCK level_0
The following example shows similar access attempts when all variables in all blocks have the same name:

CREATE OR REPLACE PROCEDURE level_0 IS
  v_common VARCHAR2(20) := 'Value from level_0';
PROCEDURE level_1a IS
  v_common VARCHAR2(20) := 'Value from level_1a';
PROCEDURE level_2a IS
  v_common VARCHAR2(20) := 'Value from level_2a';
BEGIN
  DBMS_OUTPUT.PUT_LINE('...... BLOCK level_2a');
  DBMS_OUTPUT.PUT_LINE('...... v_common: ' || v_common);
  DBMS_OUTPUT.PUT_LINE('...... level_2a.v_common: ' || level_2a.v_common);
  DBMS_OUTPUT.PUT_LINE('...... level_1a.v_common: ' || level_1a.v_common);
  DBMS_OUTPUT.PUT_LINE('...... level_0.v_common: ' || level_0.v_common);
  DBMS_OUTPUT.PUT_LINE('...... END BLOCK level_2a');
END level_2a;
BEGIN
  DBMS_OUTPUT.PUT_LINE('.. BLOCK level_1a');
  DBMS_OUTPUT.PUT_LINE('.... v_common: ' || v_common);
  DBMS_OUTPUT.PUT_LINE('.... level_0.v_common: ' || level_0.v_common);
  level_2a;
DBMS_OUTPUT.PUT_LINE(‘.. END BLOCK level_1a’);
END level_1a;
PROCEDURE level_1b
IS
  v_common VARCHAR2(20) := ‘Value from level_1b’;
BEGIN
  DBMS_OUTPUT.PUT_LINE(‘.. BLOCK level_1b’);
  DBMS_OUTPUT.PUT_LINE(‘.... v_common: ‘ || v_common);
  DBMS_OUTPUT.PUT_LINE(‘.... level_0.v_common: ‘ || level_0.v_common);
  DBMS_OUTPUT.PUT_LINE(‘.. END BLOCK level_1b’);
END level_1b;
BEGIN
  DBMS_OUTPUT.PUT_LINE(‘BLOCK level_0’);
  DBMS_OUTPUT.PUT_LINE(‘.. v_common: ‘ || v_common);
  level_1a;
  level_1b;
  DBMS_OUTPUT.PUT_LINE(‘END BLOCK level_0’);
END level_0;

The following is the output showing the content of each variable when the procedure is invoked:

BEGIN
  level_0;
END;
BLOCK level_0
  .. v_common: Value from level_0
  .. BLOCK level_1a
    .... v_common: Value from level_1a
    .... level_0.v_common: Value from level_0
    ...... BLOCK level_2a
      ....... v_common: Value from level_2a
      ....... level_2a.v_common: Value from level_2a
      ........ level_1a.v_common: Value from level_1a
      .......... level_0.v_common: Value from level_0
      .... END BLOCK level_2a
      .. END BLOCK level_1a
      .. BLOCK level_1b
        .... v_common: Value from level_1b
        .... level_0.v_common: Value from level_0
        .. END BLOCK level_1b
  END BLOCK level_0

As previously discussed, the labels on anonymous blocks can also be used to qualify access to variables. The following example shows variable access within a set of nested anonymous blocks:

DECLARE
  v_common VARCHAR2(20) := ‘Value from level_0’;
BEGIN
  DBMS_OUTPUT.PUT_LINE(‘BLOCK level_0’);
  DBMS_OUTPUT.PUT_LINE(‘.. v_common: ‘ || v_common);
  <<level_1a>>
  DECLARE
    v_common VARCHAR2(20) := ‘Value from level_1a’;
  BEGIN
    DBMS_OUTPUT.PUT_LINE(‘.. BLOCK level_1a’);
    DBMS_OUTPUT.PUT_LINE(‘.... v_common: ‘ || v_common);
    <<level_2a>>
    DECLARE
      v_common VARCHAR2(20) := ‘Value from level_2a’;
    BEGIN
      DBMS_OUTPUT.PUT_LINE(‘.... BLOCK level_2a’);
      DBMS_OUTPUT.PUT_LINE(‘...... v_common: ‘ || v_common);
    DBMS_OUTPUT.PUT_LINE(‘...... level_1a.v_common: ‘ || level_1a.v_common);
  END level_0;
The following is the output showing the content of each variable when the anonymous block is invoked:

```
BLOCK level_0
  .. v_common: Value from level_0
  .. BLOCK level_1a
  .... v_common: Value from level_1a
  ...... BLOCK level_2a
  ........ v_common: Value from level_2a
  ....... level_1a.v_common: Value from level_1a
  ...... END BLOCK level_2a
  .. END BLOCK level_1a
  .. BLOCK level_1b
  .... v_common: Value from level_1b
  .... level_1b.v_common: Value from level_1b
  .. END BLOCK level_1b
END BLOCK level_0
```

The following example is an object type whose object type method, `display_emp`, contains record type `emp_typ` and subprocedure `emp_sal_query`. Record variable `r_emp` declared locally to `emp_sal_query` is able to access the record type `emp_typ` declared in the parent block `display_emp`.

```
CREATE OR REPLACE TYPE emp_pay_obj_typ AS OBJECT
  (empno           NUMBER(4),
   MEMBER PROCEDURE display_emp(SELF IN OUT emp_pay_obj_typ)
  );

CREATE OR REPLACE TYPE BODY emp_pay_obj_typ AS
  MEMBER PROCEDURE display_emp (SELF IN OUT emp_pay_obj_typ)
  IS
    TYPE emp_typ IS RECORD (
      ename           emp.ename%TYPE,
      job             emp.job%TYPE,
      hiredate        emp.hiredate%TYPE,
      sal             emp.sal%TYPE,
      deptno          emp.deptno%TYPE
    );
    PROCEDURE emp_sal_query (p_empno IN emp.empno%TYPE)
    IS
      r_emp           emp_typ;
      v_avgsal        emp.sal%TYPE;
      BEGIN
        SELECT ename, job, hiredate, sal, deptno
        INTO r_emp.ename, r_emp.job, r_emp.hiredate, r_emp.sal, r_emp.deptno
        FROM emp WHERE empno = p_empno;
```
The following is the output displayed when an instance of the object type is created and procedure `display_emp` is invoked:

```
DECLARE
  v_emp          EMP_PAY_OBJ_TYP;
BEGIN
  v_emp := emp_pay_obj_typ(7900);
  v_emp.display_emp;
END;
```

Employee # : 7900
Name       : JAMES
Job        : CLERK
Hire Date  : 03-DEC-81 00:00:00
Salary     : 950.00
Dept #     : 30
Employee's salary does not exceed the department average of 1566.67

The following example is a package with three levels of subprocedures. A record type, collection type, and cursor type declared in the upper level procedure can be accessed by the descendent subprocedure.

```
CREATE OR REPLACE PACKAGE emp_dept_pkg
IS
  PROCEDURE display_emp (p_deptno NUMBER);
END;
CREATE OR REPLACE PACKAGE BODY emp_dept_pkg
IS
  PROCEDURE display_emp (p_deptno NUMBER)
  IS
    TYPE emp_rec_typ IS RECORD (
      empno emp.empno%TYPE,
      ename emp.ename%TYPE
    );
    TYPE emp_arr_typ IS TABLE OF emp_rec_typ INDEX BY BINARY_INTEGER;
    TYPE emp_cur_type IS REF CURSOR RETURN emp_rec_typ;
    PROCEDURE emp_by_dept (p_deptno emp.deptno%TYPE);
END;
```
The following is the output displayed when the top level package procedure is invoked:

```
BEGIN
  emp_dept_pkg.display_emp(20);
END;

EMPNO   ENAME
------- -----
 7369    SMITH
 7566    JONES
 7788    SCOTT
 7876    ADAMS
 7902    FORD
```
3.2.7 Compilation Errors in Procedures and Functions

When the Advanced Server parsers compile a procedure or function, they confirm that both the `CREATE` statement and the program body (that portion of the program that follows the `AS` keyword) conforms to the grammar rules for SPL and SQL constructs. By default, the server will terminate the compilation process if a parser detects an error. Note that the parsers detect syntax errors in expressions, but not semantic errors (i.e. an expression referencing a non-existent column, table, or function, or a value of incorrect type).

`spl.max_error_count` instructs the server to stop parsing if it encounters the specified number of errors in SPL code, or when it encounters an error in SQL code. The default value of `spl.max_error_count` is 10; the maximum value is 1000. Setting `spl.max_error_count` to a value of 1 instructs the server to stop parsing when it encounters the first error in either SPL or SQL code.

You can use the `SET` command to specify a value for `spl.max_error_count` for your current session. The syntax is:

```
SET spl.max_error_count = number_of_errors
```

Where `number_of_errors` specifies the number of SPL errors that may occur before the server halts the compilation process. For example:

```
SET spl.max_error_count = 6
```

The example instructs the server to continue past the first five SPL errors it encounters. When the server encounters the sixth error it will stop validating, and print six detailed error messages, and one error summary.

To save time when developing new code, or when importing existing code from another source, you may want to set the `spl.max_error_count` configuration parameter to a relatively high number of errors.

Please note that if you instruct the server to continue parsing in spite of errors in the SPL code in a program body, and the parser encounters an error in a segment of SQL code, there may still be errors in any SPL or SQL code that follows the erroneous SQL code. For example, the following function results in two errors:

```
CREATE FUNCTION computeBonus(baseSalary number) RETURN number AS
BEGIN
    bonus := baseSalary * 1.10;
    total := bonus + 100;
```

RETURN bonus;
END;

ERROR: "bonus" is not a known variable
LINE 4: bonus := baseSalary * 1.10;

ERROR: "total" is not a known variable
LINE 5: total := bonus + 100;

ERROR: compilation of SPL function/procedure "computebonus" failed due to 2 errors

The following example adds a SELECT statement to the previous example. The error in the SELECT statement masks the other errors that follow:

CREATE FUNCTION computeBonus(employeeName number) RETURN number AS
BEGIN
    SELECT salary INTO baseSalary FROM emp
    WHERE ename = employeeName;

    bonus := baseSalary * 1.10;
    total := bonus + 100;

    RETURN bonus;
END;

ERROR: "basesalary" is not a known variable
LINE 3: SELECT salary INTO baseSalary FROM emp WHERE ename = emp...
3.2.8 Program Security

Security over what user may execute an SPL program and what database objects an SPL program may access for any given user executing the program is controlled by the following:

- Privilege to execute a program.
- Privileges granted on the database objects (including other SPL programs) which a program attempts to access.
- Whether the program is defined with definer’s rights or invoker’s rights.

These aspects are discussed in the following sections.

3.2.8.1 EXECUTE Privilege

An SPL program (function, procedure, or package) can begin execution only if any of the following are true:

- The current user is a superuser, or
- The current user has been granted EXECUTE privilege on the SPL program, or
- The current user inherits EXECUTE privilege on the SPL program by virtue of being a member of a group which does have such privilege, or
- EXECUTE privilege has been granted to the PUBLIC group.

Whenever an SPL program is created in Advanced Server, EXECUTE privilege is automatically granted to the PUBLIC group by default, therefore, any user can immediately execute the program.

This default privilege can be removed by using the REVOKE EXECUTE command. The following is an example:

```
REVOKE EXECUTE ON PROCEDURE list_emp FROM PUBLIC;
```

Explicit EXECUTE privilege on the program can then be granted to individual users or groups.

```
GRANT EXECUTE ON PROCEDURE list_emp TO john;
```

Now, user john can execute the list_emp program; other users who do not meet any of the conditions listed at the beginning of this section cannot.

Once a program begins execution, the next aspect of security is what privilege checks occur if the program attempts to perform an action on any database object including:
- Reading or modifying table or view data.
- Creating, modifying, or deleting a database object such as a table, view, index, or sequence.
- Obtaining the current or next value from a sequence.
- Calling another program (function, procedure, or package).

Each such action can be protected by privileges on the database object either allowed or disallowed for the user.

Note that it is possible for a database to have more than one object of the same type with the same name, but each such object belonging to a different schema in the database. If this is the case, which object is being referenced by an SPL program? This is the topic of the next section.

### 3.2.8.2 Database Object Name Resolution

A database object inside an SPL program may either be referenced by its qualified name or by an unqualified name. A qualified name is in the form of `schema.name` where `schema` is the name of the schema under which the database object with identifier, `name`, exists. An unqualified name does not have the “`schema`.” portion. When a reference is made to a qualified name, there is absolutely no ambiguity as to exactly which database object is intended – it either does or does not exist in the specified schema.

Locating an object with an unqualified name, however, requires the use of the current user’s search path. When a user becomes the current user of a session, a default search path is always associated with that user. The search path consists of a list of schemas which are searched in left-to-right order for locating an unqualified database object reference. The object is considered non-existent if it can’t be found in any of the schemas in the search path. The default search path can be displayed in PSQL using the `SHOW search_path` command.

```
SHOW search_path;
search_path
--------------------
$user,public,sys,dbo
(1 row)
```

```
$user` in the above search path is a generic placeholder that refers to the current user so if the current user of the above session is `enterprisedb`, an unqualified database object would be searched for in the following schemas in this order – first, `enterprisedb`, then `public`, then `sys`, and finally, `dbo`. ```
Once an unqualified name has been resolved in the search path, it can be determined if the current user has the appropriate privilege to perform the desired action on that specific object.

**Note:** The concept of the search path is not compatible with Oracle databases. For an unqualified reference, Oracle simply looks in the schema of the current user for the named database object. It also important to note that in Oracle, a user and his or her schema is the same entity while in Advanced Server, a user and a schema are two distinct objects.

### 3.2.8.3 Database Object Privileges

Once an SPL program begins execution, any attempt to access a database object from within the program results in a check to ensure the current user has the authorization to perform the intended action against the referenced object. Privileges on database objects are bestowed and removed using the `GRANT` and `REVOKE` commands, respectively. If the current user attempts unauthorized access on a database object, then the program will throw an exception. See Section 3.5.7 for information about exception handling.

The final topic discusses exactly who is the current user.

### 3.2.8.4 Definer’s vs. Invokers Rights

When an SPL program is about to begin execution, a determination is made as to what user is to be associated with this process. This user is referred to as the *current user*. The current user’s database object privileges are used to determine whether or not access to database objects referenced in the program will be permitted. The current, prevailing search path in effect when the program is invoked will be used to resolve any unqualified object references.

The selection of the current user is influenced by whether the SPL program was created with definer’s right or invoker’s rights. The `AUTHID` clause determines that selection. Appearance of the clause `AUTHID DEFINER` gives the program definer’s rights. This is also the default if the `AUTHID` clause is omitted. Use of the clause `AUTHID CURRENT_USER` gives the program invoker’s rights. The difference between the two is summarized as follows:

- If a program has *definer’s rights*, then the owner of the program becomes the current user when program execution begins. The program owner’s database object privileges are used to determine if access to a referenced object is permitted. In a definer’s rights program, it is irrelevant as to which user actually invoked the program.
- If a program has *invoker’s rights*, then the current user at the time the program is called remains the current user while the program is executing (but not necessarily within called subprograms – see the following bullet points). When an invoker’s rights program is invoked, the current user is typically the user that started the
session (i.e., made the database connection) although it is possible to change the current user after the session has started using the SET ROLE command. In an invoker’s rights program, it is irrelevant as to which user actually owns the program.

From the previous definitions, the following observations can be made:

- If a definer’s rights program calls a definer’s rights program, the current user changes from the owner of the calling program to the owner of the called program during execution of the called program.
- If a definer’s rights program calls an invoker’s rights program, the owner of the calling program remains the current user during execution of both the calling and called programs.
- If an invoker’s rights program calls an invoker’s rights program, the current user of the calling program remains the current user during execution of the called program.
- If an invokers’ rights program calls a definer’s rights program, the current user switches to the owner of the definer’s rights program during execution of the called program.

The same principles apply if the called program in turn calls another program in the cases cited above.

This section on security concludes with an example using the sample application.

### 3.2.8.5 Security Example

In the following example, a new database will be created along with two users – hr_mgr who will own a copy of the entire sample application in schema, hr_mgr; and sales_mgr who will own a schema named, sales_mgr, that will have a copy of only the emp table containing only the employees who work in sales.

The procedure list_emp, function hire_clerk, and package emp_admin will be used in this example. All of the default privileges that are granted upon installation of the sample application will be removed and then be explicitly re-granted so as to present a more secure environment in this example.

Programs list_emp and hire_clerk will be changed from the default of definer’s rights to invoker’s rights. It will be then illustrated that when sales_mgr runs these programs, they act upon the emp table in sales_mgr’s schema since sales_mgr’s search path and privileges will be used for name resolution and authorization checking.

Programs get_dept_name and hire_emp in the emp_admin package will then be executed by sales_mgr. In this case, the dept table and emp table in hr_mgr’s schema will be accessed as hr_mgr is the owner of the emp_admin package which is using
definer’s rights. Since the default search path is in effect with the $user placeholder, the schema matching the user (in this case, hr_mgr) is used to find the tables.

**Step 1 – Create Database and Users**

As user `enterprisedb`, create the hr database:

```sql
CREATE DATABASE hr;
```

Switch to the hr database and create the users:

```sql
\c hr enterprisedb
CREATE USER hr_mgr IDENTIFIED BY password;
CREATE USER sales_mgr IDENTIFIED BY password;
```

**Step 2 – Create the Sample Application**

Create the entire sample application, owned by hr_mgr, in hr_mgr’s schema.

```sql
\c - hr_mgr
\i /opt/edb/as10/installer/server/edb-sample.sql
BEGIN
CREATE TABLE
CREATE TABLE
CREATE TABLE
CREATE VIEW
CREATE SEQUENCE
.
.
CREATE PACKAGE
CREATE PACKAGE BODY
COMMIT
```

**Step 3 – Create the emp Table in Schema sales_mgr**

Create a subset of the emp table owned by sales_mgr in sales_mgr’s schema.

```sql
\c - hr_mgr
GRANT USAGE ON SCHEMA hr_mgr TO sales_mgr;
\c - sales_mgr
CREATE TABLE emp AS SELECT * FROM hr_mgr.emp WHERE job = 'SALESMAN';
```

In the above example, the `GRANT USAGE ON SCHEMA` command is given to allow sales_mgr access into hr_mgr’s schema to make a copy of hr_mgr’s emp table. This step is required in Advanced Server and is not compatible with Oracle databases since Oracle does not have the concept of a schema that is distinct from its user.

**Step 4 – Remove Default Privileges**

Remove all privileges to later illustrate the minimum required privileges needed.
Step 5 – Change list_emp to Invoker’s Rights

While connected as user, hr_mgr, add the AUTHID CURRENT_USER clause to the list_emp program and resave it in Advanced Server. When performing this step, be sure you are logged on as hr_mgr, otherwise the modified program may wind up in the public schema instead of in hr_mgr’s schema.

```sql
CREATE OR REPLACE PROCEDURE list_emp
AUTHID CURRENT_USER
IS
  v_empno         NUMBER(4);
  v_ename         VARCHAR2(10);
  CURSOR emp_cur IS
    SELECT empno, ename FROM emp ORDER BY empno;
BEGIN
  OPEN emp_cur;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  LOOP
    FETCH emp_cur INTO v_empno, v_ename;
    EXIT WHEN emp_cur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
  END LOOP;
  CLOSE emp_cur;
END;
```

Step 6 – Change hire_clerk to Invoker’s Rights and Qualify Call to new_empno

While connected as user, hr_mgr, add the AUTHID CURRENT_USER clause to the hire_clerk program.

Also, after the BEGIN statement, fully qualify the reference, new_empno, to hr_mgr.new_empno in order to ensure the hire_clerk function call to the new_empno function resolves to the hr_mgr schema.

When resaving the program, be sure you are logged on as hr_mgr, otherwise the modified program may wind up in the public schema instead of in hr_mgr’s schema.

```sql
CREATE OR REPLACE FUNCTION hire_clerk (p_ename         VARCHAR2,
  p_deptno        NUMBER
) RETURN NUMBER
```
AUTHID CURRENT_USER IS

BEGIN
  v_empno := hr_mgr.new_empno;
  INSERT INTO emp VALUES (v_empno, p_ename, 'CLERK', 7782,
                          TRUNC(SYSDATE), 950.00, NULL, p_deptno);
  SELECT empno, ename, job, mgr, hiredate, sal, comm, deptno INTO
              v_empno, v_ename, v_job, v_mgr, v_hiredate, v_sal, v_comm, v_deptno
              FROM emp WHERE empno = v_empno;
  DBMS_OUTPUT.PUT_LINE('Department : ' || v_deptno);
  DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_empno);
  DBMS_OUTPUT.PUT_LINE('Name       : ' || v_ename);
  DBMS_OUTPUT.PUT_LINE('Job        : ' || v_job);
  DBMS_OUTPUT.PUT_LINE('Manager    : ' || v_mgr);
  DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || v_hiredate);
  DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);
  DBMS_OUTPUT.PUT_LINE('Commission : ' || v_comm);
  RETURN v_empno;
EXCEPTION
  WHEN OTHERS THEN
    DBMS_OUTPUT.PUT_LINE('The following is SQLERRM:');
    DBMS_OUTPUT.PUT_LINE(sqlerrm);
    DBMS_OUTPUT.PUT_LINE('The following is SQLCODE:');
    DBMS_OUTPUT.PUT_LINE(sqlcode);
    RETURN -1;
END;

Step 7 – Grant Required Privileges

While connected as user, hr_mgr, grant the privileges needed so sales_mgr can execute the list_emp procedure, hire_clerk function, and emp_admin package. Note that the only data object sales_mgr has access to is the emp table in the sales_mgr schema. sales_mgr has no privileges on any table in the hr_mgr schema.

GRANT USAGE ON SCHEMA hr_mgr TO sales_mgr;
GRANT EXECUTE ON PROCEDURE list_emp TO sales_mgr;
GRANT EXECUTE ON FUNCTION hire_clerk(VARCHAR2, NUMBER) TO sales_mgr;
GRANT EXECUTE ON FUNCTION new_empno() TO sales_mgr;
GRANT EXECUTE ON PACKAGE emp_admin TO sales_mgr;

Step 8 – Run Programs list_emp and hire_clerk

Connect as user, sales_mgr, and run the following anonymous block:

\c - sales_mgr
DECLARE
  v_empno NUMBER(4);
BEGIN
  hr_mgr.list_emp;
  DBMS_OUTPUT.PUT_LINE('*** Adding new employee ***');

v_empno := hr_mgr.hire_clerk('JONES',40);
DBMS_OUTPUT.PUT_LINE('*** After new employee added ***');
h_mr_mgr.list_emp;
END;

EMPNO    ENAME
-----    -------
7499     ALLEN
7521     WARD
7654     MARTIN
7844     TURNER
*** Adding new employee ***
Department : 40
Employee No: 8000
Name       : JONES
Job        : CLERK
Manager    : 7782
Hire Date  : 08-NOV-07 00:00:00
Salary     : 950.00
*** After new employee added ***
EMPNO    ENAME
-----    -------
7499     ALLEN
7521     WARD
7654     MARTIN
7844     TURNER
8000     JONES

The table and sequence accessed by the programs of the anonymous block are illustrated in the following diagram. The gray ovals represent the schemas of sales_mgr and hr_mgr. The current user during each program execution is shown within parenthesis in bold red font.

![Diagram showing access to sales_mgr and hr_mgr schemas](image)

Figure 3 - Invoker’s Rights Programs

Selecting from sales_mgr’s emp table shows that the update was made in this table.
The following diagram shows that the `SELECT` command references the `emp` table in the `sales_mgr` schema, but the `dept` table referenced by the `get_dept_name` function in the `emp_admin` package is from the `hr_mgr` schema since the `emp_admin` package has definer’s rights and is owned by `hr_mgr`. The default search path setting with the `$user` placeholder resolves the access by user `hr_mgr` to the `dept` table in the `hr_mgr` schema.

![Diagram](image)

**Figure 4 Definer's Rights Package**

**Step 9 – Run Program hire_emp in the emp_admin Package**

While connected as user `sales_mgr`, run the `hire_emp` procedure in the `emp_admin` package.

```sql
EXEC hr_mgr.emp_admin.hire_emp(9001, 'ALICE', 'SALESMAN', 8000, TRUNC(SYSDATE), 1000, 7369, 40);
```

This diagram illustrates that the `hire_emp` procedure in the `emp_admin` definer’s rights package updates the `emp` table belonging to `hr_mgr` since the object privileges of
$hr_mgr$ are used, and the default search path setting with the $user$ placeholder resolves to the schema of $hr_mgr$.

Now connect as user, $hr_mgr$. The following `SELECT` command verifies that the new employee was added to $hr_mgr$'s `emp` table since the `$emp_admin` package has definer's rights and $hr_mgr$ is `$emp_admin`'s owner.

```sql
\c - hr_mgr
SELECT empno, ename, hiredate, sal, deptno,
hr_mgr.emp_admin.get_dept_name(deptno) FROM hr_mgr.emp;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>hiredate</th>
<th>sal</th>
<th>deptno</th>
<th>get_dept_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>17-DEC-80 00:00:00</td>
<td>800.00</td>
<td>20</td>
<td>RESEARCH</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>20-FEB-81 00:00:00</td>
<td>1600.00</td>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>22-FEB-81 00:00:00</td>
<td>1250.00</td>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>02-APR-81 00:00:00</td>
<td>2975.00</td>
<td>20</td>
<td>RESEARCH</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>28-SEP-81 00:00:00</td>
<td>1250.00</td>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>01-MAY-81 00:00:00</td>
<td>2850.00</td>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>09-JUN-81 00:00:00</td>
<td>2450.00</td>
<td>10</td>
<td>ACCOUNTING</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>19-APR-87 00:00:00</td>
<td>3000.00</td>
<td>20</td>
<td>RESEARCH</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>17-NOV-81 00:00:00</td>
<td>5000.00</td>
<td>10</td>
<td>ACCOUNTING</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>08-SEP-81 00:00:00</td>
<td>1500.00</td>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>23-MAY-87 00:00:00</td>
<td>1100.00</td>
<td>20</td>
<td>RESEARCH</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>03-DEC-81 00:00:00</td>
<td>950.00</td>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>03-DEC-81 00:00:00</td>
<td>3000.00</td>
<td>20</td>
<td>RESEARCH</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>23-JAN-82 00:00:00</td>
<td>1300.00</td>
<td>10</td>
<td>ACCOUNTING</td>
</tr>
<tr>
<td>9001</td>
<td>ALICE</td>
<td>08-NOV-07 00:00:00</td>
<td>8000.00</td>
<td>40</td>
<td>OPERATIONS</td>
</tr>
</tbody>
</table>

(15 rows)
3.3 Variable Declarations

SPL is a block-structured language. The first section that can appear in a block is the declaration. The declaration contains the definition of variables, cursors, and other types that can be used in SPL statements contained in the block.

3.3.1 Declaring a Variable

Generally, all variables used in a block must be declared in the declaration section of the block. A variable declaration consists of a name that is assigned to the variable and its data type. Optionally, the variable can be initialized to a default value in the variable declaration.

The general syntax of a variable declaration is:

```plaintext
name type [ { := | DEFAULT } { expression | NULL } ];
```

- `name` is an identifier assigned to the variable.
- `type` is the data type assigned to the variable.
- `[ := expression ]`, if given, specifies the initial value assigned to the variable when the block is entered. If the clause is not given then the variable is initialized to the SQL NULL value.

The default value is evaluated every time the block is entered. So, for example, assigning `SYSDATE` to a variable of type `DATE` causes the variable to have the time of the current invocation, not the time when the procedure or function was precompiled.

The following procedure illustrates some variable declarations that utilize defaults consisting of string and numeric expressions.

```sql
CREATE OR REPLACE PROCEDURE dept_salary_rpt (p_deptno NUMBER) IS
todays_date DATE := SYSDATE;
rpt_title VARCHAR2(60) := 'Report For Department # ' || p_deptno || ' on ' || todays_date;
base_sal INTEGER := 35525;
base_comm_rate NUMBER := 1.33333;
base_annual NUMBER := ROUND(base_sal * base_comm_rate, 2);
BEGIN
DBMS_OUTPUT.PUT_LINE(rpt_title);
DBMS_OUTPUT.PUT_LINE('Base Annual Salary: ' || base_annual);
END;
```
The following output of the above procedure shows that default values in the variable declarations are indeed assigned to the variables.

EXEC dept_salary_rpt(20);
Report For Department # 20 on 10-JUL-07 16:44:45
Base Annual Salary: 47366.55
3.3.2 Using %TYPE in Variable Declarations

Often, variables will be declared in SPL programs that will be used to hold values from tables in the database. In order to ensure compatibility between the table columns and the SPL variables, the data types of the two should be the same.

However, as quite often happens, a change might be made to the table definition. If the data type of the column is changed, the corresponding change may be required to the variable in the SPL program.

Instead of coding the specific column data type into the variable declaration the column attribute, %TYPE, can be used instead. A qualified column name in dot notation or the name of a previously declared variable must be specified as a prefix to %TYPE. The data type of the column or variable prefixed to %TYPE is assigned to the variable being declared. If the data type of the given column or variable changes, the new data type will be associated with the variable without the need to modify the declaration code.

Note: The %TYPE attribute can be used with formal parameter declarations as well.

```
name { { table | view } .column | variable } %TYPE;
```

name is the identifier assigned to the variable or formal parameter that is being declared. column is the name of a column in table or view. variable is the name of a variable that was declared prior to the variable identified by name.

Note: The variable does not inherit any of the column’s other attributes such as might be specified on the column with the NOT NULL clause or the DEFAULT clause.

In the following example a procedure queries the emp table using an employee number, displays the employee’s data, finds the average salary of all employees in the department to which the employee belongs, and then compares the chosen employee’s salary with the department average.

```sql
CREATE OR REPLACE PROCEDURE emp_sal_query (p_empno IN NUMBER) IS
  v_ename VARCHAR2(10);
  v_job VARCHAR2(9);
  v_hiredate DATE;
  v_sal NUMBER(7,2);
  v_deptno NUMBER(2);
  v_avgsal NUMBER(7,2);
BEGIN
  SELECT ename, job, hiredate, sal, deptno
  INTO v_ename, v_job, v_hiredate, v_sal, v_deptno
  FROM emp WHERE empno = p_empno;
```
DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
DBMS_OUTPUT.PUT_LINE('Name       : ' || v_ename);
DBMS_OUTPUT.PUT_LINE('Job        : ' || v_job);
DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || v_hiredate);
DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);
DBMS_OUTPUT.PUT_LINE('Dept #     : ' || v_deptno);

SELECT AVG(sal) INTO v_avgsal
    FROM emp WHERE deptno = v_deptno;
IF v_sal > v_avgsal THEN
    DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the ' || 'department average of ' || v_avgsal);
ELSE
    DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the ' || 'department average of ' || v_avgsal);
END IF;
END;

Instead of the above, the procedure could be written as follows without explicitly coding the emp table data types into the declaration section of the procedure.

CREATE OR REPLACE PROCEDURE emp_sal_query (p_empno         IN emp.empno%TYPE)
IS
    v_ename         emp.ename%TYPE;
    v_job           emp.job%TYPE;
    v_hiredate      emp.hiredate%TYPE;
    v_sal           emp.sal%TYPE;
    v_deptno        emp.deptno%TYPE;
    v_avgsal        v_sal%TYPE;
BEGIN
    SELECT ename, job, hiredate, sal, deptno
        INTO v_ename, v_job, v_hiredate, v_sal, v_deptno
        FROM emp WHERE empno = p_empno;
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name       : ' || v_ename);
    DBMS_OUTPUT.PUT_LINE('Job        : ' || v_job);
    DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || v_hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary     : ' || v_sal);
    DBMS_OUTPUT.PUT_LINE('Dept #     : ' || v_deptno);

    SELECT AVG(sal) INTO v_avgsal
        FROM emp WHERE deptno = v_deptno;
    IF v_sal > v_avgsal THEN
        DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the ' || 'department average of ' || v_avgsal);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the ' || 'department average of ' || v_avgsal);
    END IF;
END;

Note: p_empno shows an example of a formal parameter defined using %TYPE.

v_avgsal illustrates the usage of %TYPE referring to another variable instead of a table column.
The following is sample output from executing this procedure.

```
EXEC emp_sal_query(7698);
Employee # : 7698
Name       : BLAKE
Job        : MANAGER
Hire Date  : 01-MAY-81 00:00:00
Salary     : 2850.00
Dept #     : 30
Employee's salary is more than the department average of 1566.67
```
3.3.3 Using %ROWTYPE in Record Declarations

The %TYPE attribute provides an easy way to create a variable dependent upon a column’s data type. Using the %ROWTYPE attribute, you can define a record that contains fields that correspond to all columns of a given table. Each field takes on the data type of its corresponding column. The fields in the record do not inherit any of the columns’ other attributes such as might be specified with the NOT NULL clause or the DEFAULT clause.

A record is a named, ordered collection of fields. A field is similar to a variable; it has an identifier and data type, but has the additional property of belonging to a record, and must be referenced using dot notation with the record name as its qualifier.

You can use the %ROWTYPE attribute to declare a record. The %ROWTYPE attribute is prefixed by a table name. Each column in the named table defines an identically named field in the record with the same data type as the column.

```
record table%ROWTYPE;
```

record is an identifier assigned to the record. table is the name of a table (or view) whose columns are to define the fields in the record. The following example shows how the `emp_sal_query` procedure from the prior section can be modified to use `emp%ROWTYPE` to create a record named `r_emp` instead of declaring individual variables for the columns in `emp`.

```
CREATE OR REPLACE PROCEDURE emp_sal_query (p_empno IN emp.empno%TYPE)
IS
  r_emp emp%ROWTYPE;
  v_avgsal emp.sal%TYPE;
BEGIN
  SELECT ename, job, hiredate, sal, deptno
  INTO r_emp.ename, r_emp.job, r_emp.hiredate, r_emp.sal, r_emp.deptno
  FROM emp WHERE empno = p_empno;
  DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
  DBMS_OUTPUT.PUT_LINE('Name       : ' || r_emp.ename);
  DBMS_OUTPUT.PUT_LINE('Job        : ' || r_emp.job);
  DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || r_emp.hiredate);
  DBMS_OUTPUT.PUT_LINE('Salary     : ' || r_emp.sal);
  DBMS_OUTPUT.PUT_LINE('Dept #     : ' || r_emp.deptno);
  SELECT AVG(sal) INTO v_avgsal
  FROM emp WHERE deptno = r_emp.deptno;
  IF r_emp.sal > v_avgsal THEN
    DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the ' || 'department average of ' || v_avgsal);
  ELSE
    DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the ' || 'department average of ' || v_avgsal);
  END IF;
END;
```
3.3.4 User-Defined Record Types and Record Variables

Records can be declared based upon a table definition using the %ROWTYPE attribute as shown in Section 3.3.3. This section describes how a new record structure can be defined that is not tied to any particular table definition.

The TYPE IS RECORD statement is used to create the definition of a record type. A record type is a definition of a record comprised of one or more identifiers and their corresponding data types. A record type cannot, by itself, be used to manipulate data.

The syntax for a TYPE IS RECORD statement is:

```
TYPE rec_type IS RECORD ( fields )
```

Where `fields` is a comma-separated list of one or more field definitions of the following form:

```
field_name data_type [NOT NULL] [:= | DEFAULT] default_value
```

Where:

- `rec_type`

  `rec_type` is an identifier assigned to the record type.

- `field_name`

  `field_name` is the identifier assigned to the field of the record type.

- `data_type`

  `data_type` specifies the data type of `field_name`.

- `DEFAULT default_value`

  The `DEFAULT` clause assigns a default data value for the corresponding field. The data type of the default expression must match the data type of the column. If no default is specified, then the default is NULL.

A record variable or simply put, a record, is an instance of a record type. A record is declared from a record type. The properties of the record such as its field names and types are inherited from the record type.
The following is the syntax for a record declaration.

```
record rectype
```

`record` is an identifier assigned to the record variable. `rectype` is the identifier of a previously defined record type. Once declared, a record can then be used to hold data.

Dot notation is used to make reference to the fields in the record.

```
record.field
```

`record` is a previously declared record variable and `field` is the identifier of a field belonging to the record type from which `record` is defined.

The `emp_sal_query` is again modified – this time using a user-defined record type and record variable.

```sql
CREATE OR REPLACE PROCEDURE emp_sal_query (p_empno         IN emp.empno%TYPE
) IS
  TYPE emp_typ IS RECORD (
    ename       emp.ename%TYPE,
    job         emp.job%TYPE,
    hiredate    emp.hiredate%TYPE,
    sal         emp.sal%TYPE,
    deptno      emp.deptno%TYPE
  );
  r_emp           emp_typ;
  v_avgsal       emp.sal%TYPE;
BEGIN
  SELECT ename, job, hiredate, sal, deptno
    INTO r_emp.ename, r_emp.job, r_emp.hiredate, r_emp.sal, r_emp.deptno
    FROM emp WHERE empno = p_empno;
  DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
  DBMS_OUTPUT.PUT_LINE('Name       : ' || r_emp.ename);
  DBMS_OUTPUT.PUT_LINE('Job        : ' || r_emp.job);
  DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || r_emp.hiredate);
  DBMS_OUTPUT.PUT_LINE('Salary     : ' || r_emp.sal);
  DBMS_OUTPUT.PUT_LINE('Dept #     : ' || r_emp.deptno);

  SELECT AVG(sal) INTO v_avgsal
    FROM emp WHERE deptno = r_emp.deptno;
  IF r_emp.sal > v_avgsal THEN
    DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the ' || 'department average of ' || v_avgsal);
  ELSE
    DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the ' || 'department average of ' || v_avgsal);
  END IF;
END;
```

Note that instead of specifying data type names, the `%TYPE` attribute can be used for the field data types in the record type definition.
The following is the output from executing this stored procedure.

```
EXEC emp_sal_query(7698);

Employee # : 7698
Name       : BLAKE
Job        : MANAGER
Hire Date  : 01-MAY-81 00:00:00
Salary     : 2850.00
Dept #     : 30
Employee's salary is more than the department average of 1566.67
```
3.4 Basic Statements

This section begins the discussion of the programming statements that can be used in an SPL program.

3.4.1 NULL

The simplest statement is the NULL statement. This statement is an executable statement that does nothing.

    NULL;

The following is the simplest, possible valid SPL program.

    BEGIN
    NULL;
    END;

The NULL statement can act as a placeholder where an executable statement is required such as in a branch of an IF-THEN-ELSE statement.

For example:

    CREATE OR REPLACE PROCEDURE divide_it (p_numerator IN NUMBER,
    p_denominator IN NUMBER,
    p_result OUT NUMBER) IS
    BEGIN
    IF p_denominator = 0 THEN
    NULL;
    ELSE
    p_result := p_numerator / p_denominator;
    END IF;
    END;

3.4.2 Assignment

The assignment statement sets a variable or a formal parameter of mode OUT or IN OUT specified on the left side of the assignment, :=, to the evaluated expression specified on the right side of the assignment.

    variable := expression;

variable is an identifier for a previously declared variable, OUT formal parameter, or IN OUT formal parameter.
expression is an expression that produces a single value. The value produced by the expression must have a compatible data type with that of variable.

The following example shows the typical use of assignment statements in the executable section of the procedure.

```sql
CREATE OR REPLACE PROCEDURE dept_salary_rpt (p_deptno NUMBER)
IS
todays_date DATE;
rpt_title VARCHAR2(60);
base_sal INTEGER;
base_comm_rate NUMBER;
base_annual NUMBER;
BEGIN
todays_date := SYSDATE;
rpt_title := 'Report For Department # ' || p_deptno || ' on ' || todays_date;
base_sal := 35525;
base_comm_rate := 1.33333;
base_annual := ROUND(base_sal * base_comm_rate, 2);
DBMS_OUTPUT.PUT_LINE(rpt_title);
DBMS_OUTPUT.PUT_LINE('Base Annual Salary: ' || base_annual);
END;
```

### 3.4.3 SELECT INTO

The `SELECT INTO` statement is an SPL variation of the SQL `SELECT` command, the differences being:

- That `SELECT INTO` is designed to assign the results to variables or records where they can then be used in SPL program statements.
- The accessible result set of `SELECT INTO` is at most one row.

Other than the above, all of the clauses of the `SELECT` command such as `WHERE`, `ORDER BY`, `GROUP BY`, `HAVING`, etc. are valid for `SELECT INTO`. The following are the two variations of `SELECT INTO`.

```sql
SELECT select_expressions INTO target FROM ...;
```

target is a comma-separated list of simple variables. `select_expressions` and the remainder of the statement are the same as for the `SELECT` command. The selected values must exactly match in data type, number, and order the structure of the target or a runtime error occurs.

```sql
SELECT * INTO record FROM table ...;
```
**record** is a record variable that has previously been declared.

If the query returns zero rows, null values are assigned to the target(s). If the query returns multiple rows, the first row is assigned to the target(s) and the rest are discarded. (Note that "the first row" is not well-defined unless you’ve used **ORDER BY**.)

**Note:** In either cases, where no row is returned or more than one row is returned, SPL throws an exception.

**Note:** There is a variation of **SELECT INTO** using the **BULK COLLECT** clause that allows a result set of more than one row that is returned into a collection. See Section 3.12.4.1 for more information on using the **BULK COLLECT** clause with the **SELECT INTO** statement.

You can use the **WHEN NO_DATA_FOUND** clause in an **EXCEPTION** block to determine whether the assignment was successful (that is, at least one row was returned by the query).

This version of the **emp_sal_query** procedure uses the variation of **SELECT INTO** that returns the result set into a record. Also note the addition of the **EXCEPTION** block containing the **WHEN NO_DATA_FOUND** conditional expression.

```sql
CREATE OR REPLACE PROCEDURE emp_sal_query (p_empno IN emp.empno%TYPE) IS
  r_emp emp%ROWTYPE;
  v_avgsal emp.sal%TYPE;
BEGIN
  SELECT * INTO r_emp
  FROM emp WHERE empno = p_empno;
  DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
  DBMS_OUTPUT.PUT_LINE('Name       : ' || r_emp.ename);
  DBMS_OUTPUT.PUT_LINE('Job        : ' || r_emp.job);
  DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || r_emp.hiredate);
  DBMS_OUTPUT.PUT_LINE('Salary     : ' || r_emp.sal);
  DBMS_OUTPUT.PUT_LINE('Dept #     : ' || r_emp.deptno);
  SELECT AVG(sal) INTO v_avgsal
  FROM emp WHERE deptno = r_emp.deptno;
  IF r_emp.sal > v_avgsal THEN
    DBMS_OUTPUT.PUT_LINE('Employee''s salary is more than the ' || 'department average of ' || v_avgsal);
  ELSE
    DBMS_OUTPUT.PUT_LINE('Employee''s salary does not exceed the ' || 'department average of ' || v_avgsal);
  END IF;
EXCEPTION
  WHEN NO_DATA_FOUND THEN
    DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
END;
```

If the query is executed with a non-existent employee number the results appear as follows.
EXEC emp_sal_query(0);
Employee # 0 not found

Another conditional clause of use in the `EXCEPTION` section with `SELECT INTO` is the `TOO_MANY_ROWS` exception. If more than one row is selected by the `SELECT INTO` statement an exception is thrown by SPL.

When the following block is executed, the `TOO_MANY_ROWS` exception is thrown since there are many employees in the specified department.

```
DECLARE
  v_ename         emp.ename%TYPE;
BEGIN
  SELECT ename INTO v_ename FROM emp WHERE deptno = 20 ORDER BY ename;
  EXCEPTION
    WHEN TOO_MANY_ROWS THEN
      DBMS_OUTPUT.PUT_LINE('More than one employee found');
      DBMS_OUTPUT.PUT_LINE('First employee returned is ' || v_ename);
END;
```

More than one employee found
First employee returned is ADAMS

Note: See Section 3.5.7 or more information on exception handling.

### 3.4.4 INSERT

The `INSERT` command available in the SQL language can also be used in SPL programs.

An expression in the SPL language can be used wherever an expression is allowed in the SQL `INSERT` command. Thus, SPL variables and parameters can be used to supply values to the insert operation.

The following is an example of a procedure that performs an insert of a new employee using data passed from a calling program.

```
CREATE OR REPLACE PROCEDURE emp_insert (p_empno         IN emp.empno%TYPE,
                                        p_ename         IN emp.ename%TYPE,
                                        p_job           IN emp.job%TYPE,
                                        p_mgr           IN emp.mgr%TYPE,
                                        p_hiredate      IN emp.hiredate%TYPE,
                                        p_sal           IN emp.sal%TYPE,
                                        p_comm          IN emp.comm%TYPE,
                                        p_deptno        IN emp.deptno%TYPE )
IS
BEGIN
  INSERT INTO emp VALUES (p_empno,
                          p_ename,
                          p_job,
                          p_mgr,
                          p_hiredate,
                          p_sal,
                          p_comm,
                          p_deptno);
END;
```
If an exception occurs all database changes made in the procedure are automatically rolled back. In this example the EXCEPTION section with the WHEN OTHERS clause catches all exceptions. Two variables are displayed. SQLCODE is a number that identifies the specific exception that occurred. SQLERRM is a text message explaining the error. See Section 3.5.7 for more information on exception handling.

The following shows the output when this procedure is executed.

Note: The INSERT command can be included in a FORALL statement. A FORALL statement allows a single INSERT command to insert multiple rows from values supplied in one or more collections. See 3.12.3 for more information on the FORALL statement.
### 3.4.5 UPDATE

The **UPDATE** command available in the SQL language can also be used in SPL programs.

An expression in the SPL language can be used wherever an expression is allowed in the SQL **UPDATE** command. Thus, SPL variables and parameters can be used to supply values to the update operation.

```sql
CREATE OR REPLACE PROCEDURE emp_comp_update (
    p_empno         IN emp.empno%TYPE,
    p_sal           IN emp.sal%TYPE,
    p_comm          IN emp.comm%TYPE
) IS BEGIN
    UPDATE emp SET sal = p_sal, comm = p_comm WHERE empno = p_empno;
    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Updated Employee # : ' || p_empno);
        DBMS_OUTPUT.PUT_LINE('New Salary         : ' || p_sal);
        DBMS_OUTPUT.PUT_LINE('New Commission     : ' || p_comm);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
    END IF;
END;
```

The **SQL%FOUND** conditional expression returns **TRUE** if a row is updated, **FALSE** otherwise. See Section 3.4.8 for a discussion of **SQL%FOUND** and other similar expressions.

The following shows the update on the employee using this procedure.

```
EXEC emp_comp_update(9503, 6540, 1200);
```

Updated Employee # : 9503
New Salary         : 6540
New Commission     : 1200

SELECT * FROM emp WHERE empno = 9503;

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>job</th>
<th>mgr</th>
<th>hiredate</th>
<th>sal</th>
<th>comm</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>9503</td>
<td>PETERSON</td>
<td>ANALYST</td>
<td>7902</td>
<td>31-MAR-05 00:00:00</td>
<td>6540.00</td>
<td>1200.00</td>
<td>40</td>
</tr>
</tbody>
</table>

(1 row)

**Note:** The **UPDATE** command can be included in a **FORALL** statement. A **FORALL** statement allows a single **UPDATE** command to update multiple rows from values supplied in one or more collections. See Section 3.12.3 for more information on the **FORALL** statement.

### 3.4.6 DELETE

The **DELETE** command (available in the SQL language) can also be used in SPL programs.
An expression in the SPL language can be used wherever an expression is allowed in the SQL DELETE command. Thus, SPL variables and parameters can be used to supply values to the delete operation.

```sql
CREATE OR REPLACE PROCEDURE emp_delete (
    p_empno         IN emp.empno%TYPE
) IS
BEGIN
    DELETE FROM emp WHERE empno = p_empno;
    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Deleted Employee # : ' || p_empno);
    ELSE
        DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');</p_empno
    END IF;
END;
```

The SQL%FOUND conditional expression returns TRUE if a row is deleted, FALSE otherwise. See Section 3.4.8 for a discussion of SQL%FOUND and other similar expressions.

The following shows the deletion of an employee using this procedure.

```sql
EXEC emp_delete(9503);
Deleted Employee # : 9503
SELECT * FROM emp WHERE empno = 9503;
empno | ename | job | mgr | hiredate | sal | comm | deptno
-------+-------+-----+-----+----------+-----+-------+--------
(0 rows)
```

Note: The DELETE command can be included in a FORALL statement. A FORALL statement allows a single DELETE command to delete multiple rows from values supplied in one or more collections. See Section 3.12.3 for more information on the FORALL statement.

3.4.7 Using the RETURNING INTO Clause

The INSERT, UPDATE, and DELETE commands may be appended by the optional RETURNING INTO clause. This clause allows the SPL program to capture the newly added, modified, or deleted values from the results of an INSERT, UPDATE, or DELETE command, respectively.

The following is the syntax.

```sql
{ insert | update | delete }
RETURNING { * | expr_1 [, expr_2 ] ...}
INTO { record | field_1 [, field_2 ] ...};
```
**insert** is a valid **INSERT** command. **update** is a valid **UPDATE** command. **delete** is a valid **DELETE** command. If * is specified, then the values from the row affected by the **INSERT**, **UPDATE**, or **DELETE** command are made available for assignment to the record or fields to the right of the INTO keyword. (Note that the use of * is an Advanced Server extension and is not compatible with Oracle databases.) **expr_1, expr_2...** are expressions evaluated upon the row affected by the **INSERT**, **UPDATE**, or **DELETE** command. The evaluated results are assigned to the record or fields to the right of the INTO keyword. **record** is the identifier of a record that must contain fields that match in number and order, and are data type compatible with the values in the **RETURNING** clause. **field_1, field_2...** are variables that must match in number and order, and are data type compatible with the set of values in the **RETURNING** clause.

If the **INSERT**, **UPDATE**, or **DELETE** command returns a result set with more than one row, then an exception is thrown with SQLCODE 01422, query returned more than one row. If no rows are in the result set, then the variables following the INTO keyword are set to null.

**Note:** There is a variation of **RETURNING INTO** using the **BULK COLLECT** clause that allows a result set of more than one row that is returned into a collection. See Section 3.12.4 for more information on the **BULK COLLECT** clause.

The following example is a modification of the **emp_comp_update** procedure introduced in Section 3.4.5, with the addition of the **RETURNING INTO** clause.

```sql
CREATE OR REPLACE PROCEDURE emp_comp_update (
    p_empno         IN emp.empno%TYPE,
    p_sal           IN emp.sal%TYPE,
    p_comm          IN emp.comm%TYPE )
IS
    v_empno         emp.empno%TYPE;
    v_ename         emp.ename%TYPE;
    v_job           emp.job%TYPE;
    v_sal           emp.sal%TYPE;
    v_comm          emp.comm%TYPE;
    v_deptno        emp.deptno%TYPE;
BEGIN
    UPDATE emp SET sal = p_sal, comm = p_comm WHERE empno = p_empno
    RETURNING empno, ename, job, sal, comm, deptno
    INTO v_empno, v_ename, v_job, v_sal, v_comm, v_deptno;
```
IF SQL%FOUND THEN
  DBMS_OUTPUT.PUT_LINE('Updated Employee # : ' || v_empno);
  DBMS_OUTPUT.PUT_LINE('Name               : ' || v_ename);
  DBMS_OUTPUT.PUT_LINE('Job                : ' || v_job);
  DBMS_OUTPUT.PUT_LINE('Department         : ' || v_deptno);
  DBMS_OUTPUT.PUT_LINE('New Salary         : ' || v_sal);
  DBMS_OUTPUT.PUT_LINE('New Commission     : ' || v_comm);
ELSE
  DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
END IF;
END;

The following is the output from this procedure (assuming employee 9503 created by the emp_insert procedure still exists within the table).

EXEC emp_comp_update(9503, 6540, 1200);

Updated Employee # : 9503
Name               : PETERSON
Job                : ANALYST
Department         : 40
New Salary         : 6540.00
New Commission     : 1200.00

The following example is a modification of the emp_delete procedure, with the addition of the RETURNING INTO clause using record types.

CREATE OR REPLACE PROCEDURE emp_delete (
  p_empno         IN emp.empno%TYPE
) IS
  r_emp           emp%ROWTYPE;
BEGIN
  DELETE FROM emp WHERE empno = p_empno
  RETURNING *
  INTO r_emp;
  IF SQL%FOUND THEN
    DBMS_OUTPUT.PUT_LINE('Deleted Employee # : ' || r_emp.empno);
    DBMS_OUTPUT.PUT_LINE('Name               : ' || r_emp.ename);
    DBMS_OUTPUT.PUT_LINE('Job                : ' || r_emp.job);
    DBMS_OUTPUT.PUT_LINE('Manager            : ' || r_emp.mgr);
    DBMS_OUTPUT.PUT_LINE('Hire Date          : ' || r_emp.hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary             : ' || r_emp.sal);
    DBMS_OUTPUT.PUT_LINE('Commission         : ' || r_emp.comm);
    DBMS_OUTPUT.PUT_LINE('Department         : ' || r_emp.deptno);
  ELSE
    DBMS_OUTPUT.PUT_LINE('Employee # ' || p_empno || ' not found');
  END IF;
END;

The following is the output from this procedure.

EXEC emp_delete(9503);

Deleted Employee # : 9503
Name               : PETERSON
### 3.4.8 Obtaining the Result Status

There are several attributes that can be used to determine the effect of a command. `SQL%FOUND` is a Boolean that returns `TRUE` if at least one row was affected by an `INSERT`, `UPDATE` or `DELETE` command or a `SELECT INTO` command retrieved one or more rows.

The following anonymous block inserts a row and then displays the fact that the row has been inserted.

```
BEGIN
    INSERT INTO emp (empno, ename, job, sal, deptno) VALUES (9001, 'JONES', 'CLERK', 850.00, 40);
    IF SQL%FOUND THEN
        DBMS_OUTPUT.PUT_LINE('Row has been inserted');
    END IF;
END;
Row has been inserted
```

`SQL%ROWCOUNT` provides the number of rows affected by an `INSERT`, `UPDATE`, `DELETE`, or `SELECT INTO` command. The `SQL%ROWCOUNT` value is returned as a `BIGINT` data type. The following example updates the row that was just inserted and displays `SQL%ROWCOUNT`.

```
BEGIN
    UPDATE emp SET hiredate = '03-JUN-07' WHERE empno = 9001;
    DBMS_OUTPUT.PUT_LINE('# rows updated: ' || SQL%ROWCOUNT);
END;
# rows updated: 1
```

`SQL%NOTFOUND` is the opposite of `SQL%FOUND`. `SQL%NOTFOUND` returns `TRUE` if no rows were affected by an `INSERT`, `UPDATE` or `DELETE` command or a `SELECT INTO` command retrieved no rows.

```
BEGIN
    UPDATE emp SET hiredate = '03-JUN-07' WHERE empno = 9000;
    IF SQL%NOTFOUND THEN
        DBMS_OUTPUT.PUT_LINE('No rows were updated');
    END IF;
END;
No rows were updated
```
3.5 Control Structures

The programming statements in SPL that make it a full procedural complement to SQL are described in this section.

3.5.1 IF Statement

IF statements let you execute commands based on certain conditions. SPL has four forms of IF:

- IF ... THEN
- IF ... THEN ... ELSE
- IF ... THEN ... ELSE IF
- IF ... THEN ... ELSIF ... THEN ... ELSE

3.5.1.1 IF-THEN

IF boolean-expression THEN

statements

END IF;

IF-THEN statements are the simplest form of IF. The statements between THEN and END IF will be executed if the condition is TRUE. Otherwise, they are skipped.

In the following example an IF-THEN statement is used to test and display employees who have a commission.

```sql
DECLARE
    v_empno    emp.empno%TYPE;
    v_comm    emp.comm%TYPE;
    CURSOR emp_cursor IS SELECT empno, comm FROM emp;
BEGIN
    OPEN emp_cursor;
    DBMS_OUTPUT.PUT_LINE('EMPNO    COMM');
    DBMS_OUTPUT.PUT_LINE('-----    -------');
    LOOP
        FETCH emp_cursor INTO v_empno, v_comm;
        EXIT WHEN emp_cursor%NOTFOUND;
        -- Test whether or not the employee gets a commission
        IF v_comm IS NOT NULL AND v_comm > 0 THEN
            DBMS_OUTPUT.PUT_LINE(v_empno || ' ' || TO_CHAR(v_comm,'$99999.99'));
        END IF;
    END LOOP;
    CLOSE emp_cursor;
END;
```
The following is the output from this program.

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>COMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----</td>
<td>-------</td>
</tr>
<tr>
<td>7499</td>
<td>$300.00</td>
</tr>
<tr>
<td>7521</td>
<td>$500.00</td>
</tr>
<tr>
<td>7654</td>
<td>$1400.00</td>
</tr>
</tbody>
</table>

### 3.5.1.2 IF-THEN-ELSE

```sql
IF boolean-expression THEN
  statements
ELSE
  statements
END IF;
```

**IF-THEN-ELSE** statements add to **IF-THEN** by letting you specify an alternative set of statements that should be executed if the condition evaluates to false.

The previous example is modified so an **IF-THEN-ELSE** statement is used to display the text **Non-commission** if the employee does not get a commission.

```sql
DECLARE
  v_empno emp.empno%TYPE;
  v_comm emp.comm%TYPE;
  CURSOR emp_cursor IS SELECT empno, comm FROM emp;
BEGIN
  OPEN emp_cursor;
  DBMS_OUTPUT.PUT_LINE('EMPNO    COMM');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  LOOP
    FETCH emp_cursor INTO v_empno, v_comm;
    EXIT WHEN emp_cursor%NOTFOUND;
    -- Test whether or not the employee gets a commission
    IF v_comm IS NOT NULL AND v_comm > 0 THEN
      DBMS_OUTPUT.PUT_LINE(v_empno || ' ' || TO_CHAR(v_comm,'$99999.99'));
    ELSE
      DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || 'Non-commission');
    END IF;
  END LOOP;
  CLOSE emp_cursor;
END;
```

The following is the output from this program.

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>COMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>-----</td>
<td>----------</td>
</tr>
<tr>
<td>7369</td>
<td>Non-commission</td>
</tr>
<tr>
<td>7499</td>
<td>$300.00</td>
</tr>
<tr>
<td>7521</td>
<td>$500.00</td>
</tr>
<tr>
<td>7566</td>
<td>Non-commission</td>
</tr>
<tr>
<td>7654</td>
<td>$1400.00</td>
</tr>
</tbody>
</table>
3.5.1.3 IF-THEN-ELSE IF

IF statements can be nested so that alternative IF statements can be invoked once it is determined whether or not the conditional of an outer IF statement is TRUE or FALSE.

In the following example the outer IF-THEN-ELSE statement tests whether or not an employee has a commission. The inner IF-THEN-ELSE statements then test whether the employee’s total compensation exceeds or is less than the company average.

```
DECLARE
  v_empno         emp.empno%TYPE;
  v_sal           emp.sal%TYPE;
  v_comm          emp.comm%TYPE;
  v_avg           NUMBER(7,2);
  CURSOR emp_cursor IS SELECT empno, sal, comm FROM emp;
BEGIN
  -- Calculate the average yearly compensation in the company
  SELECT AVG((sal + NVL(comm,0)) * 24) INTO v_avg FROM emp;
  DBMS_OUTPUT.PUT_LINE('Average Yearly Compensation: ' ||
                       TO_CHAR(v_avg,'$999,999.99'));
  OPEN emp_cursor;
  DBMS_OUTPUT.PUT_LINE('EMPNO    YEARLY COMP');
  DBMS_OUTPUT.PUT_LINE('-----    --------------');
  LOOP
    FETCH emp_cursor INTO v_empno, v_sal, v_comm;
    EXIT WHEN emp_cursor%NOTFOUND;
    -- Test whether or not the employee gets a commission
    IF v_comm IS NOT NULL AND v_comm > 0 THEN
      -- Test if the employee's compensation with commission exceeds the average
      IF (v_sal + v_comm) * 24 > v_avg THEN
        DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                             TO_CHAR((v_sal + v_comm) * 24,'$999,999.99') ||
                             ' Exceeds Average');
      ELSE
        DBMS_OUTPUT.PUT_LINE(v_empno || ' ' ||
                             TO_CHAR((v_sal + v_comm) * 24,'$999,999.99') ||
                             ' Below Average');
      END IF;
    ELSE
      -- Test if the employee's compensation without commission exceeds the average
      END IF;
    ELSE
      -- Test if the employee's compensation without commission exceeds the average
    END LOOP;
  END;
```

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IF v_sal * 24 > v_avg THEN
    DBMS_OUTPUT.PUT_LINE(v_empno || '  ' ||
    TO_CHAR(v_sal * 24,'$999,999.99') || ' Exceeds Average');
ELSE
    DBMS_OUTPUT.PUT_LINE(v_empno || '  ' ||
    TO_CHAR(v_sal * 24,'$999,999.99') || ' Below Average');
END IF;
END LOOP;
CLOSE emp_cursor;
END;

Note: The logic in this program can be simplified considerably by calculating the employee’s yearly compensation using the NVL function within the SELECT command of the cursor declaration, however, the purpose of this example is to demonstrate how IF statements can be used.

The following is the output from this program.

Average Yearly Compensation: $ 53,528.57
EMPNO YEARLY COMP
----- -----------
7369 $ 19,200.00 Below Average
7499 $ 45,600.00 Below Average
7521 $ 42,000.00 Below Average
7566 $ 71,400.00 Exceeds Average
7654 $ 63,600.00 Exceeds Average
7698 $ 68,400.00 Exceeds Average
7782 $ 58,800.00 Exceeds Average
7788 $ 72,000.00 Exceeds Average
7839 $ 120,000.00 Exceeds Average
7844 $ 36,000.00 Below Average
7876 $ 26,400.00 Below Average
7900 $ 22,800.00 Below Average
7902 $ 72,000.00 Exceeds Average
7934 $ 31,200.00 Below Average

When you use this form, you are actually nesting an IF statement inside the ELSE part of an outer IF statement. Thus you need one END IF statement for each nested IF and one for the parent IF-ELSE.

3.5.1.4 IF-THEN-ELSIF-ELSE

    IF boolean-expression THEN
      statements
      [ ELSIF boolean-expression THEN
        statements
        [ ELSIF boolean-expression THEN
          statements ] ...]
      [ ELSE
        statements ]
    END IF;
**IF-THEN-ELSIF-ELSE** provides a method of checking many alternatives in one statement. Formally it is equivalent to nested **IF-THEN-ELSE-IF-THEN** commands, but only one **END IF** is needed.

The following example uses an **IF-THEN-ELSIF-ELSE** statement to count the number of employees by compensation ranges of $25,000.

```sql
DECLARE
    v_empno emp.empno%TYPE;
    v_comp NUMBER(8,2);
    v_lt_25K SMALLINT := 0;
    v_25K_50K SMALLINT := 0;
    v_50K_75K SMALLINT := 0;
    v_75K_100K SMALLINT := 0;
    v_ge_100K SMALLINT := 0;
CURSOR emp_cursor IS SELECT empno, (sal + NVL(comm,0)) * 24 FROM emp;
BEGIN
    OPEN emp_cursor;
    LOOP
        FETCH emp_cursor INTO v_empno, v_comp;
        EXIT WHEN emp_cursor%NOTFOUND;
        IF v_comp < 25000 THEN
            v_lt_25K := v_lt_25K + 1;
        ELSIF v_comp < 50000 THEN
            v_25K_50K := v_25K_50K + 1;
        ELSIF v_comp < 75000 THEN
            v_50K_75K := v_50K_75K + 1;
        ELSIF v_comp < 100000 THEN
            v_75K_100K := v_75K_100K + 1;
        ELSE
            v_ge_100K := v_ge_100K + 1;
        END IF;
    END LOOP;
    CLOSE emp_cursor;
    DBMS_OUTPUT.PUT_LINE('Number of employees by yearly compensation');
    DBMS_OUTPUT.PUT_LINE('Less than 25,000 : ' || v_lt_25K);
    DBMS_OUTPUT.PUT_LINE('25,000 - 49,999 : ' || v_25K_50K);
    DBMS_OUTPUT.PUT_LINE('50,000 - 74,999 : ' || v_50K_75K);
    DBMS_OUTPUT.PUT_LINE('75,000 - 99,999 : ' || v_75K_100K);
    DBMS_OUTPUT.PUT_LINE('100,000 and over : ' || v_ge_100K);
END;
```

The following is the output from this program.

```
Number of employees by yearly compensation
Less than 25,000 : 2
25,000 - 49,999 : 5
50,000 - 74,999 : 6
75,000 - 99,999 : 0
100,000 and over : 1
```
3.5.2 RETURN Statement

The RETURN statement terminates the current function, procedure or anonymous block and returns control to the caller.

There are two forms of the RETURN Statement. The first form of the RETURN statement is used to terminate a procedure or function that returns void. The syntax of the first form is:

```
RETURN;
```

The second form of RETURN returns a value to the caller. The syntax of the second form of the RETURN statement is:

```
RETURN expression;
```

expression must evaluate to the same data type as the return type of the function.

The following example uses the RETURN statement returns a value to the caller:

```sql
CREATE OR REPLACE FUNCTION emp_comp (p_sal NUMBER, p_comm NUMBER) RETURN NUMBER IS BEGIN RETURN (p_sal + NVL(p_comm, 0)) * 24; END emp_comp;
```
3.5.3 GOTO Statement

The **GOTO** statement causes the point of execution to jump to the statement with the specified label. The syntax of a **GOTO** statement is:

\[
\text{GOTO label}
\]

*label* is a name assigned to an executable statement. *label* must be unique within the scope of the function, procedure or anonymous block.

To label a statement, use the syntax:

\[
<<\text{label}>> \text{ statement}
\]

*statement* is the point of execution that the program jumps to.

You can label assignment statements, any SQL statement (like **INSERT**, **UPDATE**, **CREATE**, etc.) and selected procedural language statements. The procedural language statements that can be labeled are:

- **IF**
- **EXIT**
- **RETURN**
- **RAISE**
- **EXECUTE**
- **PERFORM**
- **GET DIAGNOSTICS**
- **OPEN**
- **FETCH**
- **MOVE**
- **CLOSE**
- **NULL**
- **COMMIT**
- **ROLLBACK**
- **GOTO**
- **CASE**
- **LOOP**
- **WHILE**
- **FOR**

Please note that **exit** is considered a keyword, and cannot be used as the name of a label.

**GOTO** statements cannot transfer control *into* a conditional block or sub-block, but can transfer control *from* a conditional block or sub-block.
The following example verifies that an employee record contains a name, job description, and employee hire date; if any piece of information is missing, a GOTO statement transfers the point of execution to a statement that prints a message that the employee is not valid.

```sql
CREATE OR REPLACE PROCEDURE verify_emp (p_empno NUMBER) IS
  v_ename emp.ename%TYPE;
  v_job emp.job%TYPE;
  v_hiredate emp.hiredate%TYPE;
BEGIN
  SELECT ename, job, hiredate
  INTO v_ename, v_job, v_hiredate FROM emp
  WHERE empno = p_empno;
  IF v_ename IS NULL THEN
    GOTO invalid_emp;
  END IF;
  IF v_job IS NULL THEN
    GOTO invalid_emp;
  END IF;
  IF v_hiredate IS NULL THEN
    GOTO invalid_emp;
  END IF;
  DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno || ' validated without errors.');
  RETURN;
<<invalid_emp>>
  DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno || ' is not a valid employee.');
END;
```

GOTO statements have the following restrictions:

- A GOTO statement cannot jump to a declaration.
- A GOTO statement cannot transfer control to another function or procedure.
- A label should not be placed at the end of a block, function or procedure.
3.5.4 CASE Expression

The `CASE` expression returns a value that is substituted where the `CASE` expression is located within an expression.

There are two formats of the `CASE` expression - one that is called a searched `CASE` and the other that uses a selector.

3.5.4.1 Selector CASE Expression

The selector `CASE` expression attempts to match an expression called the selector to the expression specified in one or more `WHEN` clauses. `result` is an expression that is type-compatible in the context where the `CASE` expression is used. If a match is found, the value given in the corresponding `THEN` clause is returned by the `CASE` expression. If there are no matches, the value following `ELSE` is returned. If `ELSE` is omitted, the `CASE` expression returns null.

```
CASE selector-expression
  WHEN match-expression THEN
    result
  [ WHEN match-expression THEN
    result
  [ WHEN match-expression THEN
    result
  [ ELSE
    result
  ] ...]
END;
```

`match-expression` is evaluated in the order in which it appears within the `CASE` expression. `result` is an expression that is type-compatible in the context where the `CASE` expression is used. When the first `match-expression` is encountered that equals `selector-expression`, `result` in the corresponding `THEN` clause is returned as the value of the `CASE` expression. If none of `match-expression equals selector-expression` then `result` following `ELSE` is returned. If no `ELSE` is specified, the `CASE` expression returns null.

The following example uses a selector `CASE` expression to assign the department name to a variable based upon the department number.

```
DECLARE
  v_empno       emp.empno%TYPE;
  v_ename       emp.ename%TYPE;
  v_deptno      emp.deptno%TYPE;
  v_dname       dept.dname%TYPE;
CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
  OPEN emp_cursor;
```
The following is the output from this program.

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>DEPTNO</th>
<th>DNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>10</td>
<td>Accounting</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>10</td>
<td>Accounting</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>10</td>
<td>Accounting</td>
</tr>
</tbody>
</table>

### 3.5.4.2 Searched CASE Expression

A searched \texttt{CASE} expression uses one or more \texttt{Boolean} expressions to determine the resulting value to return.

```sql
CASE WHEN boolean-expression THEN result
    [ WHEN boolean-expression THEN result
    [ WHEN boolean-expression THEN result ] ...]
    [ ELSE result ]
END;
```

\texttt{boolean-expression} is evaluated in the order in which it appears within the \texttt{CASE} expression. \texttt{result} is an expression that is type-compatible in the context where the \texttt{CASE} expression is used. When the first \texttt{boolean-expression} is encountered that
evaluates to TRUE, result in the corresponding THEN clause is returned as the value of the CASE expression. If none of boolean-expression evaluates to true then result following ELSE is returned. If no ELSE is specified, the CASE expression returns null.

The following example uses a searched CASE expression to assign the department name to a variable based upon the department number.

```sql
DECLARE
  v_empno         emp.empno%TYPE;
  v_ename         emp.ename%TYPE;
  v_deptno        emp.deptno%TYPE;
  v_dname         dept.dname%TYPE;
CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
  OPEN emp_cursor;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME     DEPTNO    DNAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------     -----    ------');
  LOOP
    FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
    EXIT WHEN emp_cursor%NOTFOUND;
    v_dname :=
      CASE
        WHEN v_deptno = 10 THEN 'Accounting'
        WHEN v_deptno = 20 THEN 'Research'
        WHEN v_deptno = 30 THEN 'Sales'
        WHEN v_deptno = 40 THEN 'Operations'
        ELSE 'unknown'
      END;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || RPAD(v_ename, 10) ||
                         '  ' || v_deptno || '      ' || v_dname);
  END LOOP;
  CLOSE emp_cursor;
END;
```

The following is the output from this program.

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>DEPTNO</th>
<th>DNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>10</td>
<td>Accounting</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>10</td>
<td>Accounting</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>30</td>
<td>Sales</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>20</td>
<td>Research</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>10</td>
<td>Accounting</td>
</tr>
</tbody>
</table>
3.5.5 CASE Statement

The CASE statement executes a set of one or more statements when a specified search condition is TRUE. The CASE statement is a stand-alone statement in itself while the previously discussed CASE expression must appear as part of an expression.

There are two formats of the CASE statement - one that is called a searched CASE and the other that uses a selector.

3.5.5.1 Selector CASE Statement

The selector CASE statement attempts to match an expression called the selector to the expression specified in one or more WHEN clauses. When a match is found one or more corresponding statements are executed.

```
CASE selector-expression
  WHEN match-expression THEN
    statements
  [ WHEN match-expression THEN
    statements
  [ WHEN match-expression THEN
    statements ] ...]
  [ ELSE
    statements ]
END CASE;
```

The following example uses a selector CASE statement to assign a department name and location to a variable based upon the department number.

```sql
DECLARE
  v_empno         emp.empno%TYPE;
  v_ename         emp.ename%TYPE;
  v_deptno        emp.deptno%TYPE;
  v_dname         dept.dname%TYPE;
  v_loc           dept.loc%TYPE;
BEGIN
  CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
```
OPEN emp_cursor;
DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME     DEPTNO    DNAME     ' || ' LOC');
DBMS_OUTPUT.PUT_LINE('----- ------ ------ ---------');
LOOP
  FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
  EXIT WHEN emp_cursor%NOTFOUND;
  CASE v_deptno
    WHEN 10 THEN v_dname := 'Accounting';
      v_loc := 'New York';
    WHEN 20 THEN v_dname := 'Research';
      v_loc := 'Dallas';
    WHEN 30 THEN v_dname := 'Sales';
      v_loc := 'Chicago';
    WHEN 40 THEN v_dname := 'Operations';
      v_loc := 'Boston';
    ELSE v_dname := 'unknown';
      v_loc := '';
  END CASE;
  DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || RPAD(v_ename, 10) || '  ' || v_deptno || '      ' || RPAD(v_dname, 14) || ' ' || v_loc);
END LOOP;
CLOSE emp_cursor;
END;

The following is the output from this program.

3.5.5.2 Searched CASE statement

A searched CASE statement uses one or more Boolean expressions to determine the resulting set of statements to execute.

```
CASE WHEN boolean-expression THEN
  statements
[ WHEN boolean-expression THEN
    statements
[ WHEN boolean-expression THEN
    statements ] ...]
[ ELSE
```
boolean-expression is evaluated in the order in which it appears within the CASE statement. When the first boolean-expression is encountered that evaluates to TRUE, the statement(s) in the corresponding THEN clause are executed and control continues following the END CASE keywords. If none of boolean-expression evaluates to TRUE, the statement(s) following ELSE are executed. If none of boolean-expression evaluates to TRUE and there is no ELSE clause, an exception is thrown.

The following example uses a searched CASE statement to assign a department name and location to a variable based upon the department number.

```sql
DECLARE
  v_empno emp.empno%TYPE;
  v_ename emp.ename%TYPE;
  v_deptno emp.deptno%TYPE;
  v_dname dept.dname%TYPE;
  v_loc dept.loc%TYPE;
  CURSOR emp_cursor IS SELECT empno, ename, deptno FROM emp;
BEGIN
  OPEN emp_cursor;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME     DEPTNO    DNAME     ' || '     LOC');
  DBMS_OUTPUT.PUT_LINE('               ------     ------     --------     --------     ---------');
  LOOP
    FETCH emp_cursor INTO v_empno, v_ename, v_deptno;
    EXIT WHEN emp_cursor%NOTFOUND;
    CASE
      WHEN v_deptno = 10 THEN v_dname := 'Accounting';
        v_loc := 'New York';
      WHEN v_deptno = 20 THEN v_dname := 'Research';
        v_loc := 'Dallas';
      WHEN v_deptno = 30 THEN v_dname := 'Sales';
        v_loc := 'Chicago';
      WHEN v_deptno = 40 THEN v_dname := 'Operations';
        v_loc := 'Boston';
      ELSE v_dname := 'unknown';
        v_loc := '';
    END CASE;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || RPAD(v_ename, 10) ||
                         '     ' || v_deptno || '     ' || RPAD(v_dname, 14) || '     ' ||
                         v_loc);
  END LOOP;
  CLOSE emp_cursor;
END;
```

The following is the output from this program.

```
EMPNO    ENAME     DEPTNO    DNAME          LOC
-----     ------     -------     -------     --------     ---------
7369      SMITH       20      Research       Dallas
7499      ALLEN       30      Sales          Chicago
7521      WARD        30      Sales          Chicago
7566      JONES       30      Research       Dallas
7654      MARTIN      30      Sales          Chicago
```
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>30</td>
<td>Sales</td>
<td>Chicago</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>10</td>
<td>Accounting</td>
<td>New York</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>20</td>
<td>Research</td>
<td>Dallas</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>10</td>
<td>Accounting</td>
<td>New York</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>30</td>
<td>Sales</td>
<td>Chicago</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>20</td>
<td>Research</td>
<td>Dallas</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>30</td>
<td>Sales</td>
<td>Chicago</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>20</td>
<td>Research</td>
<td>Dallas</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>10</td>
<td>Accounting</td>
<td>New York</td>
</tr>
</tbody>
</table>
3.5.6 Loops

With the LOOP, EXIT, CONTINUE, WHILE, and FOR statements, you can arrange for your SPL program to repeat a series of commands.

3.5.6.1 LOOP

```sql
LOOP
  statements
END LOOP;
```

LOOP defines an unconditional loop that is repeated indefinitely until terminated by an EXIT or RETURN statement.

3.5.6.2 EXIT

```sql
EXIT [ WHEN expression ];
```

The innermost loop is terminated and the statement following END LOOP is executed next.

If WHEN is present, loop exit occurs only if the specified condition is TRUE, otherwise control passes to the statement after EXIT.

EXIT can be used to cause early exit from all types of loops; it is not limited to use with unconditional loops.

The following is a simple example of a loop that iterates ten times and then uses the EXIT statement to terminate.

```sql
DECLARE
  v_counter       NUMBER(2);
BEGIN
  v_counter := 1;
  LOOP
    EXIT WHEN v_counter > 10;
    DBMS_OUTPUT.PUT_LINE('Iteration # ' || v_counter);
    v_counter := v_counter + 1;
  END LOOP;
END;
```

The following is the output from this program.

```
Iteration # 1
Iteration # 2
Iteration # 3
Iteration # 4
Iteration # 5
Iteration # 6
Iteration # 7
```
3.5.6.3 CONTINUE

The `CONTINUE` statement provides a way to proceed with the next iteration of a loop while skipping intervening statements.

When the `CONTINUE` statement is encountered, the next iteration of the innermost loop is begun, skipping all statements following the `CONTINUE` statement until the end of the loop. That is, control is passed back to the loop control expression, if any, and the body of the loop is re-evaluated.

If the `WHEN` clause is used, then the next iteration of the loop is begun only if the specified expression in the `WHEN` clause evaluates to `TRUE`. Otherwise, control is passed to the next statement following the `CONTINUE` statement.

The `CONTINUE` statement may not be used outside of a loop.

The following is a variation of the previous example that uses the `CONTINUE` statement to skip the display of the odd numbers.

```sql
DECLARE
  v_counter NUMBER(2);
BEGIN
  v_counter := 0;
  LOOP
    v_counter := v_counter + 1;
    EXIT WHEN v_counter > 10;
    CONTINUE WHEN MOD(v_counter,2) = 1;
    DBMS_OUTPUT.PUT_LINE('Iteration # ' || v_counter);
  END LOOP;
END;
```

The following is the output from above program.

```
Iteration # 2
Iteration # 4
Iteration # 6
Iteration # 8
Iteration # 10
```

3.5.6.4 WHILE

```
WHILE expression LOOP
  statements
END LOOP;
```

The `WHILE` statement repeats a sequence of statements so long as the condition expression evaluates to `TRUE`. The condition is checked just before each entry to the loop body.
The following example contains the same logic as in the previous example except the
WHILE statement is used to take the place of the EXIT statement to determine when to
exit the loop.

**Note:** The conditional expression used to determine when to exit the loop must be
altered. The EXIT statement terminates the loop when its conditional expression is true. The WHILE statement terminates (or never begins the loop) when its conditional
expression is false.

```sql
DECLARE
  v_counter       NUMBER(2);
BEGIN
  v_counter := 1;
  WHILE v_counter <= 10 LOOP
    DBMS_OUTPUT.PUT_LINE('Iteration # ' || v_counter);
    v_counter := v_counter + 1;
  END LOOP;
END;
```

The same result is generated by this example as in the prior example.

```
Iteration # 1
Iteration # 2
Iteration # 3
Iteration # 4
Iteration # 5
Iteration # 6
Iteration # 7
Iteration # 8
Iteration # 9
Iteration # 10
```

### 3.5.6.5 FOR (integer variant)

```
FOR name IN [REVERSE] expression .. expression LOOP
  statements
END LOOP;
```

This form of FOR creates a loop that iterates over a range of integer values. The variable
name is automatically defined as type INTEGER and exists only inside the loop. The two
expressions giving the loop range are evaluated once when entering the loop. The
iteration step is +1 and name begins with the value of expression to the left of .. and
terminates once name exceeds the value of expression to the right of .. Thus the two
expressions take on the following roles: start-value..end-value.

The optional REVERSE clause specifies that the loop should iterate in reverse order. The
first time through the loop, name is set to the value of the right-most expression; the
loop terminates when the name is less than the left-most expression.

The following example simplifies the WHILE loop example even further by using a FOR
loop that iterates from 1 to 10.
BEGIN
  FOR i IN 1 .. 10 LOOP
    DBMS_OUTPUT.PUT_LINE('Iteration # ' || i);
  END LOOP;
END;

Here is the output using the FOR statement.

Iteration # 1
Iteration # 2
Iteration # 3
Iteration # 4
Iteration # 5
Iteration # 6
Iteration # 7
Iteration # 8
Iteration # 9
Iteration # 10

If the start value is greater than the end value the loop body is not executed at all. No error is raised as shown by the following example.

BEGIN
  FOR i IN 10 .. 1 LOOP
    DBMS_OUTPUT.PUT_LINE('Iteration # ' || i);
  END LOOP;
END;

There is no output from this example as the loop body is never executed.

Note: SPL also supports CURSOR FOR loops (see Section 3.8.7).
### 3.5.7 Exception Handling

By default, any error occurring in an SPL program aborts execution of the program. You can trap errors and recover from them by using a `BEGIN` block with an `EXCEPTION` section. The syntax is an extension of the normal syntax for a `BEGIN` block:

```
[ DECLARE
   declarations ]
BEGIN
  statements
EXCEPTION
  WHEN condition [ OR condition ]... THEN
    handler_statements
  WHEN condition [ OR condition ]... THEN
    handler_statements
  END;
```

If no error occurs, this form of block simply executes all the `statements`, and then control passes to the next statement after `END`. If an error occurs within the `statements`, further processing of the `statements` is abandoned, and control passes to the `EXCEPTION` list. The list is searched for the first `condition` matching the error that occurred. If a match is found, the corresponding `handler_statements` are executed, and then control passes to the next statement after `END`. If no match is found, the error propagates out as though the `EXCEPTION` clause were not there at all. The error can be caught by an enclosing block with `EXCEPTION`; if there is no enclosing block, it aborts processing of the subprogram.

The special condition name `OTHERS` matches every error type. Condition names are not case-sensitive.

If a new error occurs within the selected `handler_statements`, it cannot be caught by this `EXCEPTION` clause, but is propagated out. A surrounding `EXCEPTION` clause could catch it.

The following table lists the condition names that may be used:

<table>
<thead>
<tr>
<th>Condition Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CASE_NOT_FOUND</td>
<td>The application has encountered a situation where none of the cases in a CASE statement evaluates to TRUE and there is no ELSE condition.</td>
</tr>
<tr>
<td>COLLECTION_IS_NULL</td>
<td>The application has attempted to invoke a collection method on a null collection such as an uninitialized nested table.</td>
</tr>
<tr>
<td>CURSOR_ALREADY_OPEN</td>
<td>The application has attempted to open a cursor that is already open.</td>
</tr>
<tr>
<td>Condition Name</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DUP_VAL_ON_INDEX</td>
<td>The application has attempted to store a duplicate value that currently exists within a constrained column.</td>
</tr>
<tr>
<td>INVALID_CURSOR</td>
<td>The application has attempted to access an unopened cursor.</td>
</tr>
<tr>
<td>INVALID_NUMBER</td>
<td>The application has encountered a data exception (equivalent to SQLSTATE class code 22). INVALID_NUMBER is an alias for VALUE_ERROR.</td>
</tr>
<tr>
<td>NO_DATA_FOUND</td>
<td>No rows satisfy the selection criteria.</td>
</tr>
<tr>
<td>OTHERS</td>
<td>The application has encountered an exception that hasn’t been caught by a prior condition in the exception section.</td>
</tr>
<tr>
<td>SUBSCRIPT_BEYOND_COUNT</td>
<td>The application has attempted to reference a subscript of a nested table or varray beyond its initialized or extended size.</td>
</tr>
<tr>
<td>SUBSCRIPT_OUTSIDE_LIMIT</td>
<td>The application has attempted to reference a subscript or extend a varray beyond its maximum size limit.</td>
</tr>
<tr>
<td>TOO_MANY_ROWS</td>
<td>The application has encountered more than one row that satisfies the selection criteria (where only one row is allowed to be returned).</td>
</tr>
<tr>
<td>VALUE_ERROR</td>
<td>The application has encountered a data exception (equivalent to SQLSTATE class code 22). VALUE_ERROR is an alias for INVALID_NUMBER.</td>
</tr>
<tr>
<td>ZERO_DIVIDE</td>
<td>The application has tried to divide by zero.</td>
</tr>
<tr>
<td>User-defined Exception</td>
<td>See Section 3.5.8</td>
</tr>
</tbody>
</table>

**Note:** Condition names INVALID_NUMBER and VALUE_ERROR are not compatible with Oracle databases for which these condition names are for exceptions resulting only from a failed conversion of a string to a numeric literal. In addition, for Oracle databases, an INVALID_NUMBER exception is applicable only to SQL statements while a VALUE_ERROR exception is applicable only to procedural statements.
3.5.8 User-defined Exceptions

Any number of errors (referred to in PL/SQL as exceptions) can occur during program execution. When an exception is *thrown*, normal execution of the program stops, and control of the program transfers to the error-handling portion of the program. An *exception* may be a pre-defined error that is generated by the server, or may be a logical error that raises a user-defined exception.

User-defined exceptions are never raised by the server; they are raised explicitly by a `RAISE` statement. A user-defined exception is raised when a developer-defined logical rule is broken; a common example of a logical rule being broken occurs when a check is presented against an account with insufficient funds. An attempt to cash a check against an account with insufficient funds will provoke a user-defined exception.

You can define exceptions in functions, procedures, packages or anonymous blocks. While you cannot declare the same exception twice in the same block, you can declare the same exception in two different blocks.

Before implementing a user-defined exception, you must declare the exception in the declaration section of a function, procedure, package or anonymous block. You can then raise the exception using the `RAISE` statement:

```sql
DECLARE
  exception_name EXCEPTION;
BEGIN
  ...
  RAISE exception_name;
  ...
END;
```

`exception_name` is the name of the exception.

Unhandled exceptions propagate back through the call stack. If the exception remains unhandled, the exception is eventually reported to the client application.

User-defined exceptions declared in a block are considered to be local to that block, and global to any nested blocks within the block. To reference an exception that resides in an outer block, you must assign a label to the outer block; then, preface the name of the exception with the block name:

```sql
block_name.exception_name
```

Conversely, outer blocks cannot reference exceptions declared in nested blocks.
The scope of a declaration is limited to the block in which it is declared unless it is created in a package, and when referenced, qualified by the package name. For example, to raise an exception named `out_of_stock` that resides in a package named `inventory_control` a program must raise an error named:

```
inventory_control.out_of_stock
```

The following example demonstrates declaring a user-defined exception in a package. The user-defined exception does not require a package-qualifier when it is raised in `check_balance`, since it resides in the same package as the exception:

```
CREATE OR REPLACE PACKAGE ar AS
  overdrawn EXCEPTION;
  PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER);
END;

CREATE OR REPLACE PACKAGE BODY ar AS
  PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER)
  IS
    BEGIN
      IF (p_amount > p_balance) THEN
        RAISE overdrawn;
      END IF;
    END;
END;
```

The following procedure (``purchase``) calls the `check_balance` procedure. If `p_amount` is greater than `p_balance`, `check_balance` raises an exception; `purchase` catches the `ar.overdrawn` exception. `purchase` must refer to the exception with a package-qualified name (`ar.overdrawn`) because `purchase` is not defined within the `ar` package.

```
CREATE PROCEDURE purchase(customerID INT, amount NUMERIC) AS
  BEGIN
    ar.check_balance(getcustomerbalance(customerid), amount);
    record_purchase(customerid, amount);
  EXCEPTION
    WHEN ar.overdrawn THEN
      raise_credit_limit(customerid, amount*1.5);
  END;
```

When `ar.check_balance` raises an exception, execution jumps to the exception handler defined in `purchase`:

```
EXCEPTION
  WHEN ar.overdrawn THEN
    raise_credit_limit(customerid, amount*1.5);
```

The exception handler raises the customer’s credit limit and ends. When the exception handler ends, execution resumes with the statement that follows `ar.check_balance`. 
3.5.9 PRAGMA EXCEPTION_INIT

PRAGMA EXCEPTION_INIT associates a user-defined error code with an exception. A PRAGMA EXCEPTION_INIT declaration may be included in any block, sub-block or package. You can only assign an error code to an exception (using PRAGMA EXCEPTION_INIT) after declaring the exception. The format of a PRAGMA EXCEPTION_INIT declaration is:

```
PRAGMA EXCEPTION_INIT(
    exception_name, 
    {exception_number | exception_code})
```

Where:

- `exception_name` is the name of the associated exception.
- `exception_number` is a user-defined error code associated with the pragma. If you specify an unmapped `exception_number`, the server will return a warning.
- `exception_code` is the name of a pre-defined exception. For a complete list of valid exceptions, see the Postgres core documentation available at:

```
https://www.postgresql.org/docs/10/static/errcodes-appendix.html
```

The previous section (User-defined Exceptions) included an example that demonstrates declaring a user-defined exception in a package. The following example uses the same basic structure, but adds a PRAGMA EXCEPTION_INIT declaration:

```
CREATE OR REPLACE PACKAGE ar AS
    overdrawn EXCEPTION;
    PRAGMA EXCEPTION_INIT (overdrawn, -20100);
    PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER);
END;

CREATE OR REPLACE PACKAGE BODY ar AS
    PROCEDURE check_balance(p_balance NUMBER, p_amount NUMBER)
    IS
        BEGIN
            IF (p_amount > p_balance) THEN
                RAISE overdrawn;
            END IF;
        END;
    END;
```

The following procedure (purchase) calls the check_balance procedure. If `p_amount` is greater than `p_balance`, check_balance raises an exception; purchase catches the ar.overdrawn exception.
CREATE PROCEDURE purchase(customerID int, amount NUMERIC)
AS
BEGIN
    ar.check_balance(getcustomerbalance(customerid), amount);
    record_purchase(customerid, amount);
EXCEPTION
    WHEN ar.overdrawn THEN
        DBMS_OUTPUT.PUT_LINE ('This account is overdrawn.');
        DBMS_OUTPUT.PUT_LINE ('SQLCode :'||SQLCODE||' '||SQLERRM);
END;

When ar.check_balance raises an exception, execution jumps to the exception handler defined in purchase.

EXCEPTION
    WHEN ar.overdrawn THEN
        DBMS_OUTPUT.PUT_LINE ('This account is overdrawn.');
        DBMS_OUTPUT.PUT_LINE ('SQLCode :'||SQLCODE||' '||SQLERRM);

The exception handler returns an error message, followed by SQLCODE information:

This account is overdrawn.
SQLCODE: -20100 User-Defined Exception

The following example demonstrates using a pre-defined exception. The code creates a more meaningful name for the no_data_found exception; if the given customer does not exist, the code catches the exception, calls DBMS_OUTPUT.PUT_LINE to report the error, and then re-raises the original exception:

CREATE OR REPLACE PACKAGE ar AS
    overdrawn EXCEPTION;
    PRAGMA EXCEPTION_INIT (unknown_customer, no_data_found);
    PROCEDURE check_balance(p_customer_id NUMBER);
END;

CREATE OR REPLACE PACKAGE BODY ar AS
    PROCEDURE check_balance(p_customer_id NUMBER) IS
        DECLARE
            v_balance NUMBER;
        BEGIN
            SELECT balance INTO v_balance FROM customer
                WHERE cust_id = p_customer_id;
        EXCEPTION WHEN unknown_customer THEN
            DBMS_OUTPUT.PUT_LINE('invalid customer id');
            RAISE;
        END;
END;
3.5.10 RAISE_APPLICATION_ERROR

The procedure, RAISE_APPLICATION_ERROR, allows a developer to intentionally abort processing within an SPL program from which it is called by causing an exception. The exception is handled in the same manner as described in Section 3.5.7. In addition, the RAISE_APPLICATION_ERROR procedure makes a user-defined code and error message available to the program which can then be used to identify the exception.

RAISE_APPLICATION_ERROR(error_number, message);

Where:

- **error_number** is an integer value or expression that is returned in a variable named SQLCODE when the procedure is executed. error_number must be a value between -20000 and -20999.

- **message** is a string literal or expression that is returned in a variable named SQLERRM.

For additional information on the SQLCODE and SQLERRM variables, see Section 3.13, Errors and Messages.

The following example uses the RAISE_APPLICATION_ERROR procedure to display a different code and message depending upon the information missing from an employee.

```sql
CREATE OR REPLACE PROCEDURE verify_emp (p_empno NUMBER ) IS
  v_ename emp.ename%TYPE;
  v_job emp.job%TYPE;
  v_mg m emp.mgr%TYPE;
  v_hiredate emp.hiredate%TYPE;
BEGIN
  SELECT ename, job, mgr, hiredate
  INTO v_ename, v_job, v_mg m, v_hiredate FROM emp
  WHERE empno = p_empno;
  IF v_ename IS NULL THEN
    RAISE_APPLICATION_ERROR(-20010, 'No name for ' || p_empno);
  END IF;
  IF v_job IS NULL THEN
    RAISE_APPLICATION_ERROR(-20020, 'No job for' || p_empno);
  END IF;
  IF v_mg m IS NULL THEN
    RAISE_APPLICATION_ERROR(-20030, 'No manager for ' || p_empno);
  END IF;
  IF v_hiredate IS NULL THEN
    RAISE_APPLICATION_ERROR(-20040, 'No hire date for ' || p_empno);
  END IF;
  DBMS_OUTPUT.PUT_LINE('Employee ' || p_empno ||
    ' validated without errors');
EXCEPTION
```

```sql```
WHEN OTHERS THEN
    DBMS_OUTPUT.PUT_LINE('SQLCODE: ' || SQLCODE);
    DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
END;

The following shows the output in a case where the manager number is missing from an employee record.

EXEC verify_emp(7839);

SQLCODE: -20030
SQLERRM: EDB-20030: No manager for 7839
### 3.6 Transaction Control

There may be circumstances where it is desired that all updates to a database are to occur successfully, or none are to occur at all if any error occurs. A set of database updates that are to all occur successfully as a single unit, or are not to occur at all, is said to be a transaction.

A common example in banking is a funds transfer between two accounts. The two parts of the transaction are the withdrawal of funds from one account, and the deposit of the funds in another account. Both parts of this transaction must occur otherwise the bank’s books will be out of balance. The deposit and withdrawal are one transaction.

An SPL application can be created that uses a style of transaction control compatible with Oracle databases if the following conditions are met:

- The `edb_stmt_level_tx` parameter must be set to `TRUE`. This prevents the action of unconditionally rolling back all database updates within the `BEGIN/END` block if any exception occurs. See Section 1.3.4 for more information on the `edb_stmt_level_tx` parameter.
- The application must not be running in autocommit mode. If autocommit mode is on, each successful database update is immediately committed and cannot be undone. The manner in which autocommit mode is turned on or off is application dependent.

A transaction begins when the first SQL command is encountered in the SPL program. All subsequent SQL commands are included as part of that transaction. The transaction ends when one of the following occurs:

- An unhandled exception occurs in which case the effects of all database updates made during the transaction are rolled back and the transaction is aborted.
- A `COMMIT` command is encountered in which case the effect of all database updates made during the transaction become permanent.
- A `ROLLBACK` command is encountered in which case the effects of all database updates made during the transaction are rolled back and the transaction is aborted. If a new SQL command is encountered, a new transaction begins.
- Control returns to the calling application (such as Java, PSQL, etc.) in which case the action of the application determines whether the transaction is committed or rolled back.

**Note:** Unlike Oracle, DDL commands such as `CREATE TABLE` do not implicitly occur within their own transaction. Therefore, DDL commands do not automatically cause an immediate database commit as in Oracle, and DDL commands may be rolled back just like DML commands.
A transaction may span one or more \texttt{BEGIN/END} blocks, or a single \texttt{BEGIN/END} block may contain one or more transactions.

The following sections discuss the \texttt{COMMIT} and \texttt{ROLLBACK} commands in more detail.

### 3.6.1 COMMIT

The \texttt{COMMIT} command makes all database updates made during the current transaction permanent, and ends the current transaction.

\[
\text{COMMIT [ WORK ];}
\]

The \texttt{COMMIT} command may be used within anonymous blocks, stored procedures, or functions. Within an SPL program, it may appear in the executable section and/or the exception section.

In the following example, the third \texttt{INSERT} command in the anonymous block results in an error. The effect of the first two \texttt{INSERT} commands are retained as shown by the first \texttt{SELECT} command. Even after issuing a \texttt{ROLLBACK} command, the two rows remain in the table as shown by the second \texttt{SELECT} command verifying that they were indeed committed.

\textbf{Note:} The \texttt{edb_stmt_level_tx} configuration parameter shown in the example below can be set for the entire database using the \texttt{ALTER DATABASE} command, or it can be set for the entire database server by changing it in the \texttt{postgresql.conf} file.

```sql
\texttt{\set AUTOCOMMIT off}
\texttt{SET edb_stmt_level_tx TO on;}
\texttt{BEGIN}
\texttt{    INSERT INTO dept VALUES (50, 'FINANCE', 'DALLAS');}
\texttt{    INSERT INTO dept VALUES (60, 'MARKETING', 'CHICAGO');}
\texttt{    COMMIT;}
\texttt{    INSERT INTO dept VALUES (70, 'HUMAN RESOURCES', 'CHICAGO');}
\texttt{EXCEPTION}
\texttt{    WHEN OTHERS THEN}
\texttt{        DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);}
\texttt{        DBMS_OUTPUT.PUT_LINE('SQLCODE: ' || SQLCODE);}
\texttt{END;}
\texttt{SELECT * FROM dept;}
```

\begin{verbatim}
deptno |   dname    |   loc
--------+------------+-------
10 | ACCOUNTING | NEW YORK
20 | RESEARCH   | DALLAS
30 | SALES      | CHICAGO
\end{verbatim}
3.6.2 ROLLBACK

The **ROLLBACK** command undoes all database updates made during the current transaction, and ends the current transaction.

```
ROLLBACK [ WORK ];
```

The **ROLLBACK** command may be used within anonymous blocks, stored procedures, or functions. Within an SPL program, it may appear in the executable section and/or the exception section.

In the following example, the exception section contains a **ROLLBACK** command. Even though the first two **INSERT** commands are executed successfully, the third results in an exception that results in the rollback of all the **INSERT** commands in the anonymous block.

```sql
\set AUTOCOMMIT off
SET edb_stmt_level_tx TO on;
BEGIN
  INSERT INTO dept VALUES (50, 'FINANCE', 'DALLAS');
  INSERT INTO dept VALUES (60, 'MARKETING', 'CHICAGO');
  INSERT INTO dept VALUES (70, 'HUMAN RESOURCES', 'CHICAGO');
EXCEPTION
  WHEN OTHERS THEN
    ROLLBACK;
    DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
    DBMS_OUTPUT.PUT_LINE('SQLCODE: ' || SQLCODE);
END;
```

SQLERRM: value too long for type character varying(14)
SQLCODE: 22001

```
SELECT * FROM dept;
```

deptno |   dname    |   loc
--------+----------+---------
   10 | ACCOUNTING | NEW YORK
   20 | RESEARCH   | DALLAS
   30 | SALES      | CHICAGO
   40 | OPERATIONS | BOSTON
   50 | FINANCE    | DALLAS
   60 | MARKETING  | CHICAGO
(6 rows)
The following is a more complex example using both COMMIT and ROLLBACK. First, the following stored procedure is created which inserts a new employee.

```sql
\set AUTOCOMMIT off
SET edb_stmt_level_tx TO on;

CREATE OR REPLACE PROCEDURE emp_insert (p_empno IN emp.empno%TYPE,
                                       p_ename IN emp.ename%TYPE,
                                       p_job IN emp.job%TYPE,
                                       p_mgr IN emp.mgr%TYPE,
                                       p_hiredate IN emp.hiredate%TYPE,
                                       p_sal IN emp.sal%TYPE,
                                       p_comm IN emp.comm%TYPE,
                                       p_deptno IN emp.deptno%TYPE)
IS
BEGIN
    INSERT INTO emp VALUES (p_empno,
                            p_ename,
                            p_job,
                            p_mgr,
                            p_hiredate,
                            p_sal,
                            p_comm,
                            p_deptno);

    DBMS_OUTPUT.PUT_LINE('Added employee...');
    DBMS_OUTPUT.PUT_LINE('Employee # : ' || p_empno);
    DBMS_OUTPUT.PUT_LINE('Name       : ' || p_ename);
    DBMS_OUTPUT.PUT_LINE('Job        : ' || p_job);
    DBMS_OUTPUT.PUT_LINE('Manager    : ' || p_mgr);
    DBMS_OUTPUT.PUT_LINE('Hire Date  : ' || p_hiredate);
    DBMS_OUTPUT.PUT_LINE('Salary     : ' || p_sal);
    DBMS_OUTPUT.PUT_LINE('Commission : ' || p_comm);
    DBMS_OUTPUT.PUT_LINE('Dept #     : ' || p_deptno);

END;
```

Note that this procedure has no exception section so any error that may occur is propagated up to the calling program.

The following anonymous block is run. Note the use of the COMMIT command after all calls to the `emp_insert` procedure and the ROLLBACK command in the exception section.

```sql
BEGIN
    emp_insert(9601,'FARRELL','ANALYST',7902,'03-MAR-08',5000,NULL,40);
    emp_insert(9602,'TYLER','ANALYST',7900,'25-JAN-08',4800,NULL,40);
    COMMIT;
EXCEPTION
```

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The following `SELECT` command shows that employees Farrell and Tyler were successfully added.

```sql
SELECT * FROM emp WHERE empno > 9600;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>job</th>
<th>mgr</th>
<th>hiredate</th>
<th>sal</th>
<th>comm</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>9601</td>
<td>FARRELL</td>
<td>ANALYST</td>
<td>7902</td>
<td>03-MAR-08 00:00:00</td>
<td>5000.00</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>9602</td>
<td>TYLER</td>
<td>ANALYST</td>
<td>7900</td>
<td>25-JAN-08 00:00:00</td>
<td>4800.00</td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

(2 rows)

Now, execute the following anonymous block:

```sql
BEGIN
  emp_insert(9603,'HARRISON','SALESMAN',7902,'13-DEC-07',5000,3000,20);
  emp_insert(9604,'JARVIS','SALESMAN',7902,'05-MAY-08',4800,4100,11);
  COMMIT;
EXCEPTION
  WHEN OTHERS THEN
    DBMS_OUTPUT.PUT_LINE('SQLERRM: ' || SQLERRM);
    DBMS_OUTPUT.PUT_LINE('An error occurred - roll back inserts');
    ROLLBACK;
END;
```
SQLERRM: insert or update on table "emp" violates foreign key constraint "emp_ref_dept_fk"
An error occurred - roll back inserts

A SELECT command run against the table yields the following:

```
SELECT * FROM emp WHERE empno > 9600;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>job</th>
<th>mgr</th>
<th>hiredate</th>
<th>sal</th>
<th>comm</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>9601</td>
<td>FARRELL</td>
<td>ANALYST</td>
<td>7902</td>
<td>03-MAR-08 00:00:00</td>
<td>5000.00</td>
<td></td>
<td>40</td>
</tr>
<tr>
<td>9602</td>
<td>TYLER</td>
<td>ANALYST</td>
<td>7900</td>
<td>25-JAN-08 00:00:00</td>
<td>4800.00</td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

(2 rows)

The ROLLBACK command in the exception section successfully undoes the insert of employee Harrison. Also note that employees Farrell and Tyler are still in the table as their inserts were made permanent by the COMMIT command in the first anonymous block.
3.7 Dynamic SQL

Dynamic SQL is a technique that provides the ability to execute SQL commands that are not known until the commands are about to be executed. Up to this point, the SQL commands that have been illustrated in SPL programs have been static SQL - the full command (with the exception of variables) must be known and coded into the program before the program, itself, can begin to execute. Thus using dynamic SQL, the executed SQL can change during program runtime.

In addition, dynamic SQL is the only method by which data definition commands, such as CREATE TABLE, can be executed from within an SPL program.

Note, however, that the runtime performance of dynamic SQL will be slower than static SQL.

The EXECUTE IMMEDIATE command is used to run SQL commands dynamically.

```
EXECUTE IMMEDIATE 'sql_expression;'
[ INTO { variable [, ...] | record } ]
[ USING expression [, ...] ]
```

`sql_expression` is a string expression containing the SQL command to be dynamically executed. `variable` receives the output of the result set, typically from a SELECT command, created as a result of executing the SQL command in `sql_expression`. The number, order, and type of variables must match the number, order, and be type-compatible with the fields of the result set. Alternatively, a record can be specified as long as the record’s fields match the number, order, and are type-compatible with the result set. When using the INTO clause, exactly one row must be returned in the result set, otherwise an exception occurs. When using the USING clause the value of expression is passed to a placeholder. Placeholders appear embedded within the SQL command in `sql_expression` where variables may be used. Placeholders are denoted by an identifier with a colon (:) prefix - :name. The number, order, and resultant data types of the evaluated expressions must match the number, order and be type-compatible with the placeholders in `sql_expression`. Note that placeholders are not declared anywhere in the SPL program – they only appear in `sql_expression`.

The following example shows basic dynamic SQL commands as string literals.

```sql
DECLARE
  v_sql    VARCHAR2(50);
BEGIN
  EXECUTE IMMEDIATE 'CREATE TABLE job (jobno NUMBER(3),'
||
The following example illustrates the **USING** clause to pass values to placeholders in the SQL string.

```sql
DECLARE
  v_sql           VARCHAR2(50) := 'INSERT INTO job VALUES (' ||
                  ':p_jobno, :p_jname)';
  v_jobno         job.jobno%TYPE;
  v_jname         job.jname%TYPE;
BEGIN
  v_jobno := 300;
  v_jname := 'MANAGER';
  EXECUTE IMMEDIATE v_sql USING v_jobno, v_jname;
  v_jobno := 400;
  v_jname := 'SALESMAN';
  EXECUTE IMMEDIATE v_sql USING v_jobno, v_jname;
  v_jobno := 500;
  v_jname := 'PRESIDENT';
  EXECUTE IMMEDIATE v_sql USING v_jobno, v_jname;
END;
```

The following example shows both the **INTO** and **USING** clauses. Note the last execution of the **SELECT** command returns the results into a record instead of individual variables.

```sql
DECLARE
  v_sql           VARCHAR2(60);
  v_jobno         job.jobno%TYPE;
  v_jname         job.jname%TYPE;
  r_job           job%ROWTYPE;
BEGIN
  DBMS_OUTPUT.PUT_LINE('JOBNO    JNAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  v_sql := 'SELECT jobno, jname FROM job WHERE jobno = :p_jobno';
  EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 100;
  DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
  EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 200;
  DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
  EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 300;
  DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
  EXECUTE IMMEDIATE v_sql INTO v_jobno, v_jname USING 400;
  DBMS_OUTPUT.PUT_LINE(v_jobno || '      ' || v_jname);
  EXECUTE IMMEDIATE v_sql INTO r_job USING 500;
  DBMS_OUTPUT.PUT_LINE(r_job.jobno || '      ' || r_job.jname);
END;
```

The following is the output from the previous anonymous block:

<table>
<thead>
<tr>
<th>JOBNO</th>
<th>JNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>ANALYST</td>
</tr>
<tr>
<td>200</td>
<td>CLERK</td>
</tr>
<tr>
<td>300</td>
<td>MANAGER</td>
</tr>
<tr>
<td>400</td>
<td>SALESMAN</td>
</tr>
</tbody>
</table>
You can use the BULK COLLECT clause to assemble the result set from an EXECUTE IMMEDIATE statement into a named collection. See Section 3.12.4, EXECUTE IMMEDIATE BULK COLLECT for information about using the BULK COLLECT clause.
3.8 Static Cursors

Rather than executing a whole query at once, it is possible to set up a cursor that encapsulates the query, and then read the query result set one row at a time. This allows the creation of SPL program logic that retrieves a row from the result set, does some processing on the data in that row, and then retrieves the next row and repeats the process.

Cursors are most often used in the context of a FOR or WHILE loop. A conditional test should be included in the SPL logic that detects when the end of the result set has been reached so the program can exit the loop.

3.8.1 Declaring a Cursor

In order to use a cursor, it must first be declared in the declaration section of the SPL program. A cursor declaration appears as follows:

```sql
CURSOR name IS query;
```

`name` is an identifier that will be used to reference the cursor and its result set later in the program. `query` is a SQL SELECT command that determines the result set retrievable by the cursor.

**Note:** An extension of this syntax allows the use of parameters. This is discussed in more detail in Section 3.8.8.

The following are some examples of cursor declarations:

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
  CURSOR emp_cur_1 IS SELECT * FROM emp;
  CURSOR emp_cur_2 IS SELECT empno, ename FROM emp;
  CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10 ORDER BY empno;
BEGIN
  ...
END;
```

3.8.2 Opening a Cursor

Before a cursor can be used to retrieve rows, it must first be opened. This is accomplished with the OPEN statement.

```sql
OPEN name;
```

`name` is the identifier of a cursor that has been previously declared in the declaration section of the SPL program. The OPEN statement must not be executed on a cursor that has already been, and still is open.
The following shows an OPEN statement with its corresponding cursor declaration.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
  CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10
  ORDER BY empno;
BEGIN
  OPEN emp_cur_3;
  ...
END;
```

### 3.8.3 Fetching Rows From a Cursor

Once a cursor has been opened, rows can be retrieved from the cursor’s result set by using the FETCH statement.

```
FETCH name INTO { record | variable [ , variable_2 ] ... };
```

- `name` is the identifier of a previously opened cursor.
- `record` is the identifier of a previously defined record (for example, using `table%ROWTYPE`).
- `variable`, `variable_2`... are SPL variables that will receive the field data from the fetched row.

The fields in `record` or `variable`, `variable_2`... must match in number and order, the fields returned in the `SELECT` list of the query given in the cursor declaration. The data types of the fields in the `SELECT` list must match, or be implicitly convertible to the data types of the fields in `record` or the data types of `variable`, `variable_2`...

**Note:** There is a variation of `FETCH INTO` using the `BULK COLLECT` clause that can return multiple rows at a time into a collection. See Section 3.12.4 for more information on using the `BULK COLLECT` clause with the `FETCH INTO` statement.

The following shows the `FETCH` statement.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
  v_empno NUMBER(4);
  v_ename VARCHAR2(10);
  CURSOR emp_cur_3 IS SELECT empno, ename FROM emp WHERE deptno = 10
  ORDER BY empno;
BEGIN
  OPEN emp_cur_3;
  FETCH emp_cur_3 INTO v_empno, v_ename;
  ...
END;
```

Instead of explicitly declaring the data type of a target variable, `%TYPE` can be used instead. In this way, if the data type of the database column is changed, the target variable declaration in the SPL program does not have to be changed. `%TYPE` will automatically pick up the new data type of the specified column.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
  v_empno emp.empno%TYPE;
```
If all the columns in a table are retrieved in the order defined in the table, %ROWTYPE can be used to define a record into which the FETCH statement will place the retrieved data. Each field within the record can then be accessed using dot notation.

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
  v_emp_rec emp%ROWTYPE;
  CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
  OPEN emp_cur_1;
  FETCH emp_cur_1 INTO v_emp_rec;
  DBMS_OUTPUT.PUT_LINE('Employee Number: ' || v_emp_rec.empno);
  DBMS_OUTPUT.PUT_LINE('Employee Name  : ' || v_emp_rec.ename);
  ... 
END;
```

### 3.8.4 Closing a Cursor

Once all the desired rows have been retrieved from the cursor result set, the cursor must be closed. Once closed, the result set is no longer accessible. The `CLOSE` statement appears as follows:

```sql
CLOSE name;
```

`name` is the identifier of a cursor that is currently open. Once a cursor is closed, it must not be closed again. However, once the cursor is closed, the `OPEN` statement can be issued again on the closed cursor and the query result set will be rebuilt after which the `FETCH` statement can then be used to retrieve the rows of the new result set.

The following example illustrates the use of the `CLOSE` statement:

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
  v_emp_rec emp%ROWTYPE;
  CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
  OPEN emp_cur_1;
  FETCH emp_cur_1 INTO v_emp_rec;
  DBMS_OUTPUT.PUT_LINE('Employee Number: ' || v_emp_rec.empno);
  DBMS_OUTPUT.PUT_LINE('Employee Name  : ' || v_emp_rec.ename);
  CLOSE emp_cur_1;
END;
```
This procedure produces the following output when invoked. Employee number 7369, SMITH is the first row of the result set.

```
EXEC cursor_example;
Employee Number: 7369
Employee Name  : SMITH
```
3.8.5 Using %ROWTYPE With Cursors

Using the %ROWTYPE attribute, a record can be defined that contains fields corresponding to all columns fetched from a cursor or cursor variable. Each field takes on the data type of its corresponding column. The %ROWTYPE attribute is prefixed by a cursor name or cursor variable name.

```sql
record cursor%ROWTYPE;
```

`record` is an identifier assigned to the record. `cursor` is an explicitly declared cursor within the current scope.

The following example shows how you can use a cursor with %ROWTYPE to get information about which employee works in which department.

```sql
CREATE OR REPLACE PROCEDURE emp_info IS
  CURSOR empcur IS SELECT ename, deptno FROM emp;
  myvar empcur%ROWTYPE;
BEGIN
  OPEN empcur;
  LOOP
    FETCH empcur INTO myvar;
    EXIT WHEN empcur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE( myvar.ename || ' works in department ' || myvar.deptno );
  END LOOP;
  CLOSE empcur;
END;
```

The following is the output from this procedure.

```sql
EXEC emp_info;

SMITH works in department 20
ALLEN works in department 30
WARD works in department 30
JONES works in department 20
MARTIN works in department 30
BLAKE works in department 30
CLARK works in department 10
SCOTT works in department 20
KING works in department 10
TURNER works in department 30
ADAMS works in department 20
JAMES works in department 30
FORD works in department 20
MILLER works in department 10
```
3.8.6 Cursor Attributes

Each cursor has a set of attributes associated with it that allows the program to test the state of the cursor. These attributes are %ISOPEN, %FOUND, %NOTFOUND, and %ROWCOUNT. These attributes are described in the following sections.

3.8.6.1 %ISOPEN

The %ISOPEN attribute is used to test whether or not a cursor is open.

```plaintext
        cursor_name%ISOPEN
```

cursor_name is the name of the cursor for which a BOOLEAN data type of TRUE will be returned if the cursor is open, FALSE otherwise.

The following is an example of using %ISOPEN.

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
     ...  
     CURSOR emp_cur_1 IS SELECT * FROM emp;  
     ... 
     BEGIN 
     ...  
     IF emp_cur_1%ISOPEN THEN 
          NULL;  
     ELSE  
          OPEN emp_cur_1;  
     END IF;  
     FETCH emp_cur_1 INTO ...  
     ... 
     END;
```

3.8.6.2 %FOUND

The %FOUND attribute is used to test whether or not a row is retrieved from the result set of the specified cursor after a FETCH on the cursor.

```plaintext
        cursor_name%FOUND
```

cursor_name is the name of the cursor for which a BOOLEAN data type of TRUE will be returned if a row is retrieved from the result set of the cursor after a FETCH.

After the last row of the result set has been FETCHed the next FETCH results in %FOUND returning FALSE. FALSE is also returned after the first FETCH if there are no rows in the result set to begin with.
Referencing `%FOUND` on a cursor before it is opened or after it is closed results in an `INVALID_CURSOR` exception being thrown.

`%FOUND` returns `null` if it is referenced when the cursor is open, but before the first `FETCH`.

The following example uses `%FOUND`.

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
  v_emp_rec       emp%ROWTYPE;
  CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
  OPEN emp_cur_1;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  FETCH emp_cur_1 INTO v_emp_rec;
  WHILE emp_cur_1%FOUND LOOP
    DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '     ' || v_emp_rec.ename);
    FETCH emp_cur_1 INTO v_emp_rec;
  END LOOP;
  CLOSE emp_cur_1;
END;
```

When the previous procedure is invoked, the output appears as follows:

```
EXEC cursor_example;
EMPNO    ENAME
-----    ------
7369     SMITH
7499     ALLEN
7521     WARD
7566     JONES
7654     MARTIN
7698     BLAKE
7782     CLARK
7788     SCOTT
7839     KING
7844     TURNER
7876     ADAMS
7900     JAMES
7902     FORD
7934     MILLER
```

### 3.8.6.3 `%NOTFOUND`

The `%NOTFOUND` attribute is the logical opposite of `%FOUND`.

```
cursor_name%NOTFOUND
```

`cursor_name` is the name of the cursor for which a `BOOLEAN` data type of `FALSE` will be returned if a row is retrieved from the result set of the cursor after a `FETCH`. 
After the last row of the result set has been fetched, the next fetch results in %NOTFOUND returning TRUE. TRUE is also returned after the first fetch if there are no rows in the result set to begin with.

Referencing %NOTFOUND on a cursor before it is opened or after it is closed, results in an INVALID_CURSOR exception being thrown.

%NOTFOUND returns null if it is referenced when the cursor is open, but before the first fetch.

The following example uses %NOTFOUND.

```
CREATE OR REPLACE PROCEDURE cursor_example
IS
  v_emp_rec       emp%ROWTYPE;
  CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
  OPEN emp_cur_1;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  LOOP
    FETCH emp_cur_1 INTO v_emp_rec;
    EXIT WHEN emp_cur_1%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '     ' || v_emp_rec.ename);
  END LOOP;
  CLOSE emp_cur_1;
END;
```

Similar to the prior example, this procedure produces the same output when invoked.

```
EXEC cursor_example;
EMPNO    ENAME
-----    ------
7369     SMITH
7499     ALLEN
7521     WARD
7566     JONES
7654     MARTIN
7698     BLAKE
7782     CLARK
7788     SCOTT
7839     KING
7844     TURNER
7876     ADAMS
7900     JAMES
7902     FORD
7934     MILLER
```
3.8.6.4 %ROWCOUNT

The %ROWCOUNT attribute returns an integer showing the number of rows fetched so far from the specified cursor.

cursor_name%ROWCOUNT

cursor_name is the name of the cursor for which %ROWCOUNT returns the number of rows retrieved thus far. After the last row has been retrieved, %ROWCOUNT remains set to the total number of rows returned until the cursor is closed at which point %ROWCOUNT will throw an INVALID_CURSOR exception if referenced.

Referencing %ROWCOUNT on a cursor before it is opened or after it is closed, results in an INVALID_CURSOR exception being thrown.

%ROWCOUNT returns 0 if it is referenced when the cursor is open, but before the first FETCH. %ROWCOUNT also returns 0 after the first FETCH when there are no rows in the result set to begin with.

The following example uses %ROWCOUNT.

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
   v_emp_rec emp%ROWTYPE;
   CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
   OPEN emp_cur_1;
   DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
   DBMS_OUTPUT.PUT_LINE('-----    ------');
   LOOP
      FETCH emp_cur_1 INTO v_emp_rec;
      EXIT WHEN emp_cur_1%NOTFOUND;
      DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '     ' || v_emp_rec.ename);
   END LOOP;
   DBMS_OUTPUT.PUT_LINE('**********************');
   DBMS_OUTPUT.PUT_LINE(emp_cur_1%ROWCOUNT || ' rows were retrieved');
   CLOSE emp_cur_1;
END;
```

This procedure prints the total number of rows retrieved at the end of the employee list as follows:

```sql
EXEC cursor_example;

EMPNO  ENAME
------  ------
7369    SMITH
7499    ALLEN
7521    WARD
7566    JONES
7654    MARTIN
7698    BLAKE
7782    CLARK
```
3.8.6.5 Summary of Cursor States and Attributes

The following table summarizes the possible cursor states and the values returned by the cursor attributes.

<table>
<thead>
<tr>
<th>Cursor State</th>
<th>%ISOPEN</th>
<th>%FOUND</th>
<th>%NOTFOUND</th>
<th>%ROWCOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before OPEN</td>
<td>False</td>
<td>INVALID_CURSOR Exception</td>
<td>INVALID_CURSOR Exception</td>
<td>INVALID_CURSOR Exception</td>
</tr>
<tr>
<td>After OPEN &amp; Before 1st FETCH</td>
<td>True</td>
<td>Null</td>
<td>Null</td>
<td>0</td>
</tr>
<tr>
<td>After 1st Successful FETCH</td>
<td>True</td>
<td>True</td>
<td>False</td>
<td>1</td>
</tr>
<tr>
<td>After nth Successful FETCH (last row)</td>
<td>True</td>
<td>True</td>
<td>False</td>
<td>n</td>
</tr>
<tr>
<td>After nth Successful FETCH (after last row)</td>
<td>True</td>
<td>False</td>
<td>True</td>
<td>n</td>
</tr>
<tr>
<td>After CLOSE</td>
<td>False</td>
<td>INVALID_CURSOR Exception</td>
<td>INVALID_CURSOR Exception</td>
<td>INVALID_CURSOR Exception</td>
</tr>
</tbody>
</table>

3.8.7 Cursor FOR Loop

In the cursor examples presented so far, the programming logic required to process the result set of a cursor included a statement to open the cursor, a loop construct to retrieve each row of the result set, a test for the end of the result set, and finally a statement to close the cursor. The cursor FOR loop is a loop construct that eliminates the need to individually code the statements just listed.

The cursor FOR loop opens a previously declared cursor, fetches all rows in the cursor result set, and then closes the cursor.

The syntax for creating a cursor FOR loop is as follows.

```
FOR record IN cursor
  LOOP
    statements
  END LOOP;
```
record is an identifier assigned to an implicitly declared record with definition, cursor%ROWTYPE. cursor is the name of a previously declared cursor. statements are one or more SPL statements. There must be at least one statement.

The following example shows the example from Section 3.8.6.3, modified to use a cursor FOR loop.

```sql
CREATE OR REPLACE PROCEDURE cursor_example
IS
    CURSOR emp_cur_1 IS SELECT * FROM emp;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----    -------');
    FOR v_emp_rec IN emp_cur_1 LOOP
        DBMS_OUTPUT.PUT_LINE(v_emp_rec.empno || '     ' || v_emp_rec.ename);
    END LOOP;
END;
```

The same results are achieved as shown in the output below.

```plaintext
EXEC cursor_example;
EMPNO    ENAME
-----    -------
7369     SMITH
7499     ALLEN
7521     WARD
7566     JONES
7654     MARTIN
7698     BLAKE
7782     CLARK
7788     SCOTT
7839     KING
7844     TURNER
7876     ADAMS
7900     JAMES
7902     FORD
7934     MILLER
```

### 3.8.8 Parameterized Cursors

A user can also declare a static cursor that accepts parameters, and can pass values for those parameters when opening that cursor. In the following example we have created a parameterized cursor which will display the name and salary of all employees from the emp table that have a salary less than a specified value which is passed as a parameter.

```sql
DECLARE
    my_record emp%ROWTYPE;
    CURSOR c1 (max_wage NUMBER) IS
        SELECT * FROM emp WHERE sal < max_wage;
BEGIN
    OPEN c1(2000);
    LOOP
        FETCH c1 INTO my_record;
        EXIT WHEN c1% NOTFOUND;
    END LOOP;
END;
```
So for example if we pass the value 2000 as max wage, then we will only be shown the name and salary of all employees that have a salary less than 2000. The result of the above query is the following:

<table>
<thead>
<tr>
<th>Name</th>
<th>Salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMITH</td>
<td>800.00</td>
</tr>
<tr>
<td>ALLEN</td>
<td>1600.00</td>
</tr>
<tr>
<td>WARD</td>
<td>1250.00</td>
</tr>
<tr>
<td>MARTIN</td>
<td>1250.00</td>
</tr>
<tr>
<td>TURNER</td>
<td>1500.00</td>
</tr>
<tr>
<td>ADAMS</td>
<td>1100.00</td>
</tr>
<tr>
<td>JAMES</td>
<td>950.00</td>
</tr>
<tr>
<td>MILLER</td>
<td>1300.00</td>
</tr>
</tbody>
</table>
3.9 **REF CURSORs and Cursor Variables**

This section discusses another type of cursor that provides far greater flexibility than the previously discussed static cursors.

### 3.9.1 REF CURSOR Overview

A cursor variable is a cursor that actually contains a pointer to a query result set. The result set is determined by the execution of the `OPEN FOR` statement using the cursor variable.

A cursor variable is not tied to a single particular query like a static cursor. The same cursor variable may be opened a number of times with `OPEN FOR` statements containing different queries. Each time, a new result set is created from that query and made available via the cursor variable.

REF CURSOR types may be passed as parameters to or from stored procedures and functions. The return type of a function may also be a REF CURSOR type. This provides the capability to modularize the operations on a cursor into separate programs by passing a cursor variable between programs.

### 3.9.2 Declaring a Cursor Variable

SPL supports the declaration of a cursor variable using both the `SYS_REFCURSOR` built-in data type as well as creating a type of REF CURSOR and then declaring a variable of that type. `SYS_REFCURSOR` is a REF CURSOR type that allows any result set to be associated with it. This is known as a *weakly-typed* REF CURSOR.

Only the declaration of `SYS_REFCURSOR` and user-defined REF CURSOR variables are different. The remaining usage like opening the cursor, selecting into the cursor and closing the cursor is the same across both the cursor types. For the rest of this chapter our examples will primarily be making use of the `SYS_REFCURSOR` cursors. All you need to change in the examples to make them work for user defined REF CURSORS is the declaration section.

**Note:** *Strongly-typed* REF CURSORS require the result set to conform to a declared number and order of fields with compatible data types and can also optionally return a result set.

#### 3.9.2.1 Declaring a SYS_REFCURSOR Cursor Variable

The following is the syntax for declaring a `SYS_REFCURSOR` cursor variable:

```
name SYS_REFCURSOR;
```
name is an identifier assigned to the cursor variable.

The following is an example of a SYS_REFCURSOR variable declaration.

```
DECLARE
  emp_refcur      SYS_REFCURSOR;
...
```

### 3.9.2.2 Declaring a User Defined REF CURSOR Type Variable

You must perform two distinct declaration steps in order to use a user defined REF CURSOR variable:

- Create a referenced cursor TYPE
- Declare the actual cursor variable based on that TYPE

The syntax for creating a user defined REF CURSOR type is as follows:

```
TYPE cursor_type_name IS REF CURSOR [RETURN return_type];
```

The following is an example of a cursor variable declaration.

```
DECLARE
  TYPE emp_cur_type IS REF CURSOR RETURN emp%ROWTYPE;
  my_rec emp_cur_type;
 ...
```

### 3.9.3 Opening a Cursor Variable

Once a cursor variable is declared, it must be opened with an associated SELECT command. The `OPEN FOR` statement specifies the SELECT command to be used to create the result set.

```
OPEN name FOR query;
```

name is the identifier of a previously declared cursor variable. query is a SELECT command that determines the result set when the statement is executed. The value of the cursor variable after the `OPEN FOR` statement is executed identifies the result set.

In the following example, the result set is a list of employee numbers and names from a selected department. Note that a variable or parameter can be used in the SELECT command anywhere an expression can normally appear. In this case a parameter is used in the equality test for department number.

```
CREATE OR REPLACE PROCEDURE emp_by_dept ( 
  p_deptno        emp.deptno%TYPE
) 
```
### 3.9.4 Fetching Rows From a Cursor Variable

After a cursor variable is opened, rows may be retrieved from the result set using the `FETCH` statement. See Section 3.8.3 for details on using the `FETCH` statement to retrieve rows from a result set.

In the example below, a `FETCH` statement has been added to the previous example so now the result set is returned into two variables and then displayed. Note that the cursor attributes used to determine cursor state of static cursors can also be used with cursor variables. See Section 3.8.6 for details on cursor attributes.

```
CREATE OR REPLACE PROCEDURE emp_by_dept (p_deptno emp.deptno%TYPE)
IS
  emp_refcur SYS_REFCURSOR;
  v_empno emp.empno%TYPE;
  v_ename emp.ename%TYPE;
BEGIN
  OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    -------');
  LOOP
    FETCH emp_refcur INTO v_empno, v_ename;
    EXIT WHEN emp_refcur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
  END LOOP;
  ...
```

### 3.9.5 Closing a Cursor Variable

Use the `CLOSE` statement described in Section 3.8.4 to release the result set.

**Note:** Unlike static cursors, a cursor variable does not have to be closed before it can be re-opened again. The result set from the previous open will be lost.

The example is completed with the addition of the `CLOSE` statement.

```
CREATE OR REPLACE PROCEDURE emp_by_dept (p_deptno emp.deptno%TYPE)
IS
  emp_refcur SYS_REFCURSOR;
  v_empno emp.empno%TYPE;
  v_ename emp.ename%TYPE;
BEGIN
  OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    -------');
  LOOP
    FETCH emp_refcur INTO v_empno, v_ename;
    EXIT WHEN emp_refcur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
  END LOOP;
  ...
BEGIN
  OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE deptno = p_deptno;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    ------');
  LOOP
    FETCH emp_refcur INTO v_empno, v_ename;
    EXIT WHEN emp_refcur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
  END LOOP;
  CLOSE emp_refcur;
END;

The following is the output when this procedure is executed.

EXEC emp_by_dept(20)

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
</tr>
<tr>
<td>7836</td>
<td>ADAMS</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
</tr>
</tbody>
</table>

### 3.9.6 Usage Restrictions

The following are restrictions on cursor variable usage.

- Comparison operators cannot be used to test cursor variables for equality, inequality, null, or not null
- Null cannot be assigned to a cursor variable
- The value of a cursor variable cannot be stored in a database column
- Static cursors and cursor variables are not interchangeable. For example, a static cursor cannot be used in an OPEN FOR statement.

In addition the following table shows the permitted parameter modes for a cursor variable used as a procedure or function parameter depending upon the operations on the cursor variable within the procedure or function.

<table>
<thead>
<tr>
<th>Operation</th>
<th>IN</th>
<th>IN OUT</th>
<th>OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>OPEN</td>
<td>No</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FETCH</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>CLOSE</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

So for example, if a procedure performs all three operations, OPEN FOR, FETCH, and CLOSE on a cursor variable declared as the procedure’s formal parameter, then that parameter must be declared with IN OUT mode.
3.9.7 Examples

The following examples demonstrate cursor variable usage.

3.9.7.1 Returning a REF CURSOR From a Function

In the following example the cursor variable is opened with a query that selects employees with a given job. Note that the cursor variable is specified in this function’s RETURN statement so the result set is made available to the caller of the function.

```
CREATE OR REPLACE FUNCTION emp_by_job (p_job VARCHAR2)
    RETURN SYS_REFCURSOR
IS
    emp_refcur SYS_REFCURSOR;
BEGIN
    OPEN emp_refcur FOR SELECT empno, ename FROM emp WHERE job = p_job;
    RETURN emp_refcur;
END;
```

This function is invoked in the following anonymous block by assigning the function’s return value to a cursor variable declared in the anonymous block’s declaration section. The result set is fetched using this cursor variable and then it is closed.

```
DECLARE
    v_empno emp.empno%TYPE;
    v_ename emp.ename%TYPE;
    v_job emp.job%TYPE := 'SALESMAN';
    v_emp_refcur SYS_REFCURSOR;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPLOYEES WITH JOB ' || v_job);
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----    -------');
    v_emp_refcur := emp_by_job(v_job);
    LOOP
        FETCH v_emp_refcur INTO v_empno, v_ename;
        EXIT WHEN v_emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
    END LOOP;
    CLOSE v_emp_refcur;
END;
```

The following is the output when the anonymous block is executed.

```
EMPLOYEES WITH JOB SALESMAN
EMPNO    ENAME  
-----    ------- 
  7499     ALLEN 
  7521     WARD 
  7654     MARTIN 
  7844     TURNER
```
3.9.7.2 Modularizing Cursor Operations

The following example illustrates how the various operations on cursor variables can be modularized into separate programs.

The following procedure opens the given cursor variable with a `SELECT` command that retrieves all rows.

```
CREATE OR REPLACE PROCEDURE open_all_emp (
    p_emp_refcur IN OUT SYS_REFCURSOR
) IS
BEGIN
    OPEN p_emp_refcur FOR SELECT empno, ename FROM emp;
END;
```

This variation opens the given cursor variable with a `SELECT` command that retrieves all rows, but of a given department.

```
CREATE OR REPLACE PROCEDURE open_emp_by_dept (
    p_emp_refcur IN OUT SYS_REFCURSOR,
    p_deptno emp.deptno%TYPE
) IS
BEGIN
    OPEN p_emp_refcur FOR SELECT empno, ename FROM emp
        WHERE deptno = p_deptno;
END;
```

This third variation opens the given cursor variable with a `SELECT` command that retrieves all rows, but from a different table. Also note that the function’s return value is the opened cursor variable.

```
CREATE OR REPLACE FUNCTION open_dept (
    p_dept_refcur IN OUT SYS_REFCURSOR
) RETURN SYS_REFCURSOR
IS
    v_dept_refcur SYS_REFCURSOR;
BEGIN
    v_dept_refcur := p_dept_refcur;
    OPEN v_dept_refcur FOR SELECT deptno, dname FROM dept;
    RETURN v_dept_refcur;
END;
```

This procedure fetches and displays a cursor variable result set consisting of employee number and name.

```
CREATE OR REPLACE PROCEDURE fetch_emp (
    p_emp_refcur IN OUT SYS_REFCURSOR
) IS
    v_empno emp.empno%TYPE;
    v_ename emp.ename%TYPE;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
```
This procedure fetches and displays a cursor variable result set consisting of department number and name.

```
CREATE OR REPLACE PROCEDURE fetch_dept (  
  p_dept_refcur   IN SYS_REFCURSOR  
) IS  
  v_deptno        dept.deptno%TYPE;  
  v_dname         dept.dname%TYPE;  
BEGIN  
  DBMS_OUTPUT.PUT_LINE('DEPT   DNAME');  
  DBMS_OUTPUT.PUT_LINE('----- --------');  
  LOOP  
    FETCH p_dept_refcur INTO v_deptno, v_dname;  
    EXIT WHEN p_dept_refcur%NOTFOUND;  
    DBMS_OUTPUT.PUT_LINE(v_deptno || '     ' || v_dname);  
  END LOOP;  
END;
```

This procedure closes the given cursor variable.

```
CREATE OR REPLACE PROCEDURE close_refcur (  
  p_refcur        IN OUT SYS_REFCURSOR  
) IS  
BEGIN  
  CLOSE p_refcur;  
END;
```

The following anonymous block executes all the previously described programs.

```
DECLARE  
  gen_refcur      SYS_REFCURSOR;  
BEGIN  
  DBMS_OUTPUT.PUT_LINE('ALL EMPLOYEES');  
  open_all_emp(gen_refcur);  
  fetch_emp(gen_refcur);  
  DBMS_OUTPUT.PUT_LINE('****************');  
  DBMS_OUTPUT.PUT_LINE('EMPLOYEES IN DEPT #10');  
  open_emp_by_dept(gen_refcur, 10);  
  fetch_emp(gen_refcur);  
  DBMS_OUTPUT.PUT_LINE('****************');  
  DBMS_OUTPUT.PUT_LINE('DEPARTMENTS');  
  fetch_dept(open_dept(gen_refcur));  
  DBMS_OUTPUT.PUT_LINE('***************');  
  close_refcur(gen_refcur);  
END;
```
The following is the output from the anonymous block.

<table>
<thead>
<tr>
<th>ALL EMPLOYEES</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMPNO</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>7369</td>
</tr>
<tr>
<td>7499</td>
</tr>
<tr>
<td>7521</td>
</tr>
<tr>
<td>7566</td>
</tr>
<tr>
<td>7654</td>
</tr>
<tr>
<td>7698</td>
</tr>
<tr>
<td>7782</td>
</tr>
<tr>
<td>7788</td>
</tr>
<tr>
<td>7839</td>
</tr>
<tr>
<td>7844</td>
</tr>
<tr>
<td>7876</td>
</tr>
<tr>
<td>7900</td>
</tr>
<tr>
<td>7902</td>
</tr>
<tr>
<td>7934</td>
</tr>
</tbody>
</table>

***************

EMPLOYEES IN DEPT #10

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7782</td>
<td>CLARK</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
</tr>
</tbody>
</table>

***************

DEPARTMENTS

<table>
<thead>
<tr>
<th>DEPT</th>
<th>DNAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>ACCOUNTING</td>
</tr>
<tr>
<td>20</td>
<td>RESEARCH</td>
</tr>
<tr>
<td>30</td>
<td>SALES</td>
</tr>
<tr>
<td>40</td>
<td>OPERATIONS</td>
</tr>
</tbody>
</table>

***************

3.9.8 Dynamic Queries With REF CURSORs

Advanced Server also supports dynamic queries via the `OPEN FOR USING` statement. A string literal or string variable is supplied in the `OPEN FOR USING` statement to the `SELECT` command.

```sql
OPEN name FOR dynamic_string
[ USING bind_arg [, bind_arg_2 ] ...];
```

`name` is the identifier of a previously declared cursor variable. `dynamic_string` is a string literal or string variable containing a `SELECT` command (without the terminating semi-colon). `bind_arg, bind_arg_2...` are bind arguments that are used to pass variables to corresponding placeholders in the `SELECT` command when the cursor variable is opened. The placeholders are identifiers prefixed by a colon character.
The following is an example of a dynamic query using a string literal.

```sql
CREATE OR REPLACE PROCEDURE dept_query
IS
    emp_refcur SYS_REFCURSOR;
    v_empno emp.empno%TYPE;
    v_ename emp.ename%TYPE;
BEGIN
    OPEN emp_refcur FOR 'SELECT empno, ename FROM emp WHERE deptno = 30 ' ||
    ' AND sal >= 1500';
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----     ------');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
    END LOOP;
    CLOSE emp_refcur;
END;
```

The following is the output when the procedure is executed.

```sql
EXEC dept_query;
EMPNO    ENAME
-----     ------
7499     ALLEN
7698     BLAKE
7844     TURNER
```

In the next example, the previous query is modified to use bind arguments to pass the query parameters.

```sql
CREATE OR REPLACE PROCEDURE dept_query (p_deptno emp.deptno%TYPE, p_sal emp.sal%TYPE)
IS
    emp_refcur SYS_REFCURSOR;
    v_empno emp.empno%TYPE;
    v_ename emp.ename%TYPE;
BEGIN
    OPEN emp_refcur FOR 'SELECT empno, ename FROM emp WHERE deptno = :dept' ||
    ' AND sal >= :sal' USING p_deptno, p_sal;
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----     ------');
    LOOP
        FETCH emp_refcur INTO v_empno, v_ename;
        EXIT WHEN emp_refcur%NOTFOUND;
        DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
    END LOOP;
    CLOSE emp_refcur;
END;
```
The following is the resulting output.

```sql
EXEC dept_query(30, 1500);
EMPNO   ENAME
------   -------
7499     ALLEN
7698     BLAKE
7844     TURNER
```

Finally, a string variable is used to pass the `SELECT` providing the most flexibility.

```sql
CREATE OR REPLACE PROCEDURE dept_query (
  p_deptno        emp.deptno%TYPE,
  p_sal           emp.sal%TYPE
) IS
  emp_refcur      SYS_REFCURSOR;
  v_empno         emp.empno%TYPE;
  v_ename         emp.ename%TYPE;
  p_query_string  VARCHAR2(100);
BEGIN
  p_query_string := 'SELECT empno, ename FROM emp WHERE ' ||
                      'deptno = :dept AND sal >= :sal';
  OPEN emp_refcur FOR p_query_string USING p_deptno, p_sal;
  DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
  DBMS_OUTPUT.PUT_LINE('-----    -------');
  LOOP
    FETCH emp_refcur INTO v_empno, v_ename;
    EXIT WHEN emp_refcur%NOTFOUND;
    DBMS_OUTPUT.PUT_LINE(v_empno || '     ' || v_ename);
  END LOOP;
  CLOSE emp_refcur;
END;
EXEC dept_query(20, 1500);
EMPNO   ENAME
------   -------
7566     JONES
7788     SCOTT
7902     FORD
```
### 3.10 Collections

A *collection* is a set of ordered data items with the same data type. Generally, the data item is a scalar field, but may also be a user-defined type such as a record type or an object type as long as the structure and the data types that comprise each field of the user-defined type are the same for each element in the set. Each particular data item in the set is referenced by using subscript notation within a pair of parentheses.

**Note:** Multilevel collections (that is, where the data item of a collection is another collection) are not supported.

The most commonly known type of collection is an array. In Advanced Server, the supported collection types are *associative arrays* (formerly called *index-by-tables* in Oracle), *nested tables*, and *varrays*.

The general steps for using a collection are the following:

- A collection of the desired type must be defined. This can be done in the declaration section of an SPL program, which results in a *local type* that is accessible only within that program. For nested table and varray types this can also be done using the `CREATE TYPE` command, which creates a persistent, *standalone type* that can be referenced by any SPL program in the database.
- Variables of the collection type are declared. The collection associated with the declared variable is said to be *uninitialized* at this point if there is no value assignment made as part of the variable declaration.
- Uninitialized collections of nested tables and varrays are null. A *null collection* does not yet exist. Generally, a `COLLECTION_IS_NULL` exception is thrown if a collection method is invoked on a null collection.
- Uninitialized collections of associative arrays exist, but have no elements. An existing collection with no elements is called an *empty collection*.
- To initialize a null collection, you must either make it an empty collection or assign a non-null value to it. Generally, a null collection is initialized by using its `constructor`.
- To add elements to an empty associative array, you can simply assign values to its keys. For nested tables and varrays, generally its constructor is used to assign initial values to the nested table or varray. For nested tables and varrays, the `EXTEND` method is then used to grow the collection beyond its initial size established by the constructor.

The specific process for each collection type is described in the following sections.

#### 3.10.1 Associative Arrays

An *associative array* is a type of collection that associates a unique key with a value. The key does not have to be numeric, but can be character data as well.
An associative array has the following characteristics:

- An associative array type must be defined after which array variables can be declared of that array type. Data manipulation occurs using the array variable.
- When an array variable is declared, the associative array is created, but it is empty - just start assigning values to key values.
- The key can be any negative integer, positive integer, or zero if INDEX BY BINARY_INTEGER or PLS_INTEGER is specified.
- The key can be character data if INDEX BY VARCHAR2 is specified.
- There is no pre-defined limit on the number of elements in the array - it grows dynamically as elements are added.
- The array can be sparse - there may be gaps in the assignment of values to keys.
- An attempt to reference an array element that has not been assigned a value will result in an exception.

The `TYPE IS TABLE OF ... INDEX BY` statement is used to define an associative array type.

```sql
TYPE assoctype IS TABLE OF { datatype | rectype | objtype } 
  INDEX BY { BINARY_INTEGER | PLS_INTEGER | VARCHAR2(n) } ;
```

`assoctype` is an identifier assigned to the array type. `datatype` is a scalar data type such as VARCHAR2 or NUMBER. `rectype` is a previously defined record type. `objtype` is a previously defined object type. `n` is the maximum length of a character key.

In order to make use of the array, a variable must be declared with that array type. The following is the syntax for declaring an array variable.

```sql
array assoctype
```

`array` is an identifier assigned to the associative array. `assoctype` is the identifier of a previously defined array type.

An element of the array is referenced using the following syntax.

```sql
array(n)[.field ]
```

`array` is the identifier of a previously declared array. `n` is the key value, type-compatible with the data type given in the INDEX BY clause. If the array type of `array` is defined from a record type or object type, then `[.field ]` must reference an individual field within the record type or attribute within the object type from which the array type is defined. Alternatively, the entire record can be referenced by omitting `[.field ]`.

The following example reads the first ten employee names from the `emp` table, stores them in an array, then displays the results from the array.
DECLARE
    TYPE emp_arr_typ IS TABLE OF VARCHAR2(10) INDEX BY BINARY_INTEGER;
    emp_arr emp_arr_typ;
    CURSOR emp_cur IS SELECT ename FROM emp WHERE ROWNUM <= 10;
        i INTEGER := 0;
BEGIN
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i) := r_emp.ename;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j));
    END LOOP;
END;

The above example produces the following output:

SMITH
ALLEN
WARD
JONES
MARTIN
BLAKE
CLARK
SCOTT
KING
TURNER

The previous example is now modified to use a record type in the array definition.

DECLARE
    TYPE emp_rec_typ IS RECORD ( ename VARCHAR2(10) );
    TYPE emp_arr_typ IS TABLE OF emp_rec_typ INDEX BY BINARY_INTEGER;
    emp_arr emp_arr_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
        i INTEGER := 0;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('-----    ------');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i).empno := r_emp.empno;
        emp_arr(i).ename := r_emp.ename;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '     ' || emp_arr(j).ename);
    END LOOP;
END;

The following is the output from this anonymous block.

EMPNO    ENAME
-----    ------
7369     SMITH
7499     ALLEN
7521     WARD
The EMP%ROWTYPE attribute could be used to define EMP_ARR_TYP instead of using the EMP_REC_TYP record type as shown in the following.

DECLARE
    TYPE emp_arr_typ IS TABLE OF EMP%ROWTYPE INDEX BY BINARY_INTEGER;
    emp_arr  emp_arr_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i       INTEGER := 0;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('------    ------');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i).empno := r_emp.empno;
        emp_arr(i).ename := r_emp.ename;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '     ' ||
                  emp_arr(j).ename);
    END LOOP;
END;

The results are the same as in the prior example.

Instead of assigning each field of the record individually, a record level assignment can be made from r_emp to emp_arr.

DECLARE
    TYPE emp_rec_typ IS RECORD (  
        empno       NUMBER(4),
        ename       VARCHAR2(10)
    ) ;
    TYPE emp_arr_typ IS TABLE OF emp_rec_typ INDEX BY BINARY_INTEGER;
    emp_arr  emp_arr_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i       INTEGER := 0;
BEGIN
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('------    ------');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_arr(i) := r_emp;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_arr(j).empno || '     ' ||
                  emp_arr(j).ename);
    END LOOP;
END;
The key of an associative array can be character data as shown in the following example.

```sql
DECLARE
  TYPE job_arr_typ IS TABLE OF NUMBER INDEX BY VARCHAR2(9);
  job_arr job_arr_typ;
BEGIN
  job_arr('ANALYST')   := 100;
  job_arr('CLERK')     := 200;
  job_arr('MANAGER')   := 300;
  job_arr('SALESMAN')  := 400;
  job_arr('PRESIDENT') := 500;
  DBMS_OUTPUT.PUT_LINE('ANALYST  : ' || job_arr('ANALYST'));
  DBMS_OUTPUT.PUT_LINE('CLERK    : ' || job_arr('CLERK'));
  DBMS_OUTPUT.PUT_LINE('MANAGER  : ' || job_arr('MANAGER'));
  DBMS_OUTPUT.PUT_LINE('SALESMAN : ' || job_arr('SALESMAN'));
  DBMS_OUTPUT.PUT_LINE('PRESIDENT: ' || job_arr('PRESIDENT'));
END;

ANALYST  : 100
CLERK    : 200
MANAGER  : 300
SALESMAN : 400
PRESIDENT: 500
```

### 3.10.2 Nested Tables

A **nested table** is a type of collection that associates a positive integer with a value. A nested table has the following characteristics:

- **A nested table type** must be defined after which **nested table variables** can be declared of that nested table type. Data manipulation occurs using the nested table variable, or simply, “table” for short.
- When a nested table variable is declared, the nested table initially does not exist (it is a null collection). The null table must be initialized with a **constructor**. You can also initialize the table by using an assignment statement where the right-hand side of the assignment is an initialized table of the same type. **Note:** Initialization of a nested table is mandatory in Oracle, but optional in SPL.
- The key is a positive integer.
- The constructor establishes the number of elements in the table. The **extend** method adds additional elements to the table. See Section 3.11 for information on collection methods. **Note:** Usage of the constructor to establish the number of elements in the table and usage of the **extend** method to add additional elements to the table are mandatory in Oracle, but optional in SPL.
- The table can be sparse - there may be gaps in the assignment of values to keys.
- An attempt to reference a table element beyond its initialized or extended size will result in a **subscript beyond count exception**.

The **TYPE IS TABLE** statement is used to define a nested table type within the declaration section of an SPL program.
**Database Compatibility for Oracle® Developers Guide**

**TYPE** `tbltype` IS TABLE OF { `datatype` | `rectype` | `objtype` };

`tbltype` is an identifier assigned to the nested table type. `datatype` is a scalar data type such as `VARCHAR2` or `NUMBER`. `rectype` is a previously defined record type. `objtype` is a previously defined object type.

Note: You can use the `CREATE TYPE` command to define a nested table type that is available to all SPL programs in the database. See the Database Compatibility for Oracle Developers Reference Guide for more information about the `CREATE TYPE` command.

In order to make use of the table, a variable must be declared of that nested table type. The following is the syntax for declaring a table variable.

```
    table tbltype
```

`table` is an identifier assigned to the nested table. `tbltype` is the identifier of a previously defined nested table type.

A nested table is initialized using the nested table type’s constructor.

```
    tbltype ( [ { expr1 | NULL } [, { expr2 | NULL } ] [, ...] ] )
```

`tbltype` is the identifier of the nested table type’s constructor, which has the same name as the nested table type. `expr1, expr2,...` are expressions that are type-compatible with the element type of the table. If `NULL` is specified, the corresponding element is set to null. If the parameter list is empty, then an empty nested table is returned, which means there are no elements in the table. If the table is defined from an object type, then `exprn` must return an object of that object type. The object can be the return value of a function or the object type’s constructor, or the object can be an element of another nested table of the same type.

If a collection method other than `EXISTS` is applied to an uninitialized nested table, a `COLLECTION_IS_NULL` exception is thrown. See Section 3.11 for information on collection methods.

The following is an example of a constructor for a nested table:

```
DECLARE
  TYPE nested_typ IS TABLE OF CHAR(1);
  v_nested nested_typ := nested_typ('A','B');
```

An element of the table is referenced using the following syntax.

```
    table(n)[.element ]
```

`table` is the identifier of a previously declared table. `n` is a positive integer. If the table type of `table` is defined from a record type or object type, then `[.element ]` must
reference an individual field within the record type or attribute within the object type from which the nested table type is defined. Alternatively, the entire record or object can be referenced by omitting `.element ]`.

The following is an example of a nested table where it is known that there will be four elements.

```sql
DECLARE
    TYPE dname_tbl_typ IS TABLE OF VARCHAR2(14);
    dname_tbl       dname_tbl_typ;
    CURSOR dept_cur IS SELECT dname FROM dept ORDER BY dname;
    i               INTEGER := 0;
BEGIN
    dname_tbl := dname_tbl_typ(NULL, NULL, NULL, NULL);
    FOR r_dept IN dept_cur LOOP
        i := i + 1;
        dname_tbl(i) := r_dept.dname;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('DNAME');
    DBMS_OUTPUT.PUT_LINE('----------');
    FOR j IN 1..i LOOP
        DBMS_OUTPUT.PUT_LINE(dname_tbl(j));
    END LOOP;
END;
```

The above example produces the following output:

```
DNAME
----------
ACCOUNTING
OPERATIONS
RESEARCH
SALES
```

The following example reads the first ten employee names from the `emp` table, stores them in a nested table, then displays the results from the table. The SPL code is written to assume that the number of employees to be returned is not known beforehand.

```sql
DECLARE
    TYPE emp_rec_typ IS RECORD ( 
        empno       NUMBER(4),
        ename        VARCHAR2(10)
    );
    TYPE emp_tbl_typ IS TABLE OF emp_rec_typ;
    emp_tbl        emp_tbl_typ;
    CURSOR emp_cur IS SELECT empno, ename FROM emp WHERE ROWNUM <= 10;
    i               INTEGER := 0;
BEGIN
    emp_tbl := emp_tbl_typ();
    DBMS_OUTPUT.PUT_LINE('EMPNO    ENAME');
    DBMS_OUTPUT.PUT_LINE('----- -------');
    FOR r_emp IN emp_cur LOOP
        i := i + 1;
        emp_tbl.EXTEND;
        emp_tbl(i) := r_emp;
    END LOOP;
    FOR j IN 1..10 LOOP
        DBMS_OUTPUT.PUT_LINE(emp_tbl(j).ename);
    END LOOP;
END;
```
Note the creation of an empty table with the constructor `emp_tbl_typ()` as the first statement in the executable section of the anonymous block. The `EXTEND` collection method is then used to add an element to the table for each employee returned from the result set. See Section 3.11.4 for information on `EXTEND`.

The following is the output.

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
</tr>
</tbody>
</table>

The following example shows how a nested table of an object type can be used. First, an object type is created with attributes for the department name and location.

```
CREATE TYPE dept_obj_typ AS OBJECT (
    dname VARCHAR2(14),
    loc VARCHAR2(13)
);
```

The following anonymous block defines a nested table type whose element consists of the `dept_obj_typ` object type. A nested table variable is declared, initialized, and then populated from the `dept` table. Finally, the elements from the nested table are displayed.

```
DECLARE
    TYPE dept_tbl_typ IS TABLE OF dept_obj_typ;
    dept_tbl dept_tbl_typ;
    CURSOR dept_cur IS SELECT dname, loc FROM dept ORDER BY dname;
    i INTEGER := 0;
BEGIN
    dept_tbl := dept_tbl_typ(
      dept_obj_typ(NULL,NULL),
      dept_obj_typ(NULL,NULL),
      dept_obj_typ(NULL,NULL),
      dept_obj_typ(NULL,NULL)
    );
    FOR r_dept IN dept_cur LOOP
      i := i + 1;
      dept_tbl(i).dname := r_dept.dname;
      dept_tbl(i).loc   := r_dept.loc;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('DNAME          LOC');
    DBMS_OUTPUT.PUT_LINE('---------- ----------');
    FOR j IN 1..i LOOP
```

---

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Note: The parameters comprising the nested table’s constructor, `dept_tbl_typ`, are calls to the object type’s constructor `dept_obj_typ`.

The following is the output from the anonymous block.

<table>
<thead>
<tr>
<th>DNAME</th>
<th>LOC</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCOUNTING</td>
<td>NEW YORK</td>
</tr>
<tr>
<td>OPERATIONS</td>
<td>BOSTON</td>
</tr>
<tr>
<td>RESEARCH</td>
<td>DALLAS</td>
</tr>
<tr>
<td>SALES</td>
<td>CHICAGO</td>
</tr>
</tbody>
</table>

### 3.10.3 Varrays

A *varray* or *variable-size array* is a type of collection that associates a positive integer with a value. In many respects, it is similar to a nested table.

A varray has the following characteristics:

- A *varray type* must be defined along with a maximum size limit. After the varray type is defined, *varray variables* can be declared of that varray type. Data manipulation occurs using the varray variable, or simply, “varray” for short. The number of elements in the varray cannot exceed the maximum size limit established in the varray type definition.
- When a varray variable is declared, the varray initially does not exist (it is a null collection). The null varray must be initialized with a *constructor*. You can also initialize the varray by using an assignment statement where the right-hand side of the assignment is an initialized varray of the same type.
- The key is a positive integer.
- The constructor establishes the number of elements in the varray, which must not exceed the maximum size limit. The `EXTEND` method can add additional elements to the varray up to the maximum size limit. See Section 3.11 for information on collection methods.
- Unlike a nested table, a varray cannot be sparse - there are no gaps in the assignment of values to keys.
- An attempt to reference a varray element beyond its initialized or extended size, but within the maximum size limit will result in a `SUBSCRIPT_BEYOND_COUNT` exception.
- An attempt to reference a varray element beyond the maximum size limit or extend a varray beyond the maximum size limit will result in a `SUBSCRIPT_OUTSIDE_LIMIT` exception.
The \texttt{TYPE IS VARRAY} statement is used to define a varray type within the declaration section of an SPL program.

\begin{verbatim}
TYPE varraytype IS { VARRAY | VARYING ARRAY } (maxsize)
  OF { datatype | objtype };
\end{verbatim}

\texttt{varraytype} is an identifier assigned to the varray type. \texttt{datatype} is a scalar data type such as \texttt{VARCHAR2} or \texttt{NUMBER}. \texttt{maxsize} is the maximum number of elements permitted in varrays of that type. \texttt{objtype} is a previously defined object type.

Note: The \texttt{CREATE TYPE} command can be used to define a varray type that is available to all SPL programs in the database. In order to make use of the varray, a \texttt{variable} must be declared of that varray type. The following is the syntax for declaring a varray variable.

\begin{verbatim}
varray varraytype
\end{verbatim}

\texttt{varray} is an identifier assigned to the varray. \texttt{varraytype} is the identifier of a previously defined varray type.

A varray is initialized using the varray type’s constructor.

\begin{verbatim}
varraytype ([ { expr1 | NULL } [, { expr2 | NULL } ] [, ... ] ])
\end{verbatim}

\texttt{varraytype} is the identifier of the varray type’s constructor, which has the same name as the varray type. \texttt{expr1, expr2, …} are expressions that are type-compatible with the element type of the varray. If \texttt{NULL} is specified, the corresponding element is set to null. If the parameter list is empty, then an empty varray is returned, which means there are no elements in the varray. If the varray is defined from an object type, then \texttt{exprn} must return an object of that object type. The object can be the return value of a function or the return value of the object type’s constructor. The object can also be an element of another varray of the same varray type.

If a collection method other than \texttt{EXISTS} is applied to an uninitialized varray, a \texttt{COLLECTION_IS_NULL} exception is thrown. See Section 3.11 for information on collection methods.

The following is an example of a constructor for a varray:

\begin{verbatim}
DECLARE
  TYPE varray_typ IS VARRAY (2) OF CHAR (1);
  v_varray varray_typ := varray_typ ('A', 'B');
\end{verbatim}

An element of the varray is referenced using the following syntax.
varray(n)[.element ]

varray is the identifier of a previously declared varray. n is a positive integer. If the varray type of varray is defined from an object type, then [.element ] must reference an attribute within the object type from which the varray type is defined. Alternatively, the entire object can be referenced by omitting [.element ].

The following is an example of a varray where it is known that there will be four elements.

```sql
DECLARE
    TYPE dname_varray_typ IS VARRAY(4) OF VARCHAR2(14);
    dname_varray dname_varray_typ;
    CURSOR dept_cur IS SELECT dname FROM dept ORDER BY dname;
    i INTEGER := 0;
BEGIN
    dname_varray := dname_varray_typ(NULL, NULL, NULL, NULL);
    FOR r_dept IN dept_cur LOOP
        i := i + 1;
        dname_varray(i) := r_dept.dname;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('DNAME');
    DBMS_OUTPUT.PUT_LINE('----------');
    FOR j IN 1..i LOOP
        DBMS_OUTPUT.PUT_LINE(dname_varray(j));
    END LOOP;
END;
```

The above example produces the following output:

DNAME
----------
ACCOUNTING
OPERATIONS
RESEARCH
SALES
### 3.11 Collection Methods

*Collection methods* are functions and procedures that provide useful information about a collection that can aid in the processing of data in the collection. The following sections discuss the collection methods supported by Advanced Server.

#### 3.11.1 COUNT

**COUNT** is a method that returns the number of elements in a collection. The syntax for using **COUNT** is as follows:

```
collection.COUNT
```

*collection* is the name of a collection.

For a varray, **COUNT** always equals **LAST**.

The following example shows that an associative array can be sparsely populated (i.e., there are “gaps” in the sequence of assigned elements). **COUNT** includes only the elements that have been assigned a value.

```sql
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr sparse_arr_typ;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10)  := -10;
    sparse_arr(0)   := 0;
    sparse_arr(10)  := 10;
    sparse_arr(100) := 100;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
END;
```

The following output shows that there are five populated elements included in **COUNT**.

```
COUNT: 5
```

#### 3.11.2 DELETE

The **DELETE** method deletes entries from a collection. You can call the **DELETE** method in three different ways.

Use the first form of the **DELETE** method to remove all entries from a collection:

```
collection.DELETE
```
Use the second form of the `DELETE` method to remove the specified entry from a collection:

```
collection.DELETE(subscript)
```

Use the third form of the `DELETE` method to remove the entries that are within the range specified by `first_subscript` and `last_subscript` (including the entries for the `first_subscript` and the `last_subscript`) from a collection.

```
collection.DELETE(first_subscript, last_subscript)
```

If `first_subscript` and `last_subscript` refer to non-existent elements, elements that are in the range between the specified subscripts are deleted. If `first_subscript` is greater than `last_subscript`, or if you specify a value of `NULL` for one of the arguments, `DELETE` has no effect.

Note that when you delete an entry, the subscript remains in the collection; you can reuse the subscript with an alternate entry. If you specify a subscript that does not exist in the call to the `DELETE` method, `DELETE` does not raise an exception.

The following example demonstrates using the `DELETE` method to remove the element with subscript 0 from the collection:

```sql
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr sparse_arr_typ;
    v_results VARCHAR2(50);
    v_sub NUMBER;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10) := -10;
    sparse_arr(0) := 0;
    sparse_arr(10) := 10;
    sparse_arr(100) := 100;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.DELETE(0);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    v_sub := sparse_arr.FIRST;
    WHILE v_sub IS NOT NULL LOOP
        IF sparse_arr(v_sub) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(v_sub) || ' ';
        END IF;
        v_sub := sparse_arr.NEXT(v_sub);
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
```

```
COUNT: 5
COUNT: 4
Results: -100 -10 10 100
```
COUNT indicates that before the DELETE method, there were 5 elements in the collection; after the DELETE method was invoked, the collection contains 4 elements.

### 3.11.3 EXISTS

The EXISTS method verifies that a subscript exists within a collection. EXISTS returns TRUE if the subscript exists; if the subscript does not exist, EXISTS returns FALSE. The method takes a single argument; the subscript that you are testing for. The syntax:

```
collection.EXISTS(subscript)
```

`collection` is the name of the collection.

`subscript` is the value that you are testing for. If you specify a value of NULL, EXISTS returns false.

The following example verifies that subscript number 10 exists within the associative array:

```sql
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr sparse_arr_typ;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10) := -10;
    sparse_arr(0) := 0;
    sparse_arr(10) := 10;
    sparse_arr(100) := 100;
    DBMS_OUTPUT.PUT_LINE('The index exists: ' || CASE WHEN sparse_arr.exists(10) = TRUE THEN 'true' ELSE 'false' END);
END;
```

The index exists: true

Some collection methods raise an exception if you call them with a subscript that does not exist within the specified collection. Rather than raising an error, the EXISTS method returns a value of FALSE.

### 3.11.4 EXTEND

The EXTEND method increases the size of a collection. There are three variations of the EXTEND method. The first variation appends a single NULL element to a collection; the syntax for the first variation is:

```
collection.EXTEND
```

`collection` is the name of a collection.
The following example demonstrates using the `EXTEND` method to append a single, null element to a collection:

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.EXTEND;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
COUNT: 5
COUNT: 6
Results: -100 -10 0 10 100 NULL
```

`COUNT` indicates that before the `EXTEND` method, there were 5 elements in the collection; after the `EXTEND` method was invoked, the collection contains 6 elements.

The second variation of the `EXTEND` method appends a specified number of elements to the end of a collection.

```
collection.EXTEND(count)
```

`collection` is the name of a collection.

`count` is the number of null elements added to the end of the collection.

The following example demonstrates using the `EXTEND` method to append multiple null elements to a collection:

```
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.EXTEND(3);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
```

```
COUNT: 5
COUNT: 8
Results: -100 -10 0 10 100 NULL
RESULT: -100 -10 0 10 100 NULL NULL NULL
```

```
COUNT: 8
COUNT: 9
Results: -100 -10 0 10 100 NULL NULL NULL
RESULT: -100 -10 0 10 100 NULL NULL NULL
```

The `RESULT` variable shows the effect of appending additional null elements to the collection.
COUNT indicates that before the `EXTEND` method, there were 5 elements in the collection; after the `EXTEND` method was invoked, the collection contains 8 elements.

The third variation of the `EXTEND` method appends a specified number of copies of a particular element to the end of a collection.

```
collection.EXTEND(count, index_number)
```

`collection` is the name of a collection.

`count` is the number of elements added to the end of the collection.

`index_number` is the subscript of the element that is being copied to the collection.

The following example demonstrates using the `EXTEND` method to append multiple copies of the second element to the collection:

```
DECLARE
  TYPE sparse_arr_typ IS TABLE OF NUMBER;
  sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
  v_results       VARCHAR2(50);
BEGIN
  DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
  sparse_arr.EXTEND(3, 2);
  DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
  FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
    IF sparse_arr(i) IS NULL THEN
      v_results := v_results || 'NULL ';
    ELSE
      v_results := v_results || sparse_arr(i) || ' ';
    END IF;
  END LOOP;
  DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
```

COUNT indicates that before the `EXTEND` method, there were 5 elements in the collection; after the `EXTEND` method was invoked, the collection contains 8 elements.

**Note:** The `EXTEND` method cannot be used on a null or empty collection.
3.11.5 FIRST

FIRST is a method that returns the subscript of the first element in a collection. The syntax for using FIRST is as follows:

```
collection.FIRST
```

collection is the name of a collection.

The following example displays the first element of the associative array.

```sql
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr    sparse_arr_typ;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10)  := -10;
    sparse_arr(0)   := 0;
    sparse_arr(10)  := 10;
    sparse_arr(100) := 100;
    DBMS_OUTPUT.PUT_LINE('FIRST element: ' || sparse_arr(sparse_arr.FIRST));
END;
```

FIRST element: -100

3.11.6 LAST

LAST is a method that returns the subscript of the last element in a collection. The syntax for using LAST is as follows:

```
collection.LAST
```

collection is the name of a collection.

The following example displays the last element of the associative array.

```sql
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr    sparse_arr_typ;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10)  := -10;
    sparse_arr(0)   := 0;
    sparse_arr(10)  := 10;
    sparse_arr(100) := 100;
    DBMS_OUTPUT.PUT_LINE('LAST element: ' || sparse_arr(sparse_arr.LAST));
END;
```

LAST element: 100
3.11.7 LIMIT

LIMIT is a method that returns the maximum number of elements permitted in a collection. LIMIT is applicable only to varrays. The syntax for using LIMIT is as follows:

```
collection.LIMIT
```

collection is the name of a collection.

For an initialized varray, LIMIT returns the maximum size limit determined by the varray type definition. If the varray is uninitialized (that is, it is a null varray), an exception is thrown.

For an associative array or an initialized nested table, LIMIT returns NULL. If the nested table is uninitialized (that is, it is a null nested table), an exception is thrown.

3.11.8 NEXT

NEXT is a method that returns the subscript that follows a specified subscript. The method takes a single argument; the subscript that you are testing for.

```
collection.NEXT(subscript)
```

collection is the name of the collection.

If the specified subscript is less than the first subscript in the collection, the function returns the first subscript. If the subscript does not have a successor, NEXT returns NULL. If you specify a NULL subscript, PRIOR does not return a value.

The following example demonstrates using NEXT to return the subscript that follows subscript 10 in the associative array, sparse_arr:

```sql
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr sparse_arr_typ;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10)  := -10;
    sparse_arr(0)    := 0;
    sparse_arr(10)   := 10;
    sparse_arr(100)  := 100;
    DBMS_OUTPUT.PUT_LINE('NEXT element: ' || sparse_arr.next(10));
END;

NEXT element: 100
3.11.9 PRIOR

The PRIOR method returns the subscript that precedes a specified subscript in a collection. The method takes a single argument; the subscript that you are testing for. The syntax is:

\[ \text{collection.PRIOR(subscript)} \]

\textit{collection} is the name of the collection.

If the subscript specified does not have a predecessor, PRIOR returns NULL. If the specified subscript is greater than the last subscript in the collection, the method returns the last subscript. If you specify a NULL subscript, PRIOR does not return a value.

The following example returns the subscript that precedes subscript 100 in the associative array, \texttt{sparse_arr}:

```plaintext
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER INDEX BY BINARY_INTEGER;
    sparse_arr sparse_arr_typ;
BEGIN
    sparse_arr(-100) := -100;
    sparse_arr(-10) := -10;
    sparse_arr(0) := 0;
    sparse_arr(10) := 10;
    sparse_arr(100) := 100;
    DBMS_OUTPUT.PUT_LINE('PRIOR element: ' || sparse_arr.prior(100));
END;
PRIOR element: 10
```

3.11.10 TRIM

The TRIM method removes an element or elements from the end of a collection. The syntax for the TRIM method is:

\[ \text{collection.TRIM([count])} \]

\textit{collection} is the name of a collection.

\textit{count} is the number of elements removed from the end of the collection. Advanced Server will return an error if \textit{count} is less than 0 or greater than the number of elements in the collection.

The following example demonstrates using the TRIM method to remove an element from the end of a collection:
DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.TRIM;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
END;
COUNT: 5
COUNT: 4

COUNT indicates that before the TRIM method, there were 5 elements in the collection; after the TRIM method was invoked, the collection contains 4 elements.

You can also specify the number of elements to remove from the end of the collection with the TRIM method:

DECLARE
    TYPE sparse_arr_typ IS TABLE OF NUMBER;
    sparse_arr      sparse_arr_typ := sparse_arr_typ(-100,-10,0,10,100);
    v_results       VARCHAR2(50);
BEGIN
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    sparse_arr.TRIM(2);
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || sparse_arr.COUNT);
    FOR i IN sparse_arr.FIRST .. sparse_arr.LAST LOOP
        IF sparse_arr(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || sparse_arr(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
COUNT: 5
COUNT: 3
Results: -100 -10 0

COUNT indicates that before the TRIM method, there were 5 elements in the collection; after the TRIM method was invoked, the collection contains 3 elements.
3.12 Working with Collections

Collection operators allow you to transform, query and manipulate the contents of a collection.

3.12.1 TABLE()

Use the TABLE() function to transform the members of an array into a set of rows. The signature is:

\[
\text{TABLE}(\text{collection\_value})
\]

Where:

\[
\text{collection\_value}
\]

\[
\text{collection\_value} \text{ is an expression that evaluates to a value of collection type.}
\]

The TABLE() function expands the nested contents of a collection into a table format. You can use the TABLE() function anywhere you use a regular table expression.

The TABLE() function returns a SETOF ANYELEMENT (a set of values of any type). For example, if the argument passed to this function is an array of dates, TABLE() will return a SETOF dates. If the argument passed to this function is an array of paths, TABLE() will return a SETOF paths.

You can use the TABLE() function to expand the contents of a collection into table form:

\[
\text{postgres=# SELECT * FROM TABLE(monthly\_balance(445.00, 980.20, 552.00)));
\]

\[
\begin{align*}
\text{monthly\_balance} \\
\text{-----------} \\
\text{445.00} \\
\text{980.20} \\
\text{552.00} \\
\text{(3 rows)}
\end{align*}
\]

3.12.2 Using the MULTISET UNION Operator

The MULTISET UNION operator combines two collections to form a third collection. The signature is:

\[
\text{coll\_1 MULTISET UNION [ALL | DISTINCT] coll\_2}
\]

coll\_1 and coll\_2 specify the names of the collections to combine.
Include the `ALL` keyword to specify that duplicate elements (elements that are present in both `coll_1` and `coll_2`) should be represented in the result, once for each time they are present in the original collections. This is the default behavior of `MULTISET UNION`.

Include the `DISTINCT` keyword to specify that duplicate elements should be included in the result only once.

The following example demonstrates using the `MULTISET UNION` operator to combine two collections (`collection_1` and `collection_2`) into a third collection (`collection_3`):

```sql
DECLARE
    TYPE int_arr_typ IS TABLE OF NUMBER(2);
    collection_1    int_arr_typ;
    collection_2    int_arr_typ;
    collection_3    int_arr_typ;
    v_results       VARCHAR2(50);
BEGIN
    collection_1 := int_arr_typ(10,20,30);
    collection_2 := int_arr_typ(30,40);
    collection_3 := collection_1 MULTISET UNION ALL collection_2;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || collection_3.COUNT);
    FOR i IN collection_3.FIRST .. collection_3.LAST LOOP
        IF collection_3(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || collection_3(i) || ' ';
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
COUNT: 5
Results: 10 20 30 30 40
```

The resulting collection includes one entry for each element in `collection_1` and `collection_2`. If the `DISTINCT` keyword is used, the results are the following:

```sql
DECLARE
    TYPE int_arr_typ IS TABLE OF NUMBER(2);
    collection_1    int_arr_typ;
    collection_2    int_arr_typ;
    collection_3    int_arr_typ;
    v_results       VARCHAR2(50);
BEGIN
    collection_1 := int_arr_typ(10,20,30);
    collection_2 := int_arr_typ(30,40);
    collection_3 := collection_1 MULTISET UNION DISTINCT collection_2;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || collection_3.COUNT);
    FOR i IN collection_3.FIRST .. collection_3.LAST LOOP
        IF collection_3(i) IS NULL THEN
            v_results := v_results || 'NULL '
        ELSE
            v_results := v_results || collection_3(i) || ' '
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
COUNT: 5
Results: 10 20 30 40
```
The resulting collection includes only those members with distinct values. Note in the following example that the `MULTISET UNION DISTINCT` operator also removes duplicate entries that are stored within the same collection:

```sql
DECLARE
    TYPE int_arr_typ IS TABLE OF NUMBER(2);
    collection_1 int_arr_typ;
    collection_2 int_arr_typ;
    collection_3 int_arr_typ;
    v_results VARCHAR2(50);
BEGIN
    collection_1 := int_arr_typ(10,20,30,30);
    collection_2 := int_arr_typ(40,50);
    collection_3 := collection_1 MULTISET UNION DISTINCT collection_2;
    DBMS_OUTPUT.PUT_LINE('COUNT: ' || collection_3.COUNT);
    FOR i IN collection_3.FIRST .. collection_3.LAST LOOP
        IF collection_3(i) IS NULL THEN
            v_results := v_results || 'NULL ';
        ELSE
            v_results := v_results || collection_3(i) || ' '; // Note: Added a space
        END IF;
    END LOOP;
    DBMS_OUTPUT.PUT_LINE('Results: ' || v_results);
END;
```

COUNT: 5
Results: 10 20 30 40 50

### 3.12.3 Using the `FORALL` Statement

Collections can be used to more efficiently process DML commands by passing all the values to be used for repetitive execution of a `DELETE`, `INSERT`, or `UPDATE` command in one pass to the database server rather than re-iteratively invoking the DML command with new values. The DML command to be processed in such a manner is specified with the `FORALL` statement. In addition, one or more collections are given in the DML command where different values are to be substituted each time the command is executed.

```sql
FORALL index IN lower_bound .. upper_bound
{ insert_stmt | update_stmt | delete_stmt };
```

*index* is the position in the collection given in the `insert_stmt, update_stmt, or delete_stmt` DML command that iterates from the integer value given as `lower_bound` up to and including `upper_bound`.

**Note:** If an exception occurs during any iteration of the `FORALL` statement, all updates that occurred since the start of the execution of the `FORALL` statement are automatically
rolled back. This behavior is not compatible with Oracle databases. Oracle allows explicit use of the `COMMIT` or `ROLLBACK` commands to control whether or not to commit or roll back updates that occurred prior to the exception.

The `FORALL` statement creates a loop – each iteration of the loop increments the `index` variable (you typically use the `index` within the loop to select a member of a collection). The number of iterations is controlled by the `lower_bound .. upper_bound` clause. The loop is executed once for each integer between the `lower_bound` and `upper_bound` (inclusive) and the index is incremented by one for each iteration. For example:

```
FORALL i IN 2 .. 5
```

Creates a loop that executes four times – in the first iteration, the `index (i)` is set to the value `2`; in the second iteration, the index is set to the value `3`, and so on. The loop executes for the value `5` and then terminates.

The following example creates a table (`emp_copy`) that is an empty copy of the `emp` table. The example declares a type (`emp_tbl`) that is an array where each element in the array is of composite type, composed of the column definitions used to create the table, `emp`. The example also creates an index on the `emp_tbl` type.

```
t_emp is an associative array, of type `emp_tbl`. The `SELECT` statement uses the `BULK COLLECT INTO` command to populate the `t_emp` array. After the `t_emp` array is populated, the `FORALL` statement iterates through the values (`i`) in the `t_emp` array index and inserts a row for each record into `emp_copy`.
```

```
CREATE TABLE emp_copy (LIKE emp);
DECLARE
    TYPE emp_tbl IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;
    t_emp emp_tbl;
BEGIN
    SELECT * FROM emp BULK COLLECT INTO t_emp;
    FORALL i IN t_emp.FIRST .. t_emp.LAST
        INSERT INTO emp_copy VALUES t_emp(i);
END;
```

The following example uses a `FORALL` statement to update the salary of three employees:

```
DECLARE
    TYPE empno_tbl  IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
    TYPE sal_tbl    IS TABLE OF emp.ename%TYPE INDEX BY BINARY_INTEGER;
    t_empno         EMPNO_TBL;
    t_sal           SAL_TBL;
BEGIN
```

```
```
The following example deletes three employees in a **FORALL** statement:

```
DECLARE
  TYPE empno_tbl  IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
  t_empno  EMPNO_TBL;
BEGIN
  t_empno(1)  := 9001;
  t_empno(2)  := 9002;
  t_empno(3)  := 9003;
  FORALL i IN t_empno.FIRST..t Empno LAST
    DELETE FROM emp WHERE empno = t_empno(i);
END;
```

```
SELECT * FROM emp WHERE empno > 9000;
empno | ename | job  | mgr | hiredate | sal  | comm | deptno
-------+-------+-------+-----+----------+------+------+-------
 9001  | JONES | ANALYST |     |          | 3350.00 |      |     40
 9002  | LARSEN | CLERK |     |          | 2000.00 |      |     40
 9003  | WILSON | MANAGER |     |          | 4100.00 |      |     40
(3 rows)
```

### 3.12.4 Using the **BULK COLLECT** Clause

SQL commands that return a result set consisting of a large number of rows may not be operating as efficiently as possible due to the constant context switching that must occur between the database server and the client in order to transfer the entire result set. This inefficiency can be mitigated by using a collection to gather the entire result set in memory which the client can then access. The **BULK COLLECT** clause is used to specify the aggregation of the result set into a collection.

The **BULK COLLECT** clause can be used with the **SELECT INTO**, **FETCH INTO** and **EXECUTE IMMEDIATE** commands, and with the **RETURNING INTO** clause of the **DELETE**, **INSERT**, and **UPDATE** commands. Each of these is illustrated in the following sections.
3.12.4.1 SELECT BULK COLLECT

The `BULK COLLECT` clause can be used with the `SELECT INTO` statement as follows. (Refer to Section 3.4.3 for additional information on the `SELECT INTO` statement.)

```sql
SELECT select_expressions BULK COLLECT INTO collection [, ...] FROM ...;
```

If a single collection is specified, then `collection` may be a collection of a single field, or it may be a collection of a record type. If more than one collection is specified, then each `collection` must consist of a single field. `select_expressions` must match in number, order, and type-compatibility all fields in the target collections.

The following example shows the use of the `BULK COLLECT` clause where the target collections are associative arrays consisting of a single field.

```sql
DECLARE
  TYPE empno_tbl    IS TABLE OF emp.empno%TYPE    INDEX BY BINARY_INTEGER;
  TYPE ename_tbl    IS TABLE OF emp.ename%TYPE    INDEX BY BINARY_INTEGER;
  TYPE job_tbl      IS TABLE OF emp.job%TYPE      INDEX BY BINARY_INTEGER;
  TYPE hiredate_tbl IS TABLE OF emp.hiredate%TYPE INDEX BY BINARY_INTEGER;
  TYPE comm_tbl     IS TABLE OF emp.comm%TYPE     INDEX BY BINARY_INTEGER;
  TYPE sal_tbl      IS TABLE OF emp.sal%TYPE      INDEX BY BINARY_INTEGER;
  TYPE deptno_tbl   IS TABLE OF emp.deptno%TYPE  INDEX BY BINARY_INTEGER;
  t_empno           EMPNO_TBL;
  t_ename           ENAME_TBL;
  t_job             JOB_TBL;
  t_hiredate        HIREDATE_TBL;
  t_sal             SAL_TBL;
  t_comm            COMM_TBL;
  t_deptno          DEPTNO_TBL;
BEGIN
  SELECT empno, ename, job, hiredate, sal, comm, deptno BULK COLLECT
    INTO t_empno, t_ename, t_job, t_hiredate, t_sal, t_comm, t_deptno
    FROM emp;
  DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME    JOB        HIREDATE    SAL        COMM      DEPTNO');
  FOR i IN 1..t_empno.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(t_empno(i) || '   ' || RPAD(t_ename(i),8) || ' ' ||
      TO_CHAR(t_hiredate(i),'DD-MON-YY') || ' ' ||
      TO_CHAR(t_sal(i),'99,999.99') || ' ' ||
      TO_CHAR(NVL(t_comm(i),0),'99,999.99') || ' ' ||
      t_deptno(i));
  END LOOP;
END;
```

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>JOB</th>
<th>HIREDATE</th>
<th>SAL</th>
<th>COMM</th>
<th>DEPTNO</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
<td>17-DEC-80</td>
<td>800.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
<td>20-FEB-81</td>
<td>1,600.00</td>
<td>300.00</td>
<td>30</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
<td>22-FEB-81</td>
<td>1,250.00</td>
<td>500.00</td>
<td>30</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
<td>02-APR-81</td>
<td>2,975.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>SALESMAN</td>
<td>28-SEP-81</td>
<td>1,250.00</td>
<td>1,400.00</td>
<td>30</td>
</tr>
</tbody>
</table>
The following example produces the same result, but uses an associative array on a record type defined with the %ROWTYPE attribute.

```sql
DECLARE
    TYPE emp_tbl IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;
    t_emp           EMP_TBL;
BEGIN
    SELECT * BULK COLLECT INTO t_emp FROM emp;
    DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME    JOB        HIREDATE    ' ||
                          'SAL        ' || 'COMM      DEPTNO');
    DBMS_OUTPUT.PUT_LINE('------ ------- -------- --------- --------');
    FOR i IN 1..t_emp.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(t_emp(i).empno || '   ' ||
                             RPAD(t_emp(i).ename,8) || ' ' ||
                             RPAD(t_emp(i).job,10) || ' ' ||
                             TO_CHAR(t_emp(i).hiredate,'DD-MON-YY') || ' ' ||
                             TO_CHAR(t_emp(i).sal,'99,999.99') || ' ' ||
                             TO_CHAR(NVL(t_emp(i).comm,0),'99,999.99') || ' ' ||
                             t_emp(i).deptno);
    END LOOP;
END;
```

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>JOB</th>
<th>HIREDATE</th>
<th>SAL</th>
<th>COMM</th>
<th>DEPTNO</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
<td>17-DEC-80</td>
<td>800.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
<td>20-FEB-81</td>
<td>1,600.00</td>
<td>300.00</td>
<td>30</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
<td>22-FEB-81</td>
<td>1,250.00</td>
<td>500.00</td>
<td>30</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
<td>02-APR-81</td>
<td>2,975.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>SALESMAN</td>
<td>28-SEP-81</td>
<td>1,250.00</td>
<td>1,400.00</td>
<td>30</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>MANAGER</td>
<td>01-MAY-81</td>
<td>2,850.00</td>
<td>.00</td>
<td>30</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>MANAGER</td>
<td>09-JUN-81</td>
<td>2,450.00</td>
<td>.00</td>
<td>10</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>ANALYST</td>
<td>19-APR-87</td>
<td>3,000.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>PRESIDENT</td>
<td>17-NOV-81</td>
<td>5,000.00</td>
<td>.00</td>
<td>10</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>SALESMAN</td>
<td>08-SEP-81</td>
<td>1,500.00</td>
<td>.00</td>
<td>30</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>CLERK</td>
<td>23-MAY-87</td>
<td>1,100.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>CLERK</td>
<td>03-DEC-81</td>
<td>950.00</td>
<td>.00</td>
<td>30</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>ANALYST</td>
<td>03-DEC-81</td>
<td>3,000.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>CLERK</td>
<td>23-JAN-82</td>
<td>1,300.00</td>
<td>.00</td>
<td>10</td>
</tr>
</tbody>
</table>

### 3.12.4.2 FETCH BULK COLLECT

The `BULK COLLECT` clause can be used with a `FETCH` statement. (See Section 3.8.3 for information on the `FETCH` statement.) Instead of returning a single row at a time from the result set, the `FETCH BULK COLLECT` will return all rows at once from the result set into the specified collection unless restricted by the `LIMIT` clause.
FETCH name BULK COLLECT INTO collection [, ...] [ LIMIT n ];

If a single collection is specified, then collection may be a collection of a single field, or it may be a collection of a record type. If more than one collection is specified, then each collection must consist of a single field. The expressions in the SELECT list of the cursor identified by name must match in number, order, and type-compatibility all fields in the target collections. If LIMIT n is specified, the number of rows returned into the collection on each FETCH will not exceed n.

The following example uses the FETCH BULK COLLECT statement to retrieve rows into an associative array.

```
DECLARE
  TYPE emp_tbl IS TABLE OF emp%ROWTYPE INDEX BY BINARY_INTEGER;
  t_emp    emp_tbl;
  CURSOR emp_cur IS SELECT * FROM emp;
BEGIN
  OPEN emp_cur;
  FETCH emp_cur BULK COLLECT INTO t_emp;
  CLOSE emp_cur;
  DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME    JOB        HIREDATE    SAL        COMM      DEPTNO');
  DBMS_OUTPUT.PUT_LINE('----- ------ ------ --------- ------ ------ ------');
  FOR i IN 1..t_emp.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(t_emp(i).empno || '   ' ||
      RPAD(t_emp(i).ename,8) || ' ' ||
      RPAD(t_emp(i).job,10) || ' ' ||
      TO_CHAR(t_emp(i).hiredate,'DD-MON-YY') || ' ' ||
      TO_CHAR(t_emp(i).sal,'99,999.99') || ' ' ||
      TO_CHAR(NVL(t_emp(i).comm,0),'99,999.99') || ' ' ||
      t_emp(i).deptno);
  END LOOP;
END;
```

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>ENAME</th>
<th>JOB</th>
<th>HIREDATE</th>
<th>SAL</th>
<th>COMM</th>
<th>DEPTNO</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
<td>17-DEC-80</td>
<td>800.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7499</td>
<td>ALLEN</td>
<td>SALESMAN</td>
<td>20-FEB-81</td>
<td>1,600.00</td>
<td>300.00</td>
<td>30</td>
</tr>
<tr>
<td>7521</td>
<td>WARD</td>
<td>SALESMAN</td>
<td>22-FEB-81</td>
<td>1,250.00</td>
<td>500.00</td>
<td>30</td>
</tr>
<tr>
<td>7566</td>
<td>JONES</td>
<td>MANAGER</td>
<td>02-APR-81</td>
<td>2,975.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7654</td>
<td>MARTIN</td>
<td>SALESMAN</td>
<td>28-SEP-81</td>
<td>1,250.00</td>
<td>1,400.00</td>
<td>30</td>
</tr>
<tr>
<td>7698</td>
<td>BLAKE</td>
<td>MANAGER</td>
<td>01-MAY-81</td>
<td>2,850.00</td>
<td>.00</td>
<td>30</td>
</tr>
<tr>
<td>7782</td>
<td>CLARK</td>
<td>MANAGER</td>
<td>09-JUN-81</td>
<td>2,450.00</td>
<td>.00</td>
<td>10</td>
</tr>
<tr>
<td>7788</td>
<td>SCOTT</td>
<td>ANALYST</td>
<td>19-APR-87</td>
<td>3,000.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7839</td>
<td>KING</td>
<td>PRESIDENT</td>
<td>17-NOV-81</td>
<td>5,000.00</td>
<td>.00</td>
<td>10</td>
</tr>
<tr>
<td>7844</td>
<td>TURNER</td>
<td>SALESMAN</td>
<td>08-SEP-81</td>
<td>1,500.00</td>
<td>.00</td>
<td>30</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>CLERK</td>
<td>23-MAY-87</td>
<td>1,100.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>CLERK</td>
<td>03-DEC-81</td>
<td>950.00</td>
<td>.00</td>
<td>30</td>
</tr>
<tr>
<td>7902</td>
<td>FORD</td>
<td>ANALYST</td>
<td>03-DEC-81</td>
<td>3,000.00</td>
<td>.00</td>
<td>20</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>CLERK</td>
<td>23-JAN-82</td>
<td>1,300.00</td>
<td>.00</td>
<td>10</td>
</tr>
</tbody>
</table>
3.12.4.3 EXECUTE IMMEDIATE BULK COLLECT

The BULK COLLECT clause can be used with a EXECUTE IMMEDIATE statement to specify a collection to receive the returned rows.

```sql
EXECUTE IMMEDIATE 'sql_expression;
   BULK COLLECT INTO collection [...] [USING {[bind_type] bind_argument} [, ...]]];
```

collection specifies the name of a collection.

bind_type specifies the parameter mode of the bind_argument.

- A bind_type of IN specifies that the bind_argument contains a value that is passed to the sql_expression.
- A bind_type of OUT specifies that the bind_argument receives a value from the sql_expression.
- A bind_type of IN OUT specifies that the bind_argument is passed to sql_expression, and then stores the value returned by sql_expression.

bind_argument specifies a parameter that contains a value that is either passed to the sql_expression (specified with a bind_type of IN), or that receives a value from the sql_expression (specified with a bind_type of OUT), or both (specified with a bind_type of IN OUT).

If a single collection is specified, then collection may be a collection of a single field, or a collection of a record type; if more than one collection is specified, each collection must consist of a single field.

3.12.4.4 RETURNING BULK COLLECT

The BULK COLLECT clause can be added to the RETURNING INTO clause of a DELETE, INSERT, or UPDATE command. (See Section 3.4.7 for information on the RETURNING INTO clause.)

```sql
{ insert | update | delete }
   RETURNING { * | expr_1 [, expr_2 ] ...}
   BULK COLLECT INTO collection [, ...];
```

insert, update, and delete are the INSERT, UPDATE, and DELETE commands as described in Sections 3.4.4, 3.4.5, and 3.4.6, respectively. If a single collection is specified, then collection may be a collection of a single field, or it may be a collection of a record type. If more than one collection is specified, then each
**Database Compatibility for Oracle® Developers Guide**

**collection** must consist of a single field. The expressions following the **RETURNING** keyword must match in number, order, and type-compatibility all fields in the target collections. If * is specified, then all columns in the affected table are returned. (Note that the use of * is an Advanced Server extension and is not compatible with Oracle databases.)

The **clerkemp** table created by copying the **emp** table is used in the remaining examples in this section as shown below.

```sql
CREATE TABLE clerkemp AS SELECT * FROM emp WHERE job = 'CLERK';
```

```sql
SELECT * FROM clerkemp;
```

<table>
<thead>
<tr>
<th>empno</th>
<th>ename</th>
<th>job</th>
<th>mgr</th>
<th>hiredate</th>
<th>sal</th>
<th>comm</th>
<th>deptno</th>
</tr>
</thead>
<tbody>
<tr>
<td>7369</td>
<td>SMITH</td>
<td>CLERK</td>
<td>7902</td>
<td>17-DEC-80 00:00:00</td>
<td>800.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7876</td>
<td>ADAMS</td>
<td>CLERK</td>
<td>7788</td>
<td>23-MAY-87 00:00:00</td>
<td>1100.00</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>7900</td>
<td>JAMES</td>
<td>CLERK</td>
<td>7698</td>
<td>03-DEC-81 00:00:00</td>
<td>950.00</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>7934</td>
<td>MILLER</td>
<td>CLERK</td>
<td>7782</td>
<td>23-JAN-82 00:00:00</td>
<td>1300.00</td>
<td></td>
<td>10</td>
</tr>
</tbody>
</table>
```

(4 rows)

The following example increases everyone’s salary by 1.5, stores the employees’ numbers, names, and new salaries in three associative arrays, and finally, displays the contents of these arrays.

```sql
DECLARE
  TYPE empno_tbl IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
  TYPE ename_tbl IS TABLE OF emp.ename%TYPE INDEX BY BINARY_INTEGER;
  TYPE sal_tbl   IS TABLE OF emp.sal%TYPE   INDEX BY BINARY_INTEGER;
  t_empno         EMPNO_TBL;
  t_ename         ENAME_TBL;
  t_sal           SAL_TBL;
BEGIN
  UPDATE clerkemp SET sal = sal * 1.5 RETURNING empno, ename, sal
  BULK COLLECT INTO t_empno, t_ename, t_sal;
  DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      SAL        ');
  DBMS_OUTPUT.PUT_LINE('----- ------- -------- -------- ');
  FOR i IN 1..t_empno.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(t_empno(i) || '   ' || RPAD(t_ename(i),8) || ' ' || TO_CHAR(t_sal(i),'99,999.99'));
  END LOOP;
END;
```

```plaintext
EMPNO  ENAME      SAL
----- ------- -------- --------
7369   SMITH      1,200.00
7876   ADAMS      1,650.00
7900   JAMES      1,425.00
7934   MILLER     1,950.00
```

The following example performs the same functionality as the previous example, but uses a single collection defined with a record type to store the employees’ numbers, names, and new salaries.

```sql
DECLARE
  TYPE empno_tbl IS TABLE OF emp.empno%TYPE INDEX BY BINARY_INTEGER;
  TYPE ename_tbl IS TABLE OF emp.ename%TYPE INDEX BY BINARY_INTEGER;
  TYPE sal_tbl   IS TABLE OF emp.sal%TYPE   INDEX BY BINARY_INTEGER;
  t_empno         EMPNO_TBL;
  t_ename         ENAME_TBL;
  t_sal           SAL_TBL;
BEGIN
  UPDATE clerkemp SET sal = sal * 1.5 RETURNING empno, ename, sal
  BULK COLLECT INTO t_empno, t_ename, t_sal;
  DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME      SAL        ');
  DBMS_OUTPUT.PUT_LINE('----- ------- -------- -------- ');
  FOR i IN 1..t_empno.COUNT LOOP
    DBMS_OUTPUT.PUT_LINE(t_empno(i) || '   ' || RPAD(t_ename(i),8) || ' ' || TO_CHAR(t_sal(i),'99,999.99'));
  END LOOP;
END;
```

```plaintext
EMPNO  ENAME      SAL
----- ------- -------- --------
7369   SMITH      1,200.00
7876   ADAMS      1,650.00
7900   JAMES      1,425.00
7934   MILLER     1,950.00
```

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The following example deletes all rows from the `clerkemp` table, and returns information on the deleted rows into an associative array, which is then displayed.

```sql
DECLARE
    TYPE emp_rec IS RECORD (
        empno emp.empno%TYPE,
        ename emp.ename%TYPE,
        job emp.job%TYPE,
        hiredate emp.hiredate%TYPE,
        sal emp.sal%TYPE,
        comm emp.comm%TYPE,
        deptno emp.deptno%TYPE
    );
    TYPE emp_tbl IS TABLE OF emp_rec INDEX BY BINARY_INTEGER;
    r_emp EMP_TBL;
BEGIN
    DELETE FROM clerkemp RETURNING empno, ename, job, hiredate, sal, comm, deptno BULK COLLECT INTO r_emp;
    DBMS_OUTPUT.PUT_LINE('EMPNO  ENAME  JOB        HIREDATE    SAL        COMM      DEPTNO');
    DBMS_OUTPUT.PUT_LINE('----- ------ -------- --------- -------- -------- ');
    FOR i IN 1..r_emp.COUNT LOOP
        DBMS_OUTPUT.PUT_LINE(r_emp(i).empno || ' ' || RPAD(r_emp(i).ename,8) || ' ' ||
            RPAD(r_emp(i).job,10) || ' ' ||
            TO_CHAR(r_emp(i).hiredate,'DD-MON-YY') || ' ' ||
            TO_CHAR(r_emp(i).sal,'99,999.99') || ' ' ||
            TO_CHAR(NVL(r_emp(i).comm,0),'99,999.99') || ' ' ||
            r_emp(i).deptno);
    END LOOP;
END;
EMPNO  ENAME  JOB        HIREDATE    SAL        COMM      DEPTNO
----- ------ -------- --------- -------- -------- ------
7369   SMITH  CLERK      1-DEC-80   1,200.00        .00  20
7876   ADAMS  SALES      5-DEC-80   1,650.00        .00  10
7900   JAMES  CLERK      1-DEC-80   1,425.00        .00  20
7934   MILLER SALES      1-DEC-80   1,950.00        .00  10
```
3.13 Errors and Messages

Use the `DBMS_OUTPUT.PUT_LINE` statement to report messages.

```
DBMS_OUTPUT.PUT_LINE ( message );
```

*message* is any expression evaluating to a string.

This example displays the message on the user’s output display:

```
DBMS_OUTPUT.PUT_LINE ('My name is John');
```

The special variables `SQLCODE` and `SQLERRM` contain a numeric code and a text message, respectively, that describe the outcome of the last SQL command issued. If any other error occurs in the program such as division by zero, these variables contain information pertaining to the error.
4 Triggers

This chapter describes triggers in Advanced Server. As with procedures and functions, triggers are written in the SPL language.

4.1 Overview

A trigger is a named SPL code block that is associated with a table and stored in the database. When a specified event occurs on the associated table, the SPL code block is executed. The trigger is said to be fired when the code block is executed.

The event that causes a trigger to fire can be any combination of an insert, update, or deletion carried out on the table, either directly or indirectly. If the table is the object of a SQL INSERT, UPDATE, or DELETE command the trigger is directly fired assuming that the corresponding insert, update, or deletion event is defined as a triggering event. The events that fire the trigger are defined in the CREATE TRIGGER command.

A trigger can be fired indirectly if a triggering event occurs on the table as a result of an event initiated on another table. For example, if a trigger is defined on a table containing a foreign key defined with the ON DELETE CASCADE clause and a row in the parent table is deleted, all children of the parent would be deleted as well. If deletion is a triggering event on the child table, deletion of the children will cause the trigger to fire.
4.2 Types of Triggers

Advanced Server supports both row-level and statement-level triggers. A row-level trigger fires once for each row that is affected by a triggering event. For example, if deletion is defined as a triggering event on a table and a single \texttt{DELETE} command is issued that deletes five rows from the table, then the trigger will fire five times, once for each row.

In contrast, a statement-level trigger fires once per triggering statement regardless of the number of rows affected by the triggering event. In the prior example of a single \texttt{DELETE} command deleting five rows, a statement-level trigger would fire only once.

The sequence of actions can be defined regarding whether the trigger code block is executed before or after the triggering statement, itself, in the case of statement-level triggers; or before or after each row is affected by the triggering statement in the case of row-level triggers.

In a \textit{before} row-level trigger, the trigger code block is executed before the triggering action is carried out on each affected row. In a \textit{before} statement-level trigger, the trigger code block is executed before the action of the triggering statement is carried out.

In an \textit{after} row-level trigger, the trigger code block is executed after the triggering action is carried out on each affected row. In an \textit{after} statement-level trigger, the trigger code block is executed after the action of the triggering statement is carried out.
4.3 Creating Triggers

The CREATE TRIGGER command defines and names a trigger that will be stored in the database.

Name

CREATE TRIGGER -- define a new trigger

Synopsis

CREATE [ OR REPLACE ] TRIGGER name
    { BEFORE | AFTER | INSTEAD OF }
    { INSERT | UPDATE | DELETE }
    [ OR { INSERT | UPDATE | DELETE } ] [, ...]
ON table
[ REFERENCING { OLD AS old | NEW AS new } ...]
[ FOR EACH ROW ]
[ WHEN condition ]
[ DECLARE
    declaration; [, ...] ]
BEGIN
    statement; [, ...]
[ EXCEPTION
    { WHEN exception [ OR exception ] [...] THEN
        statement; [, ...] } [, ...]
]
END

Description

CREATE TRIGGER defines a new trigger. CREATE OR REPLACE TRIGGER will either create a new trigger, or replace an existing definition.

If you are using the CREATE TRIGGER keywords to create a new trigger, the name of the new trigger must not match any existing trigger defined on the same table. New triggers will be created in the same schema as the table on which the triggering event is defined.

If you are updating the definition of an existing trigger, use the CREATE OR REPLACE TRIGGER keywords.

When you use syntax compatible with Oracle databases to create a trigger, the trigger runs as a SECURITY DEFINER function.
Parameters

**name**

The name of the trigger to create.

**BEFORE | AFTER**

Determines whether the trigger is fired before or after the triggering event.

**INSERT | UPDATE | DELETE**

Defines the triggering event.

**table**

The name of the table on which the triggering event occurs.

**condition**

*condition* is a Boolean expression that determines if the trigger will actually be executed; if *condition* evaluates to **TRUE**, the trigger will fire.

If the trigger definition includes the **FOR EACH ROW** keywords, the **WHEN** clause can refer to columns of the old and/or new row values by writing **OLD.column_name** or **NEW.column_name** respectively. **INSERT** triggers cannot refer to **OLD** and **DELETE** triggers cannot refer to **NEW**.

If the trigger includes the **INSTEAD OF** keywords, it may not include a **WHEN** clause.

**WHEN** clauses cannot contain subqueries.

**REFERENCING { OLD AS old | NEW AS new } ...**

**REFERENCING** clause to reference old rows and new rows, but restricted in that **old** may only be replaced by an identifier named **old** or any equivalent that is saved in all lowercase (for example, **REFERENCING OLD AS old, REFERENCING OLD AS OLD, or REFERENCING OLD AS "old"**). Also, **new** may only be replaced by an identifier named **new** or any equivalent that is saved in all lowercase (for example, **REFERENCING NEW AS new, REFERENCING NEW AS NEW, or REFERENCING NEW AS "new"**).

Either one, or both phrases **OLD AS old and NEW AS new** may be specified in the **REFERENCING clause** (for example, **REFERENCING NEW AS New OLD AS Old**).
See Section 3.4 for information on how these identifiers are used as pseudo-record names to reference old rows and new rows.

This clause is not compatible with Oracle databases in that identifiers other than old or new may not be used.

FOR EACH ROW

Determines whether the trigger should be fired once for every row affected by the triggering event, or just once per SQL statement. If specified, the trigger is fired once for every affected row (row-level trigger), otherwise the trigger is a statement-level trigger.

declaration

A variable, type, REF CURSOR, or subprogram declaration. If subprogram declarations are included, they must be declared after all other variable, type, and REF CURSOR declarations.

statement

An SPL program statement. Note that a DECLARE - BEGIN - END block is considered an SPL statement unto itself. Thus, the trigger body may contain nested blocks.

exception

An exception condition name such as NO_DATA_FOUND, OTHERS, etc.
4.4 Trigger Variables

In the trigger code block, several special variables are available for use.

**NEW**

*NEW* is a pseudo-record name that refers to the new table row for insert and update operations in row-level triggers. This variable is not applicable in statement-level triggers and in delete operations of row-level triggers.

*Its usage is:*\( :\text{NEW}.\text{column} \) where \( \text{column} \) is the name of a column in the table on which the trigger is defined.

The initial content of \( :\text{NEW}.\text{column} \) is the value in the named column of the new row to be inserted or of the new row that is to replace the old one when used in a before row-level trigger. When used in an after row-level trigger, this value has already been stored in the table since the action has already occurred on the affected row.

In the trigger code block, \( :\text{NEW}.\text{column} \) can be used like any other variable. If a value is assigned to \( :\text{NEW}.\text{column} \), in the code block of a before row-level trigger, the assigned value will be used in the new inserted or updated row.

**OLD**

*OLD* is a pseudo-record name that refers to the old table row for update and delete operations in row-level triggers. This variable is not applicable in statement-level triggers and in insert operations of row-level triggers.

*Its usage is:*\( :\text{OLD}.\text{column} \) where \( \text{column} \) is the name of a column in the table on which the trigger is defined.

The initial content of \( :\text{OLD}.\text{column} \) is the value in the named column of the row to be deleted or of the old row that is to be replaced by the new one when used in a before row-level trigger. When used in an after row-level trigger, this value is no longer stored in the table since the action has already occurred on the affected row.

In the trigger code block, \( :\text{OLD}.\text{column} \) can be used like any other variable. Assigning a value to \( :\text{OLD}.\text{column} \), has no effect on the action of the trigger.

**INSERTING**

*INSERTING* is a conditional expression that returns \text{TRUE} if an insert operation fired the trigger, otherwise it returns \text{FALSE}. 
UPDATING

UPDATING is a conditional expression that returns TRUE if an update operation fired the trigger, otherwise it returns FALSE.

DELETING

DELETING is a conditional expression that returns TRUE if a delete operation fired the trigger, otherwise it returns FALSE.
4.5 Transactions and Exceptions

A trigger is always executed as part of the same transaction within which the triggering statement is executing. When no exceptions occur within the trigger code block, the effects of any DML commands within the trigger are committed if and only if the transaction containing the triggering statement is committed. Therefore, if the transaction is rolled back, the effects of any DML commands within the trigger are also rolled back.

If an exception does occur within the trigger code block, but it is caught and handled in an exception section, the effects of any DML commands within the trigger are still rolled back nonetheless. The triggering statement itself, however, is not rolled back unless the application forces a roll back of the encapsulating transaction.

If an unhandled exception occurs within the trigger code block, the transaction that encapsulates the trigger is aborted and rolled back. Therefore the effects of any DML commands within the trigger and the triggering statement, itself are all rolled back.

4.6 Trigger Examples

The following sections illustrate an example of each type of trigger.

4.6.1 Before Statement-Level Trigger

The following is an example of a simple before statement-level trigger that displays a message prior to an insert operation on the emp table.

```
CREATE OR REPLACE TRIGGER emp_alert_trig
BEFORE INSERT ON emp
BEGIN
  DBMS_OUTPUT.PUT_LINE('New employees are about to be added');
END;
```

The following insert is constructed so that several new rows are inserted upon a single execution of the command. For each row that has an employee id between 7900 and 7999, a new row is inserted with an employee id incremented by 1000. The following are the results of executing the command when three new rows are inserted.

```
INSERT INTO emp (empno, ename, deptno) SELECT empno + 1000, ename, 40
  FROM emp WHERE empno BETWEEN 7900 AND 7999;
New employees are about to be added
```

```
SELECT empno, ename, deptno FROM emp WHERE empno BETWEEN 8900 AND 8999;
```

```
EMPNO ENAME          DEPTNO
---------- ---------- ----------
 8900 JAMES             40
 8902 FORD               40
 8934 MILLER             40
```
The message, New employees are about to be added, is displayed once by the firing of the trigger even though the result is the addition of three new rows.

4.6.2 After Statement-Level Trigger

The following is an example of an after statement-level trigger. Whenever an insert, update, or delete operation occurs on the emp table, a row is added to the empauditlog table recording the date, user, and action.

```sql
CREATE TABLE empauditlog (
    audit_date DATE,
    audit_user VARCHAR2(20),
    audit_desc VARCHAR2(20)
);
CREATE OR REPLACE TRIGGER emp_audit_trig
AFTER INSERT OR UPDATE OR DELETE ON emp
DECLARE
    v_action VARCHAR2(20);
BEGIN
    IF INSERTING THEN
        v_action := 'Added employee(s)';
    ELSIF UPDATING THEN
        v_action := 'Updated employee(s)';
    ELSIF DELETING THEN
        v_action := 'Deleted employee(s)';
    END IF;
    INSERT INTO empauditlog VALUES (SYSDATE, USER, v_action);
END;
```

In the following sequence of commands, two rows are inserted into the emp table using two INSERT commands. The sal and comm columns of both rows are updated with one UPDATE command. Finally, both rows are deleted with one DELETE command.

```sql
INSERT INTO emp VALUES (9001, 'SMITH', 'ANALYST', 7782, SYSDATE, NULL, NULL, 10);
INSERT INTO emp VALUES (9002, 'JONES', 'CLERK', 7782, SYSDATE, NULL, NULL, 10);
UPDATE emp SET sal = 4000.00, comm = 1200.00 WHERE empno IN (9001, 9002);
DELETE FROM emp WHERE empno IN (9001, 9002);
SELECT TO_CHAR(AUDIT_DATE,'DD-MON-YY HH24:MI:SS') AS "AUDIT_DATE",
       audit_user, audit_desc FROM empauditlog ORDER BY 1 ASC;
```

<table>
<thead>
<tr>
<th>AUDIT_DATE</th>
<th>AUDIT_USER</th>
<th>AUDIT_DESC</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-MAR-05</td>
<td>SYSTEM</td>
<td>Added employee(s)</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>SYSTEM</td>
<td>Added employee(s)</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>SYSTEM</td>
<td>Updated employee(s)</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>SYSTEM</td>
<td>Deleted employee(s)</td>
</tr>
</tbody>
</table>

The contents of the empauditlog table show how many times the trigger was fired - once each for the two inserts, once for the update (even though two rows were changed) and once for the deletion (even though two rows were deleted).
4.6.3 Before Row-Level Trigger

The following example is a before row-level trigger that calculates the commission of every new employee belonging to department 30 that is inserted into the emp table.

```sql
CREATE OR REPLACE TRIGGER emp_comm_trig
    BEFORE INSERT ON emp
    FOR EACH ROW
BEGIN
    IF :NEW.deptno = 30 THEN
        :NEW.comm := :NEW.sal * .4;
    END IF;
END;
```

The listing following the addition of the two employees shows that the trigger computed their commissions and inserted it as part of the new employee rows.

```
INSERT INTO emp VALUES (9005,'ROBERS','SALESMAN',7782,SYSDATE,3000.00,NULL,30);
INSERT INTO emp VALUES (9006,'ALLEN','SALESMAN',7782,SYSDATE,4500.00,NULL,30);
SELECT * FROM emp WHERE empno IN (9005, 9006);
```

```
EMPNO ENAME      JOB              MGR HIREDATE         SAL   COMM  DEPTNO
---------- ---------- ------- -------------- ------ ------ -------
         ROBERS     SALESMAN        7782 01-APR-05       3000 1200 30
         ALLEN      SALESMAN        7782 01-APR-05       4500 1800 30
```

4.6.4 After Row-Level Trigger

The following example is an after row-level trigger. When a new employee row is inserted, the trigger adds a new row to the jobhist table for that employee. When an existing employee is updated, the trigger sets the enddate column of the latest jobhist row (assumed to be the one with a null enddate) to the current date and inserts a new jobhist row with the employee’s new information.

Finally, trigger adds a row to the empchglog table with a description of the action.

```sql
CREATE TABLE empchglog (  
    chg_date DATE,  
    chg_desc VARCHAR2(30)  
) ;
CREATE OR REPLACE TRIGGER emp_chg_trig
    AFTER INSERT OR UPDATE OR DELETE ON emp
    FOR EACH ROW
DECLARE  
    v_empno emp.empno%TYPE;  
    v_deptno emp.deptno%TYPE;  
    v_dname dept.dname%TYPE;  
    v_action VARCHAR2(7);  
    v_chgdesc jobhist.chgdesc%TYPE;
BEGIN
    IF INSERTING THEN  
        v_action := 'Added';  
        v_empno := :NEW.empno;  
        v_deptno := :NEW.deptno;
```
In the first sequence of commands shown below, two employees are added using two separate INSERT commands and then both are updated using a single UPDATE command. The contents of the jobhist table shows the action of the trigger for each affected row - two new hire entries for the two new employees and two changed commission records for the updated commissions on the two employees. The empchglog table also shows the trigger was fired a total of four times, once for each action on the two rows.

```
INSERT INTO emp VALUES (9003,'PETERS','ANALYST',7782,SYSDATE,5000.00,NULL,40);
INSERT INTO emp VALUES (9004,'AIKENS','ANALYST',7782,SYSDATE,4500.00,NULL,40);
UPDATE emp SET comm = sal * 1.1 WHERE empno IN (9003, 9004);
SELECT * FROM jobhist WHERE empno IN (9003, 9004);
```

<table>
<thead>
<tr>
<th>EMPNO</th>
<th>STARTDATE</th>
<th>ENDDATE</th>
<th>JOB</th>
<th>SAL</th>
<th>COMM</th>
<th>DEPTNO</th>
<th>CHGDESC</th>
</tr>
</thead>
<tbody>
<tr>
<td>9003</td>
<td>31-MAR-05</td>
<td>31-MAR-05</td>
<td>ANALYST</td>
<td>5000</td>
<td></td>
<td>40</td>
<td>New Hire</td>
</tr>
<tr>
<td>9004</td>
<td>31-MAR-05</td>
<td>31-MAR-05</td>
<td>ANALYST</td>
<td>4500</td>
<td></td>
<td>40</td>
<td>New Hire</td>
</tr>
<tr>
<td>9003</td>
<td>31-MAR-05</td>
<td>NULL</td>
<td>ANALYST</td>
<td>5000</td>
<td>5500</td>
<td>40</td>
<td>Changed</td>
</tr>
<tr>
<td>9004</td>
<td>31-MAR-05</td>
<td>31-MAR-05</td>
<td>ANALYST</td>
<td>4500</td>
<td>4950</td>
<td>40</td>
<td>Changed</td>
</tr>
</tbody>
</table>

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Finally, both employees are deleted with a single `DELETE` command. The `empchlog` table now shows the trigger was fired twice, once for each deleted employee.

```
DELETE FROM emp WHERE empno IN (9003, 9004);
SELECT * FROM empchlog;
```

<table>
<thead>
<tr>
<th>CHG_DATE</th>
<th>CHG_DESC</th>
</tr>
</thead>
<tbody>
<tr>
<td>31-MAR-05</td>
<td>Added employee # 9003</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>Added employee # 9004</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>Updated employee # 9003</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>Updated employee # 9004</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>Deleted employee # 9003</td>
</tr>
<tr>
<td>31-MAR-05</td>
<td>Deleted employee # 9004</td>
</tr>
</tbody>
</table>
5 Packages

Advanced Server provides a collection of packages that provide compatibility with Oracle packages.

A package is a named collection of functions, procedures, variables, cursors, user-defined record types, and records that are referenced using a common qualifier — the package identifier. Packages have the following characteristics:

- Packages provide a convenient means of organizing the functions and procedures that perform a related purpose. Permission to use the package functions and procedures is dependent upon one privilege granted to the entire package. All of the package programs must be referenced with a common name.
- Certain functions, procedures, variables, types, etc. in the package can be declared as public. Public entities are visible and can be referenced by other programs that are given EXECUTE privilege on the package. For public functions and procedures, only their signatures are visible - the program names, parameters if any, and return types of functions. The SPL code of these functions and procedures is not accessible to others, therefore applications that utilize a package are dependent only upon the information available in the signature — not in the procedural logic itself.
- Other functions, procedures, variables, types, etc. in the package can be declared as private. Private entities can be referenced and used by function and procedures within the package, but not by other external applications. Private entities are for use only by programs within the package.
- Function and procedure names can be overloaded within a package. One or more functions/procedures can be defined with the same name, but with different signatures. This provides the capability to create identically named programs that perform the same job, but on different types of input.

For more information about the package support provided by Advanced Server, please see the Database Compatibility for Oracle Developers Built-in Package Guide, available at:

https://www.enterprisedb.com/resources/product-documentation

For a list of built-in packages, see the Table of Contents, beginning with Chapter 3 "Built-In Packages" of the Database Compatibility for Oracle Developers Built-in Package Guide.
6 Object Types and Objects

This chapter discusses how object-oriented programming techniques can be exploited in SPL. Object-oriented programming as seen in programming languages such as Java and C++ centers on the concept of objects. An object is a representation of a real-world entity such as a person, place, or thing. The generic description or definition of a particular object such as a person for example, is called an object type. Specific people such as “Joe” or “Sally” are said to be objects of object type, person, or equivalently, instances of the object type, person, or simply, person objects.

Note: The terms “database objects” and “objects” that have been used in this document up to this point should not be confused with an object type and object as used in this chapter. The previous usage of these terms relates to the entities that can be created in a database such as tables, views, indexes, users, etc. Within the context of this chapter, object type and object refer to specific data structures supported by the SPL programming language to implement object-oriented concepts.

Note: In Oracle, the term abstract data type (ADT) is used to describe object types in PL/SQL. The SPL implementation of object types is intended to be compatible with Oracle abstract data types.

Note: Advanced Server has not yet implemented support for some features of object-oriented programming languages. This chapter documents only those features that have been implemented.

6.1 Basic Object Concepts

An object type is a description or definition of some entity. This definition of an object type is characterized by two components:

- **Attributes** – fields that describe particular characteristics of an object instance. For a person object, examples might be name, address, gender, date of birth, height, weight, eye color, occupation, etc.
- **Methods** – programs that perform some type of function or operation on, or related to an object. For a person object, examples might be calculating the person’s age, displaying the person’s attributes, changing the values assigned to the person’s attributes, etc.

The following sections elaborate on some basic object concepts.
6.1.1 Attributes

Every object type must contain at least one attribute. The data type of an attribute can be any of the following:

- A base data type such as `NUMBER`, `VARCHAR2`, etc.
- Another object type
- A globally defined collection type (created by the `CREATE TYPE` command) such as a nested table or varray

An attribute gets its initial value (which may be null) when an object instance is initially created. Each object instance has its own set of attribute values.

6.1.2 Methods

Methods are SPL procedures or functions defined within an object type. Methods can be categorized into three general types:

- **Member Methods** – procedures or functions that operate within the context of an object instance. Member methods have access to, and can change the attributes of the object instance on which they are operating.
- **Static Methods** – procedures or functions that operate independently of any particular object instance. Static methods do not have access to, and cannot change the attributes of an object instance.
- **Constructor Methods** – functions used to create an instance of an object type. A default constructor method is always provided when an object type is defined.

6.1.3 Overloading Methods

In an object type it is permissible to define two or more identically named methods of the same type (this is, either a procedure or function), but with different signatures. Such methods are referred to as overloaded methods.

A method’s signature consists of the number of formal parameters, the data types of its formal parameters, and their order.
6.2 Object Type Components

Object types are created and stored in the database by using the following two constructs of the SPL language:

- The **object type specification** - This is the public interface specifying the attributes and method signatures of the object type.
- The **object type body** - This contains the implementation of the methods specified in the object type specification.

The following sections describe the commands used to create the object type specification and the object type body.

6.2.1 Object Type Specification Syntax

The following is the syntax of the object type specification:

```
CREATE [ OR REPLACE ] TYPE name
    [ AUTHID { DEFINER | CURRENT_USER } ]
    { IS | AS } OBJECT
    ( { attribute { datatype | objtype | collecttype } } 
    [ , ... ]
    [ method_spec ] [ , ... ]
    [ constructor ] [ , ... ]
) [ [ NOT ] { FINAL | INSTANTIABLE } ] ...;
```

where `method_spec` is the following:

```
[ [ NOT ] { FINAL | INSTANTIABLE } ] ...  
[ OVERRIDING ]
    subprogram_spec
```

where `subprogram_spec` is the following:

```
{ MEMBER | STATIC }
{ PROCEDURE proc_name
    [ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
    [ DEFAULT value1 ] ]
    [, parm2 [ IN | IN OUT | OUT ] datatype2
    [ DEFAULT value2 ]
    ] ...) ] 
   | 
FUNCTION func_name
    [ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
    [ DEFAULT value1 ] ]
    [, parm2 [ IN | IN OUT | OUT ] datatype2
    [ DEFAULT value2 ]
    ] ...) ] 
```
where constructor is the following:

```
CONSTRUCTOR  func_name
    [ ( [ SELF [ IN | IN OUT ] name ]
    [ , parm1 [ IN | IN OUT | OUT ] datatype1
        [ DEFAULT value1 ] ]
    [ , parm2 [ IN | IN OUT | OUT ] datatype2
        [ DEFAULT value2 ] ]
    ) ...]
RETURN self AS RESULT
```

**Note:** The `OR REPLACE` option cannot be currently used to add, delete, or modify the attributes of an existing object type. Use the `DROP TYPE` command to first delete the existing object type. The `OR REPLACE` option can be used to add, delete, or modify the methods in an existing object type.

**Note:** The PostgreSQL form of the `ALTER TYPE ALTER ATTRIBUTE` command can be used to change the data type of an attribute in an existing object type. However, the `ALTER TYPE` command cannot add or delete attributes in the object type.

`name` is an identifier (optionally schema-qualified) assigned to the object type.

If the `AUTHID` clause is omitted or `DEFINER` is specified, the rights of the object type owner are used to determine access privileges to database objects. If `CURRENT_USER` is specified, the rights of the current user executing a method in the object are used to determine access privileges.

`attribute` is an identifier assigned to an attribute of the object type.

`datatype` is a base data type.

`objtype` is a previously defined object type.

`collecttype` is a previously defined collection type.

Following the closing parenthesis of the `CREATE TYPE` definition, `[ NOT ] FINAL` specifies whether or not a subtype can be derived from this object type. `FINAL`, which is
the default, means that no subtypes can be derived from this object type. Specify **NOT FINAL** if you want to allow subtypes to be defined under this object type.

**Note:** Even though the specification of **NOT FINAL** is accepted in the **CREATE TYPE** command, SPL does not currently support the creation of subtypes.

Following the closing parenthesis of the **CREATE TYPE** definition, `[ NOT ] INSTANTIABLE` specifies whether or not an object instance can be created of this object type. **INSTANTIABLE**, which is the default, means that an instance of this object type can be created. Specify **NOT INSTANTIABLE** if this object type is to be used only as a parent “template” from which other specialized subtypes are to be defined. If **NOT INSTANTIABLE** is specified, then **NOT FINAL** must be specified as well. If any method in the object type contains the **NOT INSTANTIABLE** qualifier, then the object type, itself, must be defined with **NOT INSTANTIABLE** and **NOT FINAL**.

**Note:** Even though the specification of **NOT INSTANTIABLE** is accepted in the **CREATE TYPE** command, SPL does not currently support the creation of subtypes.

**method_spec** denotes the specification of a member method or static method.

Prior to the definition of a method, `[ NOT ] FINAL` specifies whether or not the method can be overridden in a subtype. **NOT FINAL** is the default meaning the method can be overridden in a subtype.

Prior to the definition of a method specify **OVERLOADING** if the method overrides an identically named method in a supertype. The overriding method must have the same number of identically named method parameters with the same data types and parameter modes, in the same order, and the same return type (if the method is a function) as defined in the supertype.

Prior to the definition of a method, `[ NOT ] INSTANTIABLE` specifies whether or not the object type definition provides an implementation for the method. If **INSTANTIABLE** is specified, then the **CREATE TYPE BODY** command for the object type must specify the implementation of the method. If **NOT INSTANTIABLE** is specified, then the **CREATE TYPE BODY** command for the object type must not contain the implementation of the method. In this latter case, it is assumed a subtype contains the implementation of the method, overriding the method in this object type. If there are any **NOT INSTANTIABLE** methods in the object type, then the object type definition itself, must specify **NOT INSTANTIABLE** and **NOT FINAL** following the closing parenthesis of the object type specification. The default is **INSTANTIABLE**.

**subprogram_spec** denotes the specification of a procedure or function and begins with the specification of either **MEMBER** or **STATIC**. A member subprogram must be invoked with respect to a particular object instance while a static subprogram is not invoked with respect to any object instance.
**proc_name** is an identifier of a procedure. If the **SELF** parameter is specified, **name** is the object type name given in the **CREATE TYPE** command. If specified, **parm1, parm2, …** are the formal parameters of the procedure. **datatype1, datatype2, …** are the data types of **parm1, parm2, …** respectively. **IN, IN OUT, and OUT** are the possible parameter modes for each formal parameter. If none are specified, the default is **IN**. **value1, value2, …** are default values that may be specified for **IN** parameters.

Include the **CONSTRUCTOR** keyword and function definition to define a constructor function.

**func_name** is an identifier of a function. If the **SELF** parameter is specified, **name** is the object type name given in the **CREATE TYPE** command. If specified, **parm1, parm2, …** are the formal parameters of the function. **datatype1, datatype2, …** are the data types of **parm1, parm2, …** respectively. **IN, IN OUT, and OUT** are the possible parameter modes for each formal parameter. If none are specified, the default is **IN**. **value1, value2, …** are default values that may be specified for **IN** parameters. **return_type** is the data type of the value the function returns.

The following points should be noted about an object type specification:

- There must be at least one attribute defined in the object type.
- There may be none, one, or more methods defined in the object type.
- For each member method there is an implicit, built-in parameter named **SELF**, whose data type is that of the object type being defined.

**SELF** refers to the object instance that is currently invoking the method. **SELF** can be explicitly declared as an **IN** or **IN OUT** parameter in the parameter list (for example as **MEMBER FUNCTION (SELF IN OUT object_type ...)**).

If **SELF** is explicitly declared, **SELF** must be the first parameter in the parameter list. If **SELF** is not explicitly declared, its parameter mode defaults to **IN OUT** for member procedures and **IN** for member functions.

- A static method cannot be overridden (**OVERRIDING** and **STATIC** cannot be specified together in **method_spec**).

- A static method must be instantiable (**NOT INSTANTIABLE** and **STATIC** cannot be specified together in **method_spec**).
6.2.2 Object Type Body Syntax

The following is the syntax of the object type body:

```
CREATE [ OR REPLACE ] TYPE BODY name
  { IS | AS }
method_spec [...]  
[constructor] [...] 
END;
```

where `method_spec` is the following:

```
subprogram_spec
```

and `subprogram_spec` is the following:

```
{ MEMBER | STATIC }
{ PROCEDURE proc_name
  [ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
    [ DEFAULT value1 ] ]
    [, parm2 [ IN | IN OUT | OUT ] datatype2
    [ DEFAULT value2 ]
  ] ...)
  [ IS | AS ]
  [ declarations ]
  BEGIN
    statement; ...
  [ EXCEPTION
    WHEN ... THEN
    statement; ...]
  END;
  ]
| FUNCTION func_name
  [ ( [ SELF [ IN | IN OUT ] name ]
    [, parm1 [ IN | IN OUT | OUT ] datatype1
    [ DEFAULT value1 ] ]
    [, parm2 [ IN | IN OUT | OUT ] datatype2
    [ DEFAULT value2 ]
  ] ...)
  ]
  RETURN return_type
  { IS | AS }
  [ declarations ]
  BEGIN
    statement; ...
  [ EXCEPTION
    WHEN ... THEN
    statement; ...]
```
where constructor is:

CONSTRUCTOR func_name
    [ ( [ SELF [ IN | IN OUT ] name ]
        [ , parm1 [ IN | IN OUT | OUT ] datatype1
            [ DEFAULT value1 ] ]
        [ , parm2 [ IN | IN OUT | OUT ] datatype2
            [ DEFAULT value2 ]
        ) ...)
    ]
RETURN self AS RESULT
{ IS | AS }
[ declarations ]
BEGIN
    statement; ...
[ EXCEPTION
    WHEN ... THEN
        statement; ...
    END;

name is an identifier (optionally schema-qualified) assigned to the object type.

method_spec denotes the implementation of an instantiable method that was specified in the CREATE TYPE command.

If INSTANTIABLE was specified or omitted in method_spec of the CREATE TYPE command, then there must be a method_spec for this method in the CREATE TYPE BODY command.

If NOT INSTANTIABLE was specified in method_spec of the CREATE TYPE command, then there must be no method_spec for this method in the CREATE TYPE BODY command.

subprogram_spec denotes the specification of a procedure or function and begins with the specification of either MEMBER or STATIC. The same qualifier must be used as was specified in subprogram_spec of the CREATE TYPE command.

proc_name is an identifier of a procedure specified in the CREATE TYPE command. The parameter declarations have the same meaning as described for the CREATE TYPE command, and must be specified in the CREATE TYPE BODY command in the same manner as specified in the CREATE TYPE command.

Include the CONSTRUCTOR keyword and function definition to define a constructor function.
func_name is an identifier of a function specified in the CREATE TYPE command. The parameter declarations have the same meaning as described for the CREATE TYPE command, and must be specified in the CREATE TYPE BODY command in the same manner as specified in the CREATE TYPE command. return_type is the data type of the value the function returns and must match return_type given in the CREATE TYPE command.

declarations are variable, cursor, type, or subprogram declarations. If subprogram declarations are included, they must be declared after all other variable, cursor, and type declarations.

statement is an SPL program statement.
6.3 Creating Object Types

You can use the `CREATE TYPE` command to create an object type specification, and the `CREATE TYPE BODY` command to create an object type body. This section provides some examples using the `CREATE TYPE` and `CREATE TYPE BODY` commands.

The first example creates the `addr_object_type` object type that contains only attributes and no methods:

```sql
CREATE OR REPLACE TYPE addr_object_type AS OBJECT
(
    street VARCHAR2(30),
    city VARCHAR2(20),
    state CHAR(2),
    zip NUMBER(5)
);
```

Since there are no methods in this object type, an object type body is not required. This example creates a composite type, which allows you to treat related objects as a single attribute.

6.3.1 Member Methods

A member method is a function or procedure that is defined within an object type and can only be invoked through an instance of that type. Member methods have access to, and can change the attributes of, the object instance on which they are operating.

The following object type specification creates the `emp_obj_typ` object type:

```sql
CREATE OR REPLACE TYPE emp_obj_typ AS OBJECT
(
    empno NUMBER(4),
    ename VARCHAR2(20),
    addr ADDR_OBJ_TYP,
    MEMBER PROCEDURE display_emp(SELF IN OUT emp_obj_typ)
);
```

Object type `emp_obj_typ` contains a member method named `display_emp`. `display_emp` uses a `SELF` parameter, which passes the object instance on which the method is invoked.

A `SELF` parameter is a parameter whose data type is that of the object type being defined. `SELF` always refers to the instance that is invoking the method. A `SELF` parameter is the first parameter in a member procedure or function regardless of whether it is explicitly declared in the parameter list.
The following code snippet defines an object type body for `emp_obj_typ`:

```sql
CREATE OR REPLACE TYPE BODY emp_obj_typ AS
    MEMBER PROCEDURE display_emp (SELF IN OUT emp_obj_typ)
    IS
    BEGIN
        DBMS_OUTPUT.PUT_LINE('Employee No : ' || empno);
        DBMS_OUTPUT.PUT_LINE('Name : ' || ename);
        DBMS_OUTPUT.PUT_LINE('Street : ' || addr.street);
        DBMS_OUTPUT.PUT_LINE('City/State/Zip: ' || addr.city || ', ' || addr.state || ' ' || LPAD(addr.zip,5,'0'));
    END;
END;
```

You can also use the `SELF` parameter in an object type body. To illustrate how the `SELF` parameter would be used in the `CREATE TYPE BODY` command, the preceding object type body could be written as follows:

```sql
CREATE OR REPLACE TYPE BODY emp_obj_typ AS
    MEMBER PROCEDURE display_emp (SELF IN OUT emp_obj_typ)
    IS
    BEGIN
        DBMS_OUTPUT.PUT_LINE('Employee No : ' || SELF.empno);
        DBMS_OUTPUT.PUT_LINE('Name : ' || SELF.ename);
        DBMS_OUTPUT.PUT_LINE('Street : ' || SELF.addr.street);
        DBMS_OUTPUT.PUT_LINE('City/State/Zip: ' || SELF.addr.city || ', ' || SELF.addr.state || ' ' || LPAD(SELF.addr.zip,5,'0'));
    END;
END;
```

Both versions of the `emp_obj_typ` body are completely equivalent.

### 6.3.2 Static Methods

Like a member method, a static method belongs to a type. A static method, however, is invoked not by an `instance` of the type, but by using the `name` of the type. For example, to invoke a static function named `get_count`, defined within the `emp_obj_type` type, you would write:

```sql
emp_obj_type.get_count();
```

A static method does not have access to, and cannot change the attributes of an object instance, and does not typically work with an instance of the type.

The following object type specification includes a static function `get_dname` and a member procedure `display_dept`:

```sql
CREATE OR REPLACE TYPE dept_obj_typ AS OBJECT {
    deptno          NUMBER(2),
    STATIC FUNCTION get_dname(p_deptno IN NUMBER) RETURN VARCHAR2,
    MEMBER PROCEDURE display_dept
};
```
The object type body for `dept_obj_typ` defines a static function named `get_dname` and a member procedure named `display_dept`:

```sql
CREATE OR REPLACE TYPE BODY dept_obj_typ AS
  STATIC FUNCTION get_dname(p_deptno IN NUMBER) RETURN VARCHAR2 IS
    v_dname VARCHAR2(14);
    BEGIN
      CASE p_deptno
        WHEN 10 THEN v_dname := 'ACCOUNTING';
        WHEN 20 THEN v_dname := 'RESEARCH';
        WHEN 30 THEN v_dname := 'SALES';
        WHEN 40 THEN v_dname := 'OPERATIONS';
        ELSE v_dname := 'UNKNOWN';
      END CASE;
      RETURN v_dname;
    END;

  MEMBER PROCEDURE display_dept IS
    BEGIN
      DBMS_OUTPUT.PUT_LINE('Dept No    : ' || SELF.deptno);
      DBMS_OUTPUT.PUT_LINE('Dept Name  : ' ||
        dept_obj_typ.get_dname(SELF.deptno));
    END;
END;
```

Within the static function `get_dname`, there can be no references to `SELF`. Since a static function is invoked independently of any object instance, it has no implicit access to any object attribute.

Member procedure `display_dept` can access the `deptno` attribute of the object instance passed in the `SELF` parameter. It is not necessary to explicitly declare the `SELF` parameter in the `display_dept` parameter list.

The last `DBMS_OUTPUT.PUT_LINE` statement in the `display_dept` procedure includes a call to the static function `get_dname` (qualified by its object type name `dept_obj_typ`).

### 6.3.3 Constructor Methods

A constructor method is a function that creates an instance of an object type, typically by assigning values to the members of the object. An object type may define several constructors to accomplish different tasks. A constructor method is a member function (invoked with a `SELF` parameter) whose name matches the name of the type.

For example, if you define a type named `address`, each constructor is named `address`. You may overload a constructor by creating one or more different constructor functions with the same name, but with different argument types.
The SPL compiler will provide a default constructor for each object type. The default constructor is a member function whose name matches the name of the type and whose argument list matches the type members (in order). For example, given an object type such as:

```
CREATE TYPE address AS OBJECT
(
  street_address VARCHAR2(40),
  postal_code    VARCHAR2(10),
  city           VARCHAR2(40),
  state          VARCHAR2(2)
)
```

The SPL compiler will provide a default constructor with the following signature:

```
CONSTRUCTOR FUNCTION address
(
  street_address VARCHAR2(40),
  postal_code    VARCHAR2(10),
  city           VARCHAR2(40),
  state          VARCHAR2(2)
)
```

The body of the default constructor simply sets each member to `NULL`.

To create a custom constructor, declare the constructor function (using the keyword `constructor`) in the `CREATE TYPE` command and define the construction function in the `CREATE TYPE BODY` command. For example, you may wish to create a custom constructor for the `address` type which computes the city and state given a `street_address` and `postal_code`:

```
CREATE TYPE address AS OBJECT
(
  street_address VARCHAR2(40),
  postal_code    VARCHAR2(10),
  city           VARCHAR2(40),
  state          VARCHAR2(2),

CONSTRUCTOR FUNCTION address
(
  street_address VARCHAR2,
  postal_code VARCHAR2
) RETURN self AS RESULT
)
```

```
CREATE TYPE BODY address AS
CONSTRUCTOR FUNCTION address
(
  street_address VARCHAR2,
  postal_code VARCHAR2
) RETURN self AS RESULT
IS
BEGIN
  self.street_address := street_address;
  self.postal_code := postal_code;
  self.city := postal_code_to_city(postal_code);
  self.city := postal_code_to_city(postal_code);
```


To create an instance of an object type, you invoke one of the constructor methods for that type. For example:

```
DECLARE
  cust_addr address := address('100 Main Street', 02203);
BEGIN
  DBMS_OUTPUT.PUT_LINE(cust_addr.city); -- displays Boston
  DBMS_OUTPUT.PUT_LINE(cust_addr.state); -- displays MA
END;
```

Custom constructor functions are typically used to compute member values when given incomplete information. The preceding example computes the values for `city` and `state` when given a postal code.

Custom constructor functions are also used to enforce business rules that restrict the state of an object. For example, if you define an object type to represent a payment, you can use a custom constructor to ensure that no object of type `payment` can be created with an `amount` that is NULL, negative, or zero. The default constructor would set `payment.amount` to NULL so you must create a custom constructor (whose signature matches the default constructor) to prohibit NULL amounts.
6.4 Creating Object Instances

To create an instance of an object type, you must first declare a variable of the object type, and then initialize the declared object variable. The syntax for declaring an object variable is:

```
object obj_type
```

- `object` is an identifier assigned to the object variable.
- `obj_type` is the identifier of a previously defined object type.

After declaring the object variable, you must invoke a constructor method to initialize the object with values. Use the following syntax to invoke the constructor method:

```
[NEW] obj_type ({expr1 | NULL} [, {expr2 | NULL} ] [, ...])
```

- `obj_type` is the identifier of the object type’s constructor method; the constructor method has the same name as the previously declared object type.
- `expr1, expr2, ...` are expressions that are type-compatible with the first attribute of the object type, the second attribute of the object type, etc. If an attribute is of an object type, then the corresponding expression can be `NULL`, an object initialization expression, or any expression that returns that object type.

The following anonymous block declares and initializes a variable:

```sql
DECLARE
  v_emp           EMP_OBJ_TYP;
BEGIN
  v_emp := emp_obj_typ (9001,'JONES',
                         addr_obj_typ('123 MAIN STREET','EDISON','NJ',08817));
END;
```

The variable (`v_emp`) is declared with a previously defined object type named `EMP_OBJ_TYPE`. The body of the block initializes the variable using the `emp_obj_typ` and `addr_obj_type` constructors.

You can include the `NEW` keyword when creating a new instance of an object in the body of a block. The `NEW` keyword invokes the object constructor whose signature matches the arguments provided.

The following example declares two variables, named `mgr` and `emp`. The variables are both of `EMP_OBJ_TYPE`. The `mgr` object is initialized in the declaration, while the `emp` object is initialized to `NULL` in the declaration, and assigned a value in the body.

```sql
DECLARE
  mgr   EMP_OBJ_TYPE := (9002,'SMITH');
```
Note: In Advanced Server, the following alternate syntax can be used in place of the constructor method.

```
[ ROW ] ({ expr1 | NULL } [, { expr2 | NULL } ] [, ...])
```

ROW is an optional keyword if two or more terms are specified within the parenthesis-enclosed, comma-delimited list. If only one term is specified, then specification of the ROW keyword is mandatory.

### 6.5 Referencing an Object

Once an object variable is created and initialized, individual attributes can be referenced using dot notation of the form:

```
object.attribute
```

*object* is the identifier assigned to the object variable. *attribute* is the identifier of an object type attribute.

If *attribute*, itself, is of an object type, then the reference must take the form:

```
object.attribute.attribute_inner
```

*attribute_inner* is an identifier belonging to the object type to which *attribute* references in its definition of *object*.

The following example expands upon the previous anonymous block to display the values assigned to the emp_obj_typ object.

```sql
DECLARE
  v_emp  EMP_OBJ_TYP;
BEGIN
  v_emp := emp_obj_typ (9001, 'JONES',
     addr_obj_typ ('123 MAIN STREET', 'EDISON', 'NJ', 08817));
  DBMS_OUTPUT.PUT_LINE('Employee No: ' || v_emp.empno);
  DBMS_OUTPUT.PUT_LINE('Name: ' || v_emp.ename);
  DBMS_OUTPUT.PUT_LINE('Street: ' || v_emp.addr.street);
  DBMS_OUTPUT.PUT_LINE('City/State/Zip: ' || v_emp.addr.city || ', ' || v_emp.addr.state || ' ' || LPAD(v_emp.addr.zip, 5, '0'));
END;
```
Methods are called in a similar manner as attributes.

Once an object variable is created and initialized, member procedures or functions are called using dot notation of the form:

```
object.prog_name
```

*object* is the identifier assigned to the object variable. *prog_name* is the identifier of the procedure or function.

Static procedures or functions are not called utilizing an object variable. Instead the procedure or function is called utilizing the object type name:

```
object_type.prog_name
```

*object_type* is the identifier assigned to the object type. *prog_name* is the identifier of the procedure or function.

The results of the previous anonymous block can be duplicated by calling the member procedure *display_emp*:

```
DECLARE
  v_emp          EMP_OBJ_TYP;
BEGIN
  v_emp := emp_obj_typ(9001,'JONES',
                       addr_obj_typ('123 MAIN STREET','EDISON','NJ','08817'));
  v_emp.display_emp;
END;
```

The following is the output from this anonymous block.

```
Employee No : 9001
Name          : JONES
Street        : 123 MAIN STREET
City/State/Zip: EDISON, NJ 08817
```

The following anonymous block creates an instance of *dept_obj_typ* and calls the member procedure *display_dept*:

```
DECLARE
  v_dept          DEPT_OBJ_TYP := dept_obj_typ (20);
BEGIN
  v_dept.display_dept;
END;
```
The following is the output from this anonymous block.

<table>
<thead>
<tr>
<th>Dept No</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dept Name</td>
<td>RESEARCH</td>
</tr>
</tbody>
</table>

The static function defined in `dept_obj_typ` can be called directly by qualifying it by the object type name as follows:

```
BEGIN
    DBMS_OUTPUT.PUT_LINE(dept_obj_typ.get_dname(20));
END;
```

**6.6 Dropping an Object Type**

The syntax for deleting an object type is as follows.

```
DROP TYPE objtype;
```

`objtype` is the identifier of the object type to be dropped. If the definition of `objtype` contains attributes that are themselves object types or collection types, these nested object types or collection types must be dropped last.

If an object type body is defined for the object type, the `DROP TYPE` command deletes the object type body as well as the object type specification. In order to recreate the complete object type, both the `CREATE TYPE` and `CREATE TYPE BODY` commands must be reissued.

The following example drops the `emp_obj_typ` and the `addr_obj_typ` object types created earlier in this chapter. `emp_obj_typ` must be dropped first since it contains `addr_obj_typ` within its definition as an attribute.

```
DROP TYPE emp_obj_typ;
DROP TYPE addr_obj_typ;
```

The syntax for deleting an object type body, but not the object type specification is as follows.

```
DROP TYPE BODY objtype;
```

The object type body can be recreated by issuing the `CREATE TYPE BODY` command.

The following example drops only the object type body of the `dept_obj_typ`.

```
DROP TYPE BODY dept_obj_typ;
```
7 Open Client Library

The Open Client Library provides application interoperability with the Oracle Call Interface – an application that was formerly “locked in” can now work with either an EDB Postgres Advanced Server or an Oracle database with minimal to no changes to the application code. The EnterpriseDB implementation of the Open Client Library is written in C.

The following diagram compares the Open Client Library and Oracle Call Interface application stacks.

For detailed usage information about the Open Client Library and the supported functions, please see the EDB Postgres Advanced Server OCI Connector Guide, available at:

[https://www.enterprisedb.com/resources/product-documentation](https://www.enterprisedb.com/resources/product-documentation)

Please note: EnterpriseDB does not support use of the Open Client Library with Oracle Real Application Clusters (RAC) and Oracle Exadata; the aforementioned Oracle products have not been evaluated nor certified with this EnterpriseDB product.
8 Oracle Catalog Views

The Oracle Catalog Views provide information about database objects in a manner compatible with the Oracle data dictionary views. Information about the supported views is now available in the Database Compatibility for Oracle® Developer’s Reference Guide, available at:

https://www.enterprisedb.com/resources/product-documentation
9 Tools and Utilities

Compatible tools and utility programs can allow a developer to work with Advanced Server in a familiar environment. The tools supported by Advanced Server include:

- EDB*Plus
- EDB*Loader
- EDB*Wrap
- The Dynamic Runtime Instrumentation Tools Architecture (DRITA)

For detailed information about the functionality supported by Advanced Server, please consult the *Database Compatibility for Oracle® Developer’s Tools and Utilities Guide*, available at:

https://www.enterprisedb.com/resources/product-documentation
10 Table Partitioning

In a partitioned table, one logically large table is broken into smaller physical pieces. Partitioning can provide several benefits:

- Query performance can be improved dramatically in certain situations, particularly when most of the heavily accessed rows of the table are in a single partition or a small number of partitions. Partitioning allows you to omit the partition column from the front of an index, reducing index size and making it more likely that the heavily used parts of the index fits in memory.

- When a query or update accesses a large percentage of a single partition, performance may improve because the server will perform a sequential scan of the partition instead of using an index and random access reads scattered across the whole table.

- A bulk load (or unload) can be implemented by adding or removing partitions, if you plan that requirement into the partitioning design. `ALTER TABLE` is far faster than a bulk operation. It also entirely avoids the `VACUUM` overhead caused by a bulk `DELETE`.

- Seldom-used data can be migrated to less-expensive (or slower) storage media.

Table partitioning is worthwhile only when a table would otherwise be very large. The exact point at which a table will benefit from partitioning depends on the application; a good rule of thumb is that the size of the table should exceed the physical memory of the database server.

This document discusses the aspects of table partitioning compatible with Oracle databases that are supported by Advanced Server.

Note: This document and particularly the partitioning presented in this chapter do not describe the `declarative partitioning` feature, which has been introduced with PostgreSQL version 10. Note that PostgreSQL declarative partitioning is supported in Advanced Server 10 in addition to the table partitioning compatible with Oracle databases as described in this chapter. For information about declarative partitioning, please see the PostgreSQL core documentation available at:

https://www.postgresql.org/docs/10/static/ddl-partitioning.html

The PostgreSQL 9.6 `INSERT... ON CONFLICT DO NOTHING/UPDATE` clause (commonly known as UPSERT) is not supported on Oracle-styled partitioned tables. If you include the `ON CONFLICT DO NOTHING/UPDATE` clause when invoking the `INSERT` command to add data to a partitioned table, the server will return an error.
10.1 Selecting a Partition Type

When you create a partitioned table, you specify LIST, RANGE, or HASH partitioning rules. The partitioning rules provide a set of constraints that define the data that is stored in each partition. As new rows are added to the partitioned table, the server uses the partitioning rules to decide which partition should contain each row.

Advanced Server can also use the partitioning rules to enforce partition pruning, improving performance when responding to user queries. When selecting a partitioning type and partitioning keys for a table, you should take into consideration how the data that is stored within a table will be queried, and include often-queried columns in the partitioning rules.

List Partitioning

When you create a list-partitioned table, you specify a single partitioning key column. When adding a row to the table, the server compares the key values specified in the partitioning rule to the corresponding column within the row. If the column value matches a value in the partitioning rule, the row is stored in the partition named in the rule.

Range Partitioning

When you create a range-partitioned table, you specify one or more partitioning key columns. When you add a new row to the table, the server compares the value of the partitioning key (or keys) to the corresponding column (or columns) in a table entry. If the column values satisfy the conditions specified in the partitioning rule, the row is stored in the partition named in the rule.

Hash Partitioning

When you create a hash-partitioned table, you specify one or more partitioning key columns. Data is divided into (approx.) equal-sized partitions amongst the specified partitions. When you add a row to a hash-partitioned table, the server computes a hash value for the data in the specified column (or columns), and stores the row in a partition according to the hash value.

Subpartitioning

Subpartitioning breaks a partitioned table into smaller subsets. All subsets must be stored in the same database server cluster. A table is typically subpartitioned by a different set of columns, and may be a different subpartitioning type than the parent partition. If one partition is subpartitioned, then each partition will have at least one subpartition.

If a table is subpartitioned, no data will be stored in any of the partition tables; the data will be stored instead in the corresponding subpartitions.
10.2 Using Partition Pruning

Advanced Server's query planner uses partition pruning to compute an efficient plan to locate a row (or rows) that matches the conditions specified in the WHERE clause of a SELECT statement. To successfully prune partitions from an execution plan, the WHERE clause must constrain the information that is compared to the partitioning key column specified when creating the partitioned table. When querying a:

- list-partitioned table, partition pruning is effective when the WHERE clause compares a literal value to the partitioning key using operators like equal (=) or AND.

- range-partitioned table, partition pruning is effective when the WHERE clause compares a literal value to a partitioning key using operators such as equal (=), less than (<), or greater than (>).

- hash-partitioned table, partition pruning is effective when the WHERE clause compares a literal value to the partitioning key using an operator such as equal (=).

The partition pruning mechanism uses two optimization techniques:

- Fast Pruning
- Constraint exclusion

Partition pruning techniques limit the search for data to only those partitions in which the values for which you are searching might reside. Both pruning techniques remove partitions from a query's execution plan, increasing performance.

The difference between the fast pruning and constraint exclusion is that fast pruning understands the relationship between the partitions in an Oracle-partitioned table, while constraint exclusion does not. For example, when a query searches for a specific value within a list-partitioned table, fast pruning can reason that only a specific partition may hold that value, while constraint exclusion must examine the constraints defined for each partition. Fast pruning occurs early in the planning process to reduce the number of partitions that the planner must consider, while constraint exclusion occurs late in the planning process.

Using Constraint Exclusion

The constraint_exclusion parameter controls constraint exclusion. The constraint_exclusion parameter may have a value of on, off, or partition. To enable constraint exclusion, the parameter must be set to either partition or on. By default, the parameter is set to partition.
For more information about constraint exclusion, see:

[https://www.postgresql.org/docs/10/static/ddl-partitioning.html](https://www.postgresql.org/docs/10/static/ddl-partitioning.html)

When constraint exclusion is enabled, the server examines the constraints defined for each partition to determine if that partition can satisfy a query.

When you execute a `SELECT` statement that *does not* contain a `WHERE` clause, the query planner must recommend an execution plan that searches the entire table. When you execute a `SELECT` statement that *does* contain a `WHERE` clause, the query planner determines in which partition that row would be stored, and sends query fragments to that partition, pruning the partitions that could not contain that row from the execution plan.

If you are not using partitioned tables, disabling constraint exclusion may improve performance.

**Fast Pruning**

Like constraint exclusion, fast pruning can only optimize queries that include a `WHERE` (or join) clause, and only when the qualifiers in the `WHERE` clause match a certain form. In both cases, the query planner will avoid searching for data within partitions that cannot possibly hold the data required by the query.

Fast pruning is controlled by a boolean configuration parameter named `edb_enable_pruning`. If `edb_enable_pruning` is `ON`, Advanced Server will fast prune certain queries. If `edb_enable_pruning` is `OFF`, the server will disable fast pruning.

Please note: Fast pruning cannot optimize queries against subpartitioned tables or optimize queries against range-partitioned tables that are partitioned on more than one column.

For LIST-partitioned tables, Advanced Server can fast prune queries that contain a `WHERE` clause that constrains a partitioning column to a literal value. For example, given a LIST-partitioned table such as:

```sql
CREATE TABLE sales_hist(..., country text, ...) PARTITION BY LIST(country)

(  PARTITION americas VALUES('US', 'CA', 'MX'),
  PARTITION europe VALUES('BE', 'NL', 'FR'),
  PARTITION asia VALUES('JP', 'PK', 'CN'),
  PARTITION others VALUES(DEFAULT)
)
```

Fast pruning can reason about `WHERE` clauses such as:
WHERE country = 'US'

WHERE country IS NULL;

Given the first WHERE clause, fast pruning would eliminate partitions \texttt{europe}, \texttt{asia}, and \texttt{others} because those partitions cannot hold rows that satisfy the qualifier: \texttt{WHERE country = 'US'}.

Given the second WHERE clause, fast pruning would eliminate partitions \texttt{americas}, \texttt{europe}, and \texttt{asia} because those partitions cannot hold rows where \texttt{country IS NULL}.

The operator specified in the WHERE clause must be an equal sign (=) or the equality operator appropriate for the data type of the partitioning column.

For range-partitioned tables, Advanced Server can fast prune queries that contain a WHERE clause that constrains a partitioning column to a literal value, but the operator may be any of the following:

\[
> \\
>= \\
= \\
\leq \\
<
\]

Fast pruning will also reason about more complex expressions involving \texttt{AND} and \texttt{BETWEEN} operators, such as:

\[
\text{WHERE } size > 100 \text{ AND } size \leq 200 \\
\text{WHERE } size \text{ BETWEEN } 100 \text{ AND } 200
\]

But cannot prune based on expressions involving \texttt{OR} or \texttt{IN}.

For example, when querying a RANGE-partitioned table, such as:

\begin{verbatim}
CREATE TABLE boxes(id int, size int, color text)
    PARTITION BY RANGE(size)
    (
        PARTITION small VALUES LESS THAN(100),
        PARTITION medium VALUES LESS THAN(200),
        PARTITION large VALUES LESS THAN(300)
    )
\end{verbatim}

Fast pruning can reason about WHERE clauses such as:

\[
\text{WHERE } size > 100 \quad -- \text{scan partitions 'medium' and 'large'} \\
\text{WHERE } size \geq 100 \quad -- \text{scan partitions 'medium' and 'large'}
\]
WHERE size = 100     -- scan partition 'medium'
WHERE size <= 100   -- scan partitions 'small' and 'medium'
WHERE size < 100    -- scan partition 'small'
WHERE size > 100 AND size < 199 -- scan partition 'medium'
WHERE size BETWEEN 100 AND 199 -- scan partition 'medium'
WHERE color = 'red' AND size = 100  -- scan 'medium'
WHERE color = 'red' AND (size > 100 AND size < 199) -- scan 'medium'

In each case, fast pruning requires that the qualifier must refer to a partitioning column and literal value (or IS NULL/IS NOT NULL).

Note that fast pruning can also optimize DELETE and UPDATE statements containing WHERE clauses of the forms described above.
10.2.1 Example - Partition Pruning

The **EXPLAIN** statement displays the execution plan of a statement. You can use the **EXPLAIN** statement to confirm that Advanced Server is pruning partitions from the execution plan of a query.

To demonstrate the efficiency of partition pruning, first create a simple table:

```sql
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
    date date,
    amount number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

Then, perform a constrained query that includes the **EXPLAIN** statement:

```sql
EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE country = 'INDIA';
```

The resulting query plan shows that the server will scan only the `sales_asia` table - the table in which a row with a `country` value of `INDIA` would be stored:

```sql
edb=# EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE country = 'INDIA';
```

If you perform a query that searches for a row that matches a value not included in the partitioning key:

```sql
EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE dept_no = '30';
```

The resulting query plan shows that the server must look in all of the partitions to locate the rows that satisfy the query:

```sql
edb=# EXPLAIN (COSTS OFF) SELECT * FROM sales WHERE dept_no = '30';
```
Constraint exclusion also applies when querying subpartitioned tables:

```
CREATE TABLE sales
(
  dept_no number,
  part_no varchar2,
  country varchar2(20),
  date date,
  amount number
)
PARTITION BY RANGE(date) SUBPARTITION BY LIST (country)
(
  PARTITION "2011" VALUES LESS THAN ('01-JAN-2012')
  (SUBPARTITION europe_2011 VALUES ('ITALY', 'FRANCE'),
   SUBPARTITION asia_2011 VALUES ('PAKISTAN', 'INDIA'),
   SUBPARTITION americas_2011 VALUES ('US', 'CANADA')
  ),
  PARTITION "2012" VALUES LESS THAN ('01-JAN-2013')
  (SUBPARTITION europe_2012 VALUES ('ITALY', 'FRANCE'),
   SUBPARTITION asia_2012 VALUES ('PAKISTAN', 'INDIA'),
   SUBPARTITION americas_2012 VALUES ('US', 'CANADA')
  ),
  PARTITION "2013" VALUES LESS THAN ('01-JAN-2015')
  (SUBPARTITION europe_2013 VALUES ('ITALY', 'FRANCE'),
   SUBPARTITION asia_2013 VALUES ('PAKISTAN', 'INDIA'),
   SUBPARTITION americas_2013 VALUES ('US', 'CANADA')
  )
);
```

When you query the table, the query planner prunes any partitions or subpartitions from
the search path that cannot possibly contain the desired result set:
### 10.3 Partitioning Commands Compatible with Oracle Databases

The following sections provide information about using the table partitioning syntax compatible with Oracle databases supported by Advanced Server.

#### 10.3.1 CREATE TABLE...PARTITION BY

Use the `PARTITION BY` clause of the `CREATE TABLE` command to create a partitioned table with data distributed amongst one or more partitions (and subpartitions). The command syntax comes in the following forms:

**List Partitioning Syntax**

Use the first form to create a list-partitioned table:

```sql
CREATE TABLE [ schema. ]table_name
table_definition
PARTITION BY LIST(column)
[SUBPARTITION BY {RANGE|LIST|HASH} (column[, column ]...)]
(list_partition_definition[, list_partition_definition]...);
```

Where `list_partition_definition` is:

```sql
PARTITION [partition_name]
VALUES (value[, value]...)
[TABLESPACE tablespace_name]
[(subpartition, ...)]
```

**Range Partitioning Syntax**

Use the second form to create a range-partitioned table:

```sql
CREATE TABLE [ schema. ]table_name
table_definition
PARTITION BY RANGE(column[, column ]...)[
SUBPARTITION BY {RANGE|LIST|HASH} (column[, column ]...)]
(range_partition_definition[, range_partition_definition]...);
```

Where `range_partition_definition` is:

```sql
PARTITION [partition_name]
VALUES LESS THAN (value[, value]...)
[TABLESPACE tablespace_name]
[(subpartition, ...)]
```

**Hash Partitioning Syntax**

Use the third form to create a hash-partitioned table:

```sql
```
CREATE TABLE [ schema. ]table_name
table_definition
PARTITION BY HASH(column[, column ]...)
[SUBPARTITION BY {RANGE|LIST|HASH} (column[, column ]...)]
(hash_partition_definition[, hash_partition_definition]...);

Where hash_partition_definition is:

[PARTITION partition_name]
[TABLESPACE tablespace_name]
[(subpartition, ...)]

Subpartitioning Syntax

subpartition may be one of the following:

{list_subpartition | range_subpartition | hash_subpartition}

where list_subpartition is:

SUBPARTITION [subpartition_name]
VALUES (value[, value]...)
[TABLESPACE tablespace_name]

where range_subpartition is:

SUBPARTITION [subpartition_name]
VALUES LESS THAN (value[, value]...)
[TABLESPACE tablespace_name]

where hash_subpartition is:

[SUBPARTITION subpartition_name]
[TABLESPACE tablespace_name]

Description

The CREATE TABLE... PARTITION BY command creates a table with one or more partitions; each partition may have one or more subpartitions. There is no upper limit to the number of defined partitions, but if you include the PARTITION BY clause, you must specify at least one partitioning rule. The resulting table will be owned by the user that creates it.

Use the PARTITION BY LIST clause to divide a table into partitions based on the values entered in a specified column. Each partitioning rule must specify at least one literal value, but there is no upper limit placed on the number of values you may specify. Include a rule that specifies a matching value of DEFAULT to direct any un-qualified rows
to the given partition; for more information about using the DEFAULT keyword, see Section 10.4.

Use the PARTITION BY RANGE clause to specify boundary rules by which to create partitions. Each partitioning rule must contain at least one column of a data type that has two operators (i.e., a greater-than or equal to operator, and a less-than operator). Range boundaries are evaluated against a LESS THAN clause and are non-inclusive; a date boundary of January 1, 2013 will include only those date values that fall on or before December 31, 2012.

Range partition rules must be specified in ascending order. INSERT commands that store rows with values that exceed the top boundary of a range-partitioned table will fail unless the partitioning rules include a boundary rule that specifies a value of MAXVALUE. If you do not include a MAXVALUE partitioning rule, any row that exceeds the maximum limit specified by the boundary rules will result in an error.

For more information about using the MAXVALUE keyword, see Section 10.4.

Use the PARTITION BY HASH clause to create a hash-partitioned table. In a HASH partitioned table, data is divided amongst equal-sized partitions based on the hash value of the column specified in the partitioning syntax. When specifying a HASH partition, choose a column (or combination of columns) that is as close to unique as possible to help ensure that data is evenly distributed amongst the partitions. When selecting a partitioning column (or combination of columns), select a column (or columns) that you frequently search for exact matches for best performance.

Use the TABLESPACE keyword to specify the name of a tablespace on which a partition or subpartition will reside; if you do not specify a tablespace, the partition or subpartition will reside in the default tablespace.

If a table definition includes the SUBPARTITION BY clause, each partition within that table will have at least one subpartition. Each subpartition may be explicitly defined or system-defined.

If the subpartition is system-defined, the server-generated subpartition will reside in the default tablespace, and the name of the subpartition will be assigned by the server. The server will create:

- A DEFAULT subpartition if the SUBPARTITION BY clause specifies LIST.
- A MAXVALUE subpartition if the SUBPARTITION BY clause specifies RANGE.

The server will generate a subpartition name that is a combination of the partition table name and a unique identifier. You can query the ALL_TAB_SUBPARTITIONS table to review a complete list of subpartition names.
Note: For Advanced Server 10, an index cannot be created on a partitioned table. For example on the partitioned table named sales, you will get the following error message:

```
edb=# CREATE INDEX ON sales (part_no);
ERROR: cannot create index on partitioned table "sales"
```

Parameters

`table_name`

The name (optionally schema-qualified) of the table to be created.

`table_definition`

The column names, data types, and constraint information as described in the PostgreSQL core documentation for the `CREATE TABLE` statement, available at:

https://www.postgresql.org/docs/10/static/sql-createtable.html

`partition_name`

The name of the partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`subpartition_name`

The name of the subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`column`

The name of a column on which the partitioning rules are based. Each row will be stored in a partition that corresponds to the value of the specified column(s).

`(value[, value]...)`

Use value to specify a quoted literal value (or comma-delimited list of literal values) by which table entries will be grouped into partitions. Each partitioning rule must specify at least one value, but there is no limit placed on the number of values specified within a rule. value may be NULL, DEFAULT (if specifying a LIST partition), or MAXVALUE (if specifying a RANGE partition).

When specifying rules for a list-partitioned table, include the DEFAULT keyword in the last partition rule to direct any un-matched rows to the given partition. If you do not include a rule that includes a value of DEFAULT, any INSERT statement that attempts to
add a row that does not match the specified rules of at least one partition will fail, and return an error.

When specifying rules for a list-partitioned table, include the `MAXVALUE` keyword in the last partition rule to direct any un-categorized rows to the given partition. If you do not include a `MAXVALUE` partition, any `INSERT` statement that attempts to add a row where the partitioning key is greater than the highest value specified will fail, and return an error.

tablespace_name

The name of the tablespace in which the partition or subpartition resides.

10.3.1.1 Example - PARTITION BY LIST

The following example creates a partitioned table (`sales`) using the `PARTITION BY LIST` clause. The `sales` table stores information in three partitions (`europe`, `asia`, and `americas`):

```sql
CREATE TABLE sales
(
  dept_no     number,
  part_no     varchar2,
  country     varchar2(20),
  date        date,
  amount      number
)
PARTITION BY LIST(country)
(
  PARTITION europe VALUES('FRANCE', 'ITALY'),
  PARTITION asia VALUES('INDIA', 'PAKISTAN'),
  PARTITION americas VALUES('US', 'CANADA')
);
```

The resulting table is partitioned by the value specified in the `country` column:

```
acctg=# SELECT partition_name, high_value from ALL_TAB_PARTITIONS;
<table>
<thead>
<tr>
<th>partition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>FOR VALUES IN ('FRANCE', 'ITALY')</td>
</tr>
<tr>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
</tbody>
</table>
(3 rows)
```

- Rows with a value of `US` or `CANADA` in the `country` column are stored in the `americas` partition.
- Rows with a value of `INDIA` or `PAKISTAN` in the `country` column are stored in the `asia` partition.

- Rows with a value of `FRANCE` or `ITALY` in the `country` column are stored in the `europe` partition.

The server would evaluate the following statement against the partitioning rules, and store the row in the `europe` partition:

```
INSERT INTO sales VALUES (10, '9519a', 'FRANCE', '18-Aug-2012', '650000');
```

### 10.3.1.2 Example - PARTITION BY RANGE

The following example creates a partitioned table (`sales`) using the `PARTITION BY RANGE` clause. The `sales` table stores information in four partitions (`q1_2012`, `q2_2012`, `q3_2012` and `q4_2012`):

```sql
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
) PARTITION BY RANGE(date)
(
    PARTITION q1_2012
        VALUES LESS THAN('2012-Apr-01'),
    PARTITION q2_2012
        VALUES LESS THAN('2012-Jul-01'),
    PARTITION q3_2012
        VALUES LESS THAN('2012-Oct-01'),
    PARTITION q4_2012
        VALUES LESS THAN('2013-Jan-01')
);
```

The resulting table is partitioned by the value specified in the `date` column:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name | high_value
----------------|-----------------------------------------------------------
Q1_2012         | FOR VALUES FROM (MINVALUE) TO ('01-APR-12 00:00:00')
Q2_2012         | FOR VALUES FROM ('01-APR-12 00:00:00') TO ('01-JUL-12 00:00:00')
Q3_2012         | FOR VALUES FROM ('01-JUL-12 00:00:00') TO ('01-OCT-12 00:00:00')
Q4_2012         | FOR VALUES FROM ('01-OCT-12 00:00:00') TO ('01-JAN-13 00:00:00')
(4 rows)
```
• Any row with a value in the `date` column before April 1, 2012 is stored in a partition named `q1_2012`.

• Any row with a value in the `date` column before July 1, 2012 is stored in a partition named `q2_2012`.

• Any row with a value in the `date` column before October 1, 2012 is stored in a partition named `q3_2012`.

• Any row with a value in the `date` column before January 1, 2013 is stored in a partition named `q4_2012`.

The server would evaluate the following statement against the partitioning rules and store the row in the `q3_2012` partition:

```sql
INSERT INTO sales VALUES (10, '9519a', 'FRANCE', '18-Aug-2012', '650000');
```

### 10.3.1.3 Example - PARTITION BY HASH

The following example creates a partitioned table (sales) using the `PARTITION BY HASH` clause. The `sales` table stores information in three partitions (p1, p2, and p3):

```sql
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
)
PARTITION BY HASH (part_no)
(
    PARTITION p1,
    PARTITION p2,
    PARTITION p3
);
```

The table is partitioned by the hash value of the value specified in the `part_no` column:

```sql
acctg=# SELECT partition_name, high_value from ALL_TAB_PARTITIONS;
partition_name | high_value
----------------+------------------------------------------
P1              | FOR VALUES WITH (modulus 3, remainder 0)
P2              | FOR VALUES WITH (modulus 3, remainder 1)
P3              | FOR VALUES WITH (modulus 3, remainder 2)
(3 rows)
```
The server will evaluate the hash value of the `part_no` column, and distribute the rows into approximately equal partitions.

### 10.3.1.4 Example - PARTITION BY RANGE, SUBPARTITION BY LIST

The following example creates a partitioned table (`sales`) that is first partitioned by the transaction date; the range partitions (`q1_2012`, `q2_2012`, `q3_2012` and `q4_2012`) are then list-subpartitioned using the value of the `country` column.

```sql
CREATE TABLE sales
(
  dept_no number,
  part_no varchar2,
  country varchar2(20),
  date date,
  amount number
)
PARTITION BY RANGE(date)
   SUBPARTITION BY LIST(country)
   (
     PARTITION q1_2012
       VALUES LESS THAN('2012-Apr-01')
         (SUBPARTITION q1_europe VALUES ('FRANCE', 'ITALY'),
          SUBPARTITION q1_asia VALUES ('INDIA', 'PAKISTAN'),
          SUBPARTITION q1_americas VALUES ('US', 'CANADA')),
     PARTITION q2_2012
       VALUES LESS THAN('2012-Jul-01')
         (SUBPARTITION q2_europe VALUES ('FRANCE', 'ITALY'),
          SUBPARTITION q2_asia VALUES ('INDIA', 'PAKISTAN'),
          SUBPARTITION q2_americas VALUES ('US', 'CANADA')),
     PARTITION q3_2012
       VALUES LESS THAN('2012-Oct-01')
         (SUBPARTITION q3_europe VALUES ('FRANCE', 'ITALY'),
          SUBPARTITION q3_asia VALUES ('INDIA', 'PAKISTAN'),
          SUBPARTITION q3_americas VALUES ('US', 'CANADA')),
     PARTITION q4_2012
       VALUES LESS THAN('2013-Jan-01')
         (SUBPARTITION q4_europe VALUES ('FRANCE', 'ITALY'),
          SUBPARTITION q4_asia VALUES ('INDIA', 'PAKISTAN'),
          SUBPARTITION q4_americas VALUES ('US', 'CANADA'))
   );
```
This statement creates a table with four partitions; each partition has three subpartitions:

```
acctg=# SELECT subpartition_name, high_value, partition_name FROM ALL_TAB_SUBPARTITIONS;
subpartition_name |             high_value              | partition_name
-------------------+-------------------------------------+----------------
Q1_AMERICAS       | FOR VALUES IN ('US', 'CANADA')      | Q1_2012
Q1_ASIA           | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q1_2012
Q1_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY')   | Q1_2012
Q2_AMERICAS       | FOR VALUES IN ('US', 'CANADA')      | Q2_2012
Q2_ASIA           | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q2_2012
Q2_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY')   | Q2_2012
Q3_AMERICAS       | FOR VALUES IN ('US', 'CANADA')      | Q3_2012
Q3_ASIA           | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q3_2012
Q3_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY')   | Q3_2012
Q4_AMERICAS       | FOR VALUES IN ('US', 'CANADA')      | Q4_2012
Q4_ASIA           | FOR VALUES IN ('INDIA', 'PAKISTAN') | Q4_2012
Q4_EUROPE         | FOR VALUES IN ('FRANCE', 'ITALY')   | Q4_2012
(12 rows)
```

When a row is added to this table, the value in the `date` column is compared to the values specified in the range partitioning rules, and the server selects the partition in which the row should reside. The value in the `country` column is then compared to the values specified in the list subpartitioning rules; when the server locates a match for the value, the row is stored in the corresponding subpartition.

Any row added to the table will be stored in a subpartition, so the partitions will contain no data.

The server would evaluate the following statement against the partitioning and subpartitioning rules and store the row in the `q3_europe` partition:

```
INSERT INTO sales VALUES (10, '9519a', 'FRANCE', '18-Aug-2012', '650000');
```
10.3.2 ALTER TABLE...ADD PARTITION

Use the ALTER TABLE...ADD PARTITION command to add a partition to an existing partitioned table. The syntax is:

ALTER TABLE table_name ADD PARTITION partition_definition;

Where partition_definition is:

{list_partition | range_partition }

and list_partition is:

PARTITION [partition_name]
VALUES (value[, value]...)
[TABLESPACE tablespace_name]
[(subpartition, ...)]

and range_partition is:

PARTITION [partition_name]
VALUES LESS THAN (value[, value]...)
[TABLESPACE tablespace_name]
[(subpartition, ...)]

Where subpartition is:

{list_subpartition | range_subpartition | hash_subpartition}

and list_subpartition is:

SUBPARTITION [subpartition_name]
VALUES (value[, value]...)
[TABLESPACE tablespace_name]

and range_subpartition is:

SUBPARTITION [subpartition_name]
VALUES LESS THAN (value[, value]...)
[TABLESPACE tablespace_name]

Description

The ALTER TABLE...ADD PARTITION command adds a partition to an existing partitioned table. There is no upper limit to the number of defined partitions in a partitioned table.
New partitions must be of the same type (LIST, RANGE or HASH) as existing partitions. The new partition rules must reference the same column specified in the partitioning rules that define the existing partition(s).

You cannot use the `ALTER TABLE...ADD PARTITION` statement to add a partition to a table with a MAXVALUE or DEFAULT rule. Note that you can alternatively use the `ALTER TABLE...SPLIT PARTITION` statement to split an existing partition, effectively increasing the number of partitions in a table.

RANGE partitions must be specified in ascending order. You cannot add a new partition that precedes existing partitions in a RANGE partitioned table.

Include the `TABLESPACE` clause to specify the tablespace in which the new partition will reside. If you do not specify a tablespace, the partition will reside in the default tablespace.

If the table is indexed, the index will be created on the new partition.

To use the `ALTER TABLE...ADD PARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

**Parameters**

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`partition_name`

The name of the partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`subpartition_name`

The name of the subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

(value[, value]...)

Use `value` to specify a quoted literal value (or comma-delimited list of literal values) by which rows will be distributed into partitions. Each partitioning rule must specify at least one `value`, but there is no limit placed on the number of
values specified within a rule. value may also be NULL, DEFAULT (if specifying a LIST partition), or MAXVALUE (if specifying a RANGE partition).

For information about creating a DEFAULT or MAXVALUE partition, see Section 10.4.

tablespace_name

The name of the tablespace in which a partition or subpartition resides.

10.3.2.1 Example - Adding a Partition to a LIST Partitioned Table

The example that follows adds a partition to the list-partitioned sales table. The table was created using the command:

```sql
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

The table contains three partitions (americas, asia, and europe):

<table>
<thead>
<tr>
<th>partition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>FOR VALUES IN ('FRANCE', 'ITALY')</td>
</tr>
<tr>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
</tbody>
</table>

The following command adds a partition named east_asia to the sales table:

```sql
ALTER TABLE sales ADD PARTITION east_asia VALUES ('CHINA', 'KOREA');
```

After invoking the command, the table includes the east_asia partition:

<table>
<thead>
<tr>
<th>partition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>FOR VALUES IN ('FRANCE', 'ITALY')</td>
</tr>
<tr>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>EAST_ASIA</td>
<td>FOR VALUES IN ('CHINA', 'KOREA')</td>
</tr>
</tbody>
</table>

(3 rows)
10.3.2.2 Example - Adding a Partition to a RANGE Partitioned Table

The example that follows adds a partition to a range-partitioned table named `sales`:

```sql
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
    date date,
    amount number
)
PARTITION BY RANGE(date)
(
    PARTITION q1_2012 VALUES LESS THAN('2012-Apr-01'),
    PARTITION q2_2012 VALUES LESS THAN('2012-Jul-01'),
    PARTITION q3_2012 VALUES LESS THAN('2012-Oct-01'),
    PARTITION q4_2012 VALUES LESS THAN('2013-Jan-01')
);
```

The table contains four partitions (`q1_2012`, `q2_2012`, `q3_2012`, and `q4_2012`):

```sql
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
+----------------+------------------------------------------------------------------+
| partition_name  | high_value                                                          |
|----------------+------------------------------------------------------------------|
| Q1_2012        | FOR VALUES FROM (MINVALUE) TO ('01-APR-12 00:00:00')               |
| Q2_2012        | FOR VALUES FROM ('01-APR-12 00:00:00') TO ('01-JUL-12 00:00:00') |
| Q3_2012        | FOR VALUES FROM ('01-JUL-12 00:00:00') TO ('01-OCT-12 00:00:00') |
| Q4_2012        | FOR VALUES FROM ('01-OCT-12 00:00:00') TO ('01-JAN-13 00:00:00') |
+----------------+------------------------------------------------------------------+
(4 rows)
```

The following command adds a partition named `q1_2013` to the `sales` table:

```sql
ALTER TABLE sales ADD PARTITION q1_2013 VALUES LESS THAN('01-APR-2013');
```

After invoking the command, the table includes the `q1_2013` partition:

```sql
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
+----------------+------------------------------------------------------------------+
| partition_name  | high_value                                                          |
|----------------+------------------------------------------------------------------|
| Q1_2012        | FOR VALUES FROM (MINVALUE) TO ('01-APR-12 00:00:00')               |
+----------------+------------------------------------------------------------------+
```

(4 rows)
| Q2_2012 | FOR VALUES FROM ('01-APR-12 00:00:00') TO ('01-JUL-12 00:00:00') |
| Q3_2012 | FOR VALUES FROM ('01-JUL-12 00:00:00') TO ('01-OCT-12 00:00:00') |
| Q4_2012 | FOR VALUES FROM ('01-OCT-12 00:00:00') TO ('01-JAN-13 00:00:00') |
| Q1_2013 | FOR VALUES FROM ('01-JAN-13 00:00:00') TO ('01-APR-13 00:00:00') |

(5 rows)
10.3.3 ALTER TABLE... ADD SUBPARTITION

The ALTER TABLE... ADD SUBPARTITION command adds a subpartition to an existing subpartitioned partition. The syntax is:

```
ALTER TABLE table_name MODIFY PARTITION partition_name
ADD SUBPARTITION subpartition_definition;
```

Where `subpartition_definition` is:

```{list_subpartition | range_subpartition}
```

and `list_subpartition` is:

```
SUBPARTITION [subpartition_name]
VALUES (value[, value]...)
[TABLESPACE tablespace_name]
```

and `range_subpartition` is:

```
SUBPARTITION [subpartition_name]
VALUES LESS THAN (value[, value]...)
[TABLESPACE tablespace_name]
```

Description

The ALTER TABLE... ADD SUBPARTITION command adds a subpartition to an existing partition; the partition must already be subpartitioned. There is no upper limit to the number of defined subpartitions.

New subpartitions must be of the same type (LIST, RANGE or HASH) as existing subpartitions. The new subpartition rules must reference the same column specified in the subpartitioning rules that define the existing subpartition(s).

You cannot use the ALTER TABLE... ADD SUBPARTITION statement to add a subpartition to a table with a MAXVALUE or DEFAULT rule, but you can split an existing subpartition with the ALTER TABLE... SPLIT SUBPARTITION statement, effectively adding a subpartition to a table.

You cannot add a new subpartition that precedes existing subpartitions in a range subpartitioned table; range subpartitions must be specified in ascending order.

Include the TABLESPACE clause to specify the tablespace in which the subpartition will reside. If you do not specify a tablespace, the subpartition will be created in the default tablespace.
If the table is indexed, the index will be created on the new subpartition.

To use the `ALTER TABLE ... ADD SUBPARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

**Parameters**

`table_name`

The name (optionally schema-qualified) of the partitioned table in which the subpartition will reside.

`partition_name`

The name of the partition in which the new subpartition will reside.

`subpartition_name`

The name of the subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`(value[, value]...)`

Use `value` to specify a quoted literal value (or comma-delimited list of literal values) by which table entries will be grouped into partitions. Each partitioning rule must specify at least one value, but there is no limit placed on the number of values specified within a rule. `value` may also be `NULL`, `DEFAULT` (if specifying a `LIST` partition), or `MAXVALUE` (if specifying a `RANGE` partition).

For information about creating a `DEFAULT` or `MAXVALUE` partition, see Section 10.4.

`tablespace_name`

The name of the tablespace in which the subpartition resides.

### 10.3.3.1 Example - Adding a Subpartition to a LIST-RANGE Partitioned Table

The following example adds a `RANGE` subpartition to the list-partitioned `sales` table. The `sales` table was created with the command:

```
CREATE TABLE sales
```
PARTITION BY LIST(country)
  SUBPARTITION BY RANGE(date)
  
  PARTITION europe VALUES('FRANCE', 'ITALY')
  
<table>
<thead>
<tr>
<th>partition_name</th>
<th>subpartition_name, high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>EUROPE_2011</td>
</tr>
<tr>
<td></td>
<td>VALUES LESS THAN ('2012-Jan-01')</td>
</tr>
<tr>
<td></td>
<td>EUROPE_2012</td>
</tr>
<tr>
<td></td>
<td>VALUES LESS THAN ('2013-Jan-01')</td>
</tr>
<tr>
<td>ASIA</td>
<td>ASIA_2011</td>
</tr>
<tr>
<td></td>
<td>VALUES LESS THAN ('2012-Jan-01')</td>
</tr>
<tr>
<td></td>
<td>ASIA_2012</td>
</tr>
<tr>
<td></td>
<td>VALUES LESS THAN ('2013-Jan-01')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_2011</td>
</tr>
<tr>
<td></td>
<td>VALUES LESS THAN ('2012-Jan-01')</td>
</tr>
<tr>
<td></td>
<td>AMERICAS_2012</td>
</tr>
<tr>
<td></td>
<td>VALUES LESS THAN ('2013-Jan-01')</td>
</tr>
</tbody>
</table>

The sales table has three partitions, named europe, asia, and americas. Each partition has two range-defined subpartitions:

acctg# SELECT partition_name, subpartition_name, high_value FROM
  ALL_TAB_SUBPARTITIONS;

<table>
<thead>
<tr>
<th>partition_name</th>
<th>subpartition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>EUROPE_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>ASIA</td>
<td>ASIA_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
</tbody>
</table>

The following command adds a subpartition named europe_2013:
ALTER TABLE sales MODIFY PARTITION europe
ADD SUBPARTITION europe_2013 VALUES LESS THAN ('2015-Jan-01');

After invoking the command, the table includes a subpartition named europe_2013:

```sql
acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;
partition_name | subpartition_name |                            high_value
-----------------+-------------------+--------------------------------------------------
   EUROPE        |   EUROPE_2011     | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')
   EUROPE        |   EUROPE_2012     | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')
   EUROPE        |   EUROPE_2013     | FOR VALUES FROM ('01-JAN-13 00:00:00') TO ('01-JAN-15 00:00:00')
    ASIA         |    ASIA_2011      | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')
    ASIA         |    ASIA_2012      | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')
  AMERICAS      |  AMERICAS_2011    | FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')
  AMERICAS      |  AMERICAS_2012    | FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')
```

(7 rows)

Note that when adding a new range subpartition, the subpartitioning rules must specify a range that falls after any existing subpartitions.

10.3.3.2 Example - Adding a Subpartition to a RANGE-LIST Partitioned Table

The following example adds a LIST subpartition to the RANGE partitioned sales table. The sales table was created with the command:

```sql
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
)
PARTITION BY RANGE(date)
SUBPARTITION BY LIST (country)
(
    PARTITION first_half_2012 VALUES LESS THAN ('01-JUL-2012')
    (
        SUBPARTITION europe VALUES ('ITALY', 'FRANCE'),
        SUBPARTITION americas VALUES ('US', 'CANADA')
    ),
    PARTITION second_half_2012 VALUES LESS THAN ('01-JAN-2013')
    (
        SUBPARTITION asia VALUES ('INDIA', 'PAKISTAN')
    )
);```
After executing the above command, the sales table will have two partitions, named `first_half_2012` and `second_half_2012`. The `first_half_2012` partition has two subpartitions, named `europe` and `americas`, and the `second_half_2012` partition has one partition, named `asia`:

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;

<table>
<thead>
<tr>
<th>partition_name</th>
<th>subpartition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST_HALF_2012</td>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>FIRST_HALF_2012</td>
<td>EUROPE</td>
<td>FOR VALUES IN ('ITALY', 'FRANCE')</td>
</tr>
<tr>
<td>SECOND_HALF_2012</td>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
</tbody>
</table>
```

The following command adds a subpartition to the `second_half_2012` partition, named `east_asia`:

```
ALTER TABLE sales MODIFY PARTITION second_half_2012 ADD SUBPARTITION east_asia VALUES ('CHINA');
```

After invoking the command, the table includes a subpartition named `east_asia`:

```
acctg=# SELECT partition_name, subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;

<table>
<thead>
<tr>
<th>partition_name</th>
<th>subpartition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST_HALF_2012</td>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>FIRST_HALF_2012</td>
<td>EUROPE</td>
<td>FOR VALUES IN ('ITALY', 'FRANCE')</td>
</tr>
<tr>
<td>SECOND_HALF_2012</td>
<td>EAST ASIA</td>
<td>FOR VALUES IN ('CHINA')</td>
</tr>
<tr>
<td>SECOND_HALF_2012</td>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
</tbody>
</table>
```

(3 rows)
10.3.4 ALTER TABLE...SPLIT PARTITION

Use the ALTER TABLE...SPLIT PARTITION command to divide a single partition into two partitions, and redistribute the partition's contents between the new partitions. The command syntax comes in two forms.

The first form splits a RANGE partition into two partitions:

```
ALTER TABLE table_name SPLIT PARTITION partition_name
  AT (range_part_value)
  INTO
  (
    PARTITION new_part1
    [TABLESPACE tablespace_name],
    PARTITION new_part2
    [TABLESPACE tablespace_name]
  );
```

The second form splits a LIST partition into two partitions:

```
ALTER TABLE table_name SPLIT PARTITION partition_name
  VALUES (value[, value]...)
  INTO
  (
    PARTITION new_part1
    [TABLESPACE tablespace_name],
    PARTITION new_part2
    [TABLESPACE tablespace_name]
  );
```

**Description**

The ALTER TABLE...SPLIT PARTITION command adds a partition to an existing LIST or RANGE partitioned table. Please note that the ALTER TABLE...SPLIT PARTITION command cannot add a partition to a HASH partitioned table. There is no upper limit to the number of partitions that a table may have.

When you execute an ALTER TABLE...SPLIT PARTITION command, Advanced Server creates two new partitions, and redistributes the content of the old partition between them (as constrained by the partitioning rules).

Include the TABLESPACE clause to specify the tablespace in which a partition will reside. If you do not specify a tablespace, the partition will reside in the default tablespace.

If the table is indexed, the index will be created on the new partition.
To use the `ALTER TABLE... SPLIT PARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

**Parameters**

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`partition_name`

The name of the partition that is being split.

`new_part1`

The name of the first new partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`new_part1` will receive the rows that meet the partitioning constraints specified in the `ALTER TABLE... SPLIT PARTITION` command.

`new_part2`

The name of the second new partition to be created. Partition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`new_part2` will receive the rows are not directed to `new_part1` by the partitioning constraints specified in the `ALTER TABLE... SPLIT PARTITION` command.

`range_part_value`

Use `range_part_value` to specify the boundary rules by which to create the new partition. The partitioning rule must contain at least one column of a data type that has two operators (i.e., a greater-than-or-equal to operator, and a less-than operator). Range boundaries are evaluated against a `LESS THAN` clause and are non-inclusive; a date boundary of January 1, 2010 will include only those date values that fall on or before December 31, 2009.

`(value[, value]...)

Use `value` to specify a quoted literal value (or comma-delimited list of literal values) by which rows will be distributed into partitions. Each partitioning rule
must specify at least one value, but there is no limit placed on the number of values specified within a rule.

For information about creating a `DEFAULT` or `MAXVALUE` partition, see Section 10.4.

tablespace_name

The name of the tablespace in which the partition or subpartition resides.

10.3.4.1 Example - Splitting a LIST Partition

Our example will divide one of the partitions in the list-partitioned `sales` table into two new partitions, and redistribute the contents of the partition between them. The `sales` table is created with the statement:

```sql
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
    date date,
    amount number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

The table definition creates three partitions (europe, asia, and americas). The following command adds rows to each partition:

```sql
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
```
The rows are distributed amongst the partitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>21-SEP-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
</tbody>
</table>

(17 rows)

The following command splits the americas partition into two partitions named us and canada:

```
ALTER TABLE sales SPLIT PARTITION americas
VALUES ('US')
INTO (PARTITION us, PARTITION canada);
```

A SELECT statement confirms that the rows have been redistributed across the correct partitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_us</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_us</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
</tbody>
</table>

(17 rows)
10.3.4.2 Example - Splitting a RANGE Partition

This example divides the q4_2012 partition (of the range-partitioned sales table) into two partitions, and redistribute the partition's contents. Use the following command to create the sales table:

```sql
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
    date date,
    amount number
)
PARTITION BY RANGE (date)
(
    PARTITION q1_2012
        VALUES LESS THAN ('2012-Apr-01'),
    PARTITION q2_2012
        VALUES LESS THAN ('2012-Jul-01'),
    PARTITION q3_2012
        VALUES LESS THAN ('2012-Oct-01'),
    PARTITION q4_2012
        VALUES LESS THAN ('2013-Jan-01')
);
```

The table definition creates four partitions (q1_2012, q2_2012, q3_2012, and q4_2012). The following command adds rows to each partition:

```sql
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');
```
A SELECT statement confirms that the rows are distributed amongst the partitions as expected:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_q1_2012</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_q1_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_q1_2012</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>21-SEP-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>12-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>18-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>(17 rows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The following command splits the `q4_2012` partition into two partitions named `q4_2012_p1` and `q4_2012_p2`:

```
ALTER TABLE sales SPLIT PARTITION q4_2012
    AT ('15-Nov-2012')
    INTO
    (PARTITION q4_2012_p1,
    PARTITION q4_2012_p2);
```

A SELECT statement confirms that the rows have been redistributed across the new partitions:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_q1_2012</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_q1_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_q1_2012</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>21-SEP-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>12-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>18-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>(17 rows)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sales_q4_2012_p2</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_q4_2012_p2</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
</tbody>
</table>

(17 rows)
10.3.5 ALTER TABLE...SPLIT SUBPARTITION

Use the ALTER TABLE...SPLIT SUBPARTITION command to divide a single subpartition into two subpartitions, and redistribute the subpartition's contents. The command comes in two variations.

The first variation splits a range subpartition into two subpartitions:

```
ALTER TABLE table_name SPLIT SUBPARTITION subpartition_name
AT (range_part_value)
INTO
  (  
    SUBPARTITION new_subpart1
      [TABLESPACE tablespace_name],
    SUBPARTITION new_subpart2
      [TABLESPACE tablespace_name]
  ) ;
```

The second variation splits a list subpartition into two subpartitions:

```
ALTER TABLE table_name SPLIT SUBPARTITION subpartition_name
VALUES (value[, value]...)
INTO
  (  
    SUBPARTITION new_subpart1
      [TABLESPACE tablespace_name],
    SUBPARTITION new_subpart2
      [TABLESPACE tablespace_name]
  ) ;
```

Description

The ALTER TABLE...SPLIT SUBPARTITION command adds a subpartition to an existing subpartitioned table. There is no upper limit to the number of defined subpartitions. When you execute an ALTER TABLE...SPLIT SUBPARTITION command, Advanced Server creates two new subpartitions, moving any rows that contain values that are constrained by the specified subpartition rules into new_subpart1, and any remaining rows into new_subpart2.

The new subpartition rules must reference the column specified in the rules that define the existing subpartition(s).
Include the `TABLESPACE` clause to specify a tablespace in which a new subpartition will reside. If you do not specify a tablespace, the subpartition will be created in the default tablespace.

If the table is indexed, the index will be created on the new subpartition.

To use the `ALTER TABLE ... SPLIT SUBPARTITION` command you must be the table owner, or have superuser (or administrative) privileges.

**Parameters**

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`subpartition_name`

The name of the subpartition that is being split.

`new_subpart1`

The name of the first new subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`new_subpart1` will receive the rows that meet the subpartitioning constraints specified in the `ALTER TABLE... SPLIT SUBPARTITION` command.

`new_subpart2`

The name of the second new subpartition to be created. Subpartition names must be unique amongst all partitions and subpartitions, and must follow the naming conventions for object identifiers.

`new_subpart2` will receive the rows are not directed to `new_subpart1` by the subpartitioning constraints specified in the `ALTER TABLE... SPLIT SUBPARTITION` command.

`(value[, value]...)`

Use `value` to specify a quoted literal value (or comma-delimited list of literal values) by which table entries will be grouped into partitions. Each partitioning rule must specify at least one value, but there is no limit placed on the number of values specified within a rule. `value` may also be `NULL`, `DEFAULT` (if specifying a `LIST` subpartition), or `MAXVALUE` (if specifying a `RANGE` subpartition).
For information about creating a DEFAULT or MAXVALUE partition, see Section 10.4.

\textit{tablespace_name}

The name of the tablespace in which the partition or subpartition resides.

\subsection*{10.3.5.1 Example - Splitting a LIST Subpartition}

The following example splits a list subpartition, redistributing the subpartition's contents between two new subpartitions. The sample table (\textit{sales}) was created with the command:

\begin{verbatim}
CREATE TABLE sales
(
  dept_no       number,
  part_no       varchar2,
  country       varchar2(20),
  date          date,
  amount        number
)
PARTITION BY RANGE(date)
SUBPARTITION BY LIST (country)
  (PARTITION first_half_2012 VALUES LESS THAN('01-JUL-2012')
   (SUBPARTITION p1_europe VALUES ('ITALY', 'FRANCE'),
    SUBPARTITION p1_americas VALUES ('US', 'CANADA')),
  PARTITION second_half_2012 VALUES LESS THAN('01-JAN-2013')
   (SUBPARTITION p2_europe VALUES ('ITALY', 'FRANCE'),
    SUBPARTITION p2_americas VALUES ('US', 'CANADA'))
);
\end{verbatim}

The \textit{sales} table has two partitions, named \textit{first_half_2012}, and \textit{second_half_2012}. Each partition has two range-defined subpartitions that distribute the partition's contents into subpartitions based on the value of the \textit{country} column:

\begin{verbatim}
acctg=# SELECT partition_name, subpartition_name, high_value FROM
  ALL_TAB_SUBPARTITIONS;
  partition_name | subpartition_name | high_value
----------------|------------------|-------------------
  FIRST_HALF_2012 | P1_AMERICAS      | FOR VALUES IN ('US', 'CANADA')
  FIRST_HALF_2012 | P1_EUROPE        | FOR VALUES IN ('ITALY', 'FRANCE')
  SECOND_HALF_2012| P2_AMERICAS      | FOR VALUES IN ('US', 'CANADA')
  SECOND_HALF_2012| P2_EUROPE        | FOR VALUES IN ('ITALY', 'FRANCE')
(4 rows)
\end{verbatim}

The following command adds rows to each subpartition:
A `SELECT` statement confirms that the rows are correctly distributed amongst the subpartitions:

```
SELECT tableoid::regclass, * FROM sales;
```

The following command splits the `p2_americas` subpartition into two new subpartitions, and redistributes the contents:

```
ALTER TABLE sales SPLIT SUBPARTITION p2_americas VALUES ('US') INTO
(
    SUBPARTITION p2_us,
    SUBPARTITION p2_canada
);
```

After invoking the command, the `p2_americas` subpartition has been deleted; in its place, the server has created two new subpartitions (`p2_us` and `p2_canada`):

```
SELECT partition_name, subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;
```
Querying the sales table demonstrates that the content of the p2_americas subpartition has been redistributed:

```
acctg=# SELECT tableoid::regclass, * FROM sales;

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_p1_americas</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_p1_americas</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_p1_americas</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_p1_americas</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_p1_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_p2_canada</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_p2_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_p2_europe</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_p2_europe</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_p2_us</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_p2_us</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_p2_us</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
</tbody>
</table>
```

### 10.3.5.2 Example - Splitting a RANGE Subpartition

The following example splits a range subpartition, redistributing the subpartition's contents between two new subpartitions. The sample table (sales) was created with the command:

```sql
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
) PARTITION BY LIST(country)
    SUBPARTITION BY RANGE(date)
    (PARTITION europe VALUES('FRANCE', 'ITALY')
        (SUBPARTITION europe_2011
            VALUES LESS THAN('2012-Jan-01'),
            SUBPARTITION europe_2012
            VALUES LESS THAN('2013-Jan-01'))),
    PARTITION asia VALUES('INDIA', 'PAKISTAN')
        (SUBPARTITION asia_2011
            VALUES LESS THAN('2012-Jan-01')),..
SUBPARTITION asia_2012
   VALUES LESS THAN ('2013-Jan-01')
),
PARTITION americas VALUES ('US', 'CANADA')
{
   SUBPARTITION americas_2011
      VALUES LESS THAN ('2012-Jan-01'),
   SUBPARTITION americas_2012
      VALUES LESS THAN ('2013-Jan-01')
}
);

The sales table has three partitions (europe, asia, and americas). Each partition has two range-defined subpartitions that sort the partitions contents into subpartitions by the value of the date column:

acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;

<table>
<thead>
<tr>
<th>partition_name</th>
<th>subpartition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>EUROPE_2012</td>
<td>FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')</td>
</tr>
<tr>
<td>EUROPE</td>
<td>EUROPE_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>ASIA</td>
<td>ASIA_2012</td>
<td>FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')</td>
</tr>
<tr>
<td>ASIA</td>
<td>ASIA_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_2012</td>
<td>FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
</tbody>
</table>

(6 rows)

The following command adds rows to each subpartition:

INSERT INTO sales VALUES
  (10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
  (20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
  (40, '9519b', 'US', '12-Apr-2012', '145000'),
  (20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
  (40, '4577b', 'US', '11-Nov-2012', '25000'),
  (30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
  (30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
  (30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
  (40, '3788a', 'US', '12-May-2012', '4950'),
  (10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
  (10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
  (10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
  (20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
  (40, '4788a', 'US', '23-Sept-2012', '4950'),
  (40, '4788b', 'US', '09-Oct-2012', '15000'),
  (20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
  (20, '4519b', 'INDIA', '2-Dec-2012', '5090');
A `SELECT` statement confirms that the rows are distributed amongst the subpartitions:

```sql
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas_2012</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>21-SEP-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_americas_2012</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-JAN-13 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>01-JAN-13 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>01-JAN-13 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>01-JAN-13 00:00:00</td>
<td>5090</td>
</tr>
</tbody>
</table>

(17 rows)

The following command splits the `americas_2012` subpartition into two new subpartitions, and redistributes the contents:

```sql
ALTER TABLE sales
SPLIT SUBPARTITION americas_2012
AT ('2012-Jun-01')
INTO
(
    SUBPARTITION americas_p1_2012,
    SUBPARTITION americas_p2_2012
);
```

After invoking the command, the `americas_2012` subpartition has been deleted; in its place, the server has created two new subpartitions (`americas_p1_2012` and `americas_p2_2012`):

```sql
acctg=# SELECT partition_name, subpartition_name, high_value FROM
ALL_TAB_SUBPARTITIONS;
```

<table>
<thead>
<tr>
<th>partition_name</th>
<th>subpartition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>EUROPE_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>EUROPE</td>
<td>EUROPE_2012</td>
<td>FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')</td>
</tr>
<tr>
<td>ASIA</td>
<td>ASIA_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>ASIA</td>
<td>ASIA_2012</td>
<td>FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JAN-13 00:00:00')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_2011</td>
<td>FOR VALUES FROM (MINVALUE) TO ('01-JAN-12 00:00:00')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_p1_2012</td>
<td>FOR VALUES FROM ('01-JAN-12 00:00:00') TO ('01-JUN-12 00:00:00')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>AMERICAS_p2_2012</td>
<td>FOR VALUES FROM ('01-JUN-12 00:00:00') TO ('01-JAN-13 00:00:00')</td>
</tr>
</tbody>
</table>

(7 rows)
Querying the `sales` table demonstrates that the subpartition's contents are redistributed:

```sql
acctg=# SELECT tableoid::regclass, * FROM sales;

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas_p1_2012</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas_p1_2012</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_americas_p1_2012</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas_p2_2012</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_americas_p2_2012</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_americas_p2_2012</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas_p2_2012</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe_2012</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe_2012</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_europe_2012</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
</tbody>
</table>
```

(17 rows)
10.3.6 ALTER TABLE... EXCHANGE PARTITION

The `ALTER TABLE...EXCHANGE PARTITION` command swaps an existing table with a partition. If you plan to add a large quantity of data to a partitioned table, you can use the `ALTER TABLE...EXCHANGE PARTITION` command to implement a bulk load. You can also use the `ALTER TABLE...EXCHANGE PARTITION` command to remove old or unneeded data for storage.

The command syntax is available in two forms.

The first form swaps a table for a partition:

```
ALTER TABLE target_table
EXCHANGE PARTITION target_partition
WITH TABLE source_table
[(INCLUDING | EXCLUDING) INDEXES]
[(WITH | WITHOUT) VALIDATION];
```

The second form swaps a table for a subpartition:

```
ALTER TABLE target_table
EXCHANGE SUBPARTITION target_subpartition
WITH TABLE source_table
[(INCLUDING | EXCLUDING) INDEXES]
[(WITH | WITHOUT) VALIDATION];
```

Description

When the `ALTER TABLE...EXCHANGE PARTITION` command completes, the data originally located in the `target_partition` will be located in the `source_table`, and the data originally located in the `source_table` will be located in the `target_partition`.

The `ALTER TABLE...EXCHANGE PARTITION` command can exchange partitions in a `LIST`, `RANGE` or `HASH` partitioned table. The structure of the `source_table` must match the structure of the `target_table` (both tables must have matching columns and data types), and the data contained within the table must adhere to the partitioning constraints.

If the `INCLUDING INDEXES` clause is specified with `EXCHANGE PARTITION`, then matching indexes in the `target_partition` and `source_table` are swapped. Indexes in the `target_partition` with no match in the `source_table` are rebuilt and vice versa (that is, indexes in the `source_table` with no match in the `target_partition` are also rebuilt).
If the `EXCLUDING INDEXES` clause is specified with `EXCHANGE PARTITION`, then matching indexes in the `target_partition` and `source_table` are swapped, but the `target_partition` indexes with no match in the `source_table` are marked as invalid and vice versa (that is, indexes in the `source_table` with no match in the `target_partition` are also marked as invalid).

The previously used `matching index` term refers to indexes that have the same attributes such as the collation order, ascending or descending direction, ordering of nulls first or nulls last, and so forth as determined by the `CREATE INDEX` command.

If both `INCLUDING INDEXES` and `EXCLUDING INDEXES` are omitted, then the default action is the `EXCLUDING INDEXES` behavior.

The same behavior as previously described applies for the `target_subpartition` used with the `EXCHANGE SUBPARTITION` clause.

You must own a table to invoke `ALTER TABLE... EXCHANGE PARTITION` or `ALTER TABLE... EXCHANGE SUBPARTITION` against that table.

**Parameters:**

`target_table`

The name (optionally schema-qualified) of the table in which the partition or subpartition resides.

`target_partition`

The name of the partition to be replaced.

`target_subpartition`

The name of the subpartition to be replaced.

`source_table`

The name of the table that will replace the `target_partition` or `target_subpartition`.

### 10.3.6.1 Example - Exchanging a Table for a Partition

The example that follows demonstrates swapping a table for a partition (`Americas`) of the `sales` table. You can create the `sales` table with the following command:
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
    date date,
    amount number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);

Use the following command to add sample data to the sales table:

INSERT INTO sales VALUES
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '65000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '65000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(20, '4519a', 'INDIA', '18-Oct-2012', '65000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');

Querying the sales table shows that only one row resides in the americas partition:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
      tableoid     | dept_no | part_no | country |        date        | amount
----------------+---------+---------+---------+-------------------+--------
sales_americas  |      40 | 9519b   | US      | 12-Apr-2012 00:00:00 | 145000
sales_europe    |      10 | 4519b   | FRANCE  | 17-Jan-2012 00:00:00 | 45000
sales_europe    |      10 | 9519b   | ITALY   | 07-Jul-2012 00:00:00 | 15000
sales_europe    |      10 | 9519a   | FRANCE  | 18-Aug-2012 00:00:00 | 650000
sales_asia      |      20 | 3788a   | INDIA   | 01-Mar-2012 00:00:00 | 750000
sales_asia      |      20 | 3788b   | PAKISTAN| 04-Jun-2012 00:00:00 | 37500
sales_asia      |      20 | 3788b   | INDIA   | 21-Sep-2012 00:00:00 | 5090
sales_asia      |      20 | 4519a   | INDIA   | 18-Oct-2012 00:00:00 | 650000
sales_asia      |      20 | 4519b   | INDIA   | 02-Dec-2012 00:00:00 | 5090
(10 rows)
```

The following command creates a table (n_america) that matches the definition of the sales table:

CREATE TABLE n_america
(
    dept_no number,
    part_no varchar2,
The following command adds data to the `n_america` table. The data conforms to the partitioning rules of the `americas` partition:

```
INSERT INTO n_america VALUES
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(40, '4788a', 'US', '23-Sept-2012', '4950'),
(40, '4788b', 'US', '09-Oct-2012', '15000');
```

The following command swaps the table into the partitioned table:

```
ALTER TABLE sales
EXCHANGE PARTITION americas
WITH TABLE n_america;
```

Querying the `sales` table shows that the contents of the `n_america` table has been exchanged for the content of the `americas` partition:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
               tableoid | dept_no | part_no | country   |        date        | amount
-----------------+---------+---------+-----------+-------------------+--------
sales_americas   |      40 | 9519b   | US        | 12-APR-12 00:00:00 | 145000
sales_americas   |      40 | 4577b   | US        | 11-NOV-12 00:00:00 | 25000
sales_americas   |      30 | 7588b   | CANADA    | 14-DEC-12 00:00:00 | 50000
sales_americas   |      30 | 9519b   | CANADA    | 01-FEB-12 00:00:00 | 75000
sales_americas   |      30 | 4519b   | CANADA    | 08-APR-12 00:00:00 | 120000
sales_americas   |      40 | 3788a   | US        | 12-MAY-12 00:00:00 | 4950
sales_americas   |      40 | 4788a   | US        | 23-SEP-12 00:00:00 | 4950
sales_americas   |      40 | 4788b   | US        | 09-OCT-12 00:00:00 | 15000
sales_europe     |      10 | 4519b   | FRANCE    | 17-JAN-12 00:00:00 | 45000
sales_europe     |      10 | 9519b   | ITALY     | 07-JUL-12 00:00:00 | 15000
sales_europe     |      10 | 9519a   | FRANCE    | 18-AUG-12 00:00:00 | 650000
sales_europe     |      10 | 9519b   | FRANCE    | 18-AUG-12 00:00:00 | 650000
sales_asia       |      20 | 3788a   | INDIA     | 01-MAR-12 00:00:00 | 75000
sales_asia       |      20 | 3788a   | PAKISTAN  | 04-JUN-12 00:00:00 | 37500
sales_asia       |      20 | 3788b   | INDIA     | 21-SEP-12 00:00:00 | 5090
sales_asia       |      20 | 4519a   | INDIA     | 18-OCT-12 00:00:00 | 650000
sales_asia       |      20 | 4519b   | INDIA     | 02-DEC-12 00:00:00 | 5090
(17 rows)
```

Querying the `n_america` table shows that the row that was previously stored in the `americas` partition has been moved to the `n_america` table:

```
acctg=# SELECT tableoid::regclass, * FROM n_america;
               tableoid | dept_no | part_no | country |        date        | amount
-----------------+---------+---------+---------+-------------------+--------
sales_americas   |      40 | 9519b   | US      | 12-APR-12 00:00:00 | 145000
sales_americas   |      40 | 4577b   | US      | 11-NOV-12 00:00:00 | 25000
sales_americas   |      30 | 7588b   | CANADA  | 14-DEC-12 00:00:00 | 50000
sales_americas   |      30 | 9519b   | CANADA  | 01-FEB-12 00:00:00 | 75000
sales_americas   |      30 | 4519b   | CANADA  | 08-APR-12 00:00:00 | 120000
sales_americas   |      40 | 3788a   | US      | 12-MAY-12 00:00:00 | 4950
sales_americas   |      40 | 4788a   | US      | 23-SEP-12 00:00:00 | 4950
sales_americas   |      40 | 4788b   | US      | 09-OCT-12 00:00:00 | 15000
sales_europe     |      10 | 4519b   | FRANCE  | 17-JAN-12 00:00:00 | 45000
sales_europe     |      10 | 9519b   | ITALY   | 07-JUL-12 00:00:00 | 15000
sales_europe     |      10 | 9519a   | FRANCE  | 18-AUG-12 00:00:00 | 650000
sales_europe     |      10 | 9519b   | FRANCE  | 18-AUG-12 00:00:00 | 650000
sales_asia       |      20 | 3788a   | INDIA   | 01-MAR-12 00:00:00 | 75000
sales_asia       |      20 | 3788a   | PAKISTAN| 04-JUN-12 00:00:00 | 37500
sales_asia       |      20 | 3788b   | INDIA   | 21-SEP-12 00:00:00 | 5090
sales_asia       |      20 | 4519a   | INDIA   | 18-OCT-12 00:00:00 | 650000
sales_asia       |      20 | 4519b   | INDIA   | 02-DEC-12 00:00:00 | 5090
(17 rows)
```
<table>
<thead>
<tr>
<th>n_america</th>
<th>40</th>
<th>9519b</th>
<th>US</th>
<th>12-APR-12 00:00:00</th>
<th>145000</th>
</tr>
</thead>
</table>

(1 row)
10.3.7 ALTER TABLE… MOVE PARTITION

Use the ALTER TABLE…MOVE PARTITION command to move a partition to a different tablespace. The command takes two forms.

The first form moves a partition to a new tablespace:

```
ALTER TABLE table_name
    MOVE PARTITION partition_name
    TABLESPACE tablespace_name;
```

The second form moves a subpartition to a new tablespace:

```
ALTER TABLE table_name
    MOVE SUBPARTITION subpartition_name
    TABLESPACE tablespace_name;
```

Description

The ALTER TABLE…MOVE PARTITION command moves a partition from its current tablespace to a different tablespace. The ALTER TABLE…MOVE PARTITION command can move partitions of a LIST, RANGE or HASH partitioned table.

The same behavior as previously described applies for the subpartition_name used with the MOVE SUBPARTITION clause.

You must own the table to invoke ALTER TABLE…MOVE PARTITION or ALTER TABLE… MOVE SUBPARTITION.

Parameters

- `table_name`
  The name (optionally schema-qualified) of the table in which the partition or subpartition resides.

- `partition_name`
  The name of the partition to be moved.

- `subpartition_name`
  The name of the subpartition to be moved.
tablespace_name

The name of the tablespace to which the partition or subpartition will be moved.

10.3.7.1 Example - Moving a Partition to a Different Table space

The following example moves a partition of the sales table from one tablespace to another. First, create the sales table with the command:

```sql
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
)
PARTITION BY RANGE(date)
(
    PARTITION q1_2012 VALUES LESS THAN ('2012-Apr-01'),
    PARTITION q2_2012 VALUES LESS THAN ('2012-Jul-01'),
    PARTITION q3_2012 VALUES LESS THAN ('2012-Oct-01'),
    PARTITION q4_2012 VALUES LESS THAN ('2013-Jan-01') TABLESPACE ts_1,
    PARTITION q1_2013 VALUES LESS THAN ('2013-Mar-01') TABLESPACE ts_2
);
```

Querying the ALL_TAB_PARTITIONS view confirms that the partitions reside on the expected servers and tablespaces:

```sql
acctg=# SELECT partition_name, tablespace_name FROM ALL_TAB_PARTITIONS;
partition_name | tablespace_name
---------------+------------------
Q1_2012        |                 |
Q2_2012        |                 |
Q3_2012        |                 |
Q4_2012        | TS_1            |
Q1_2013        | TS_2            |
(5 rows)
```

After preparing the target tablespace, invoke the ALTER TABLE...MOVE PARTITION command to move the q1_2013 partition from a tablespace named ts_2 to a tablespace named ts_3:

```sql
ALTER TABLE sales MOVE PARTITION q1_2013 TABLESPACE ts_3;
```

Querying the ALL_TAB_PARTITIONS view shows that the move was successful:

```sql
acctg=# SELECT partition_name, tablespace_name FROM ALL_TAB_PARTITIONS;
partition_name | tablespace_name
---------------+------------------
Q1_2012        |                 |
Q2_2012        |                 |
Q3_2012        |                 |
Q4_2012        |                 |
Q1_2013        | TS_3            |
(4 rows)
```
<table>
<thead>
<tr>
<th>partition_name</th>
<th>tablespace_name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1_2012</td>
<td></td>
</tr>
<tr>
<td>Q2_2012</td>
<td></td>
</tr>
<tr>
<td>Q3_2012</td>
<td></td>
</tr>
<tr>
<td>Q4_2012</td>
<td>TS_1</td>
</tr>
<tr>
<td>Q1_2013</td>
<td>TS_3</td>
</tr>
</tbody>
</table>

(5 rows)
10.3.8 ALTER TABLE... RENAME PARTITION

Use the ALTER TABLE... RENAME PARTITION command to rename a table partition. The syntax takes two forms.

The first form renames a partition:

```
ALTER TABLE table_name
  RENAME PARTITION partition_name
  TO new_name;
```

The second form renames a subpartition:

```
ALTER TABLE table_name
  RENAME SUBPARTITION subpartition_name
  TO new_name;
```

Description

The ALTER TABLE... RENAME PARTITION command renames a partition.

The same behavior as previously described applies for the subpartition_name used with the RENAME SUBPARTITION clause.

You must own the specified table to invoke ALTER TABLE... RENAME PARTITION or ALTER TABLE... RENAME SUBPARTITION.

Parameters

table_name

The name (optionally schema-qualified) of the table in which the partition or subpartition resides.

partition_name

The name of the partition to be renamed.

subpartition_name

The name of the subpartition to be renamed.

new_name

The new name of the partition or subpartition.
10.3.8.1 Example - Renaming a Partition

The following command creates a list-partitioned table named sales:

```sql
CREATE TABLE sales
(
    dept_no    number,
    part_no    varchar2,
    country    varchar2(20),
    date       date,
    amount     number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
);
```

Query the ALL_TAB_PARTITIONS view to display the partition names:

```sql
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name |             high_value
-----------------+------------------------------------------
EUROPE           | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA             | FOR VALUES IN ('INDIA', 'PAKISTAN')
AMERICAS         | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

The following command renames the americas partition to n_america:

```sql
ALTER TABLE sales
RENAME PARTITION americas TO n_america;
```

Querying the ALL_TAB_PARTITIONS view demonstrates that the partition has been successfully renamed:

```sql
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
partition_name |             high_value
-----------------+------------------------------------------
EUROPE           | FOR VALUES IN ('FRANCE', 'ITALY')
ASIA             | FOR VALUES IN ('INDIA', 'PAKISTAN')
N_AMERICA        | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```
10.3.9 DROP TABLE

Use the PostgreSQL DROP TABLE command to remove a partitioned table definition, its partitions and subpartitions, and delete the table contents. The syntax is:

```
DROP TABLE table_name
```

**Parameters**

`table_name`

The name (optionally schema-qualified) of the partitioned table.

**Description**

The `DROP TABLE` command removes an entire table, and the data that resides in that table. When you delete a table, any partitions or subpartitions (of that table) are deleted as well.

To use the `DROP TABLE` command, you must be the owner of the partitioning root, a member of a group that owns the table, the schema owner, or a database superuser.

**Example**

To delete a table, connect to the controller node (the host of the partitioning root), and invoke the `DROP TABLE` command. For example, to delete the `sales` table, invoke the following command:

```
DROP TABLE sales;
```

The server will confirm that the table has been dropped:

```
acctg=# drop table sales;
DROP TABLE
acctg=#
```

For more information about the `DROP TABLE` command, please see the PostgreSQL core documentation at:

[https://www.postgresql.org/docs/10/static/sql-droptable.html](https://www.postgresql.org/docs/10/static/sql-droptable.html)
10.3.10 ALTER TABLE... DROP PARTITION

Use the ALTER TABLE... DROP PARTITION command to delete a partition definition, and the data stored in that partition. The syntax:

```
ALTER TABLE table_name DROP PARTITION partition_name;
```

Parameters

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`partition_name`

The name of the partition to be deleted.

Description

The ALTER TABLE... DROP PARTITION command deletes a partition and any data stored on that partition. The ALTER TABLE... DROP PARTITION command can drop partitions of a LIST or RANGE partitioned table; please note that this command does not work on a HASH partitioned table. When you delete a partition, any subpartitions (of that partition) are deleted as well.

To use the DROP PARTITION clause, you must be the owner of the partitioning root, a member of a group that owns the table, or have database superuser or administrative privileges.

10.3.10.1 Example - Deleting a Partition

The example that follows deletes a partition of the sales table. Use the following command to create the sales table:

```
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    ```
PARTITION asia VALUES('INDIA', 'PAKISTAN'),
PARTITION americas VALUES('US', 'CANADA')
);

Querying the ALL_TAB_PARTITIONS view displays the partition names:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
 partition_name |             high_value
------------------------------------------------------
 EUROPE | FOR VALUES IN ('FRANCE', 'ITALY')
 ASIA   | FOR VALUES IN ('INDIA', 'PAKISTAN')
 AMERCIAS | FOR VALUES IN ('US', 'CANADA')
(3 rows)
```

To delete the americas partition from the sales table, invoke the following command:

```
ALTER TABLE sales DROP PARTITION americas;
```

Querying the ALL_TAB_PARTITIONS view demonstrates that the partition has been successfully deleted:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
 partition_name |             high_value
------------------------------------------------------
 EUROPE | FOR VALUES IN ('FRANCE', 'ITALY')
 ASIA   | FOR VALUES IN ('INDIA', 'PAKISTAN')
(2 rows)
```
10.3.11 ALTER TABLE... DROP SUBPARTITION

Use the ALTER TABLE... DROP SUBPARTITION command to drop a subpartition definition, and the data stored in that subpartition. The syntax is:

```
ALTER TABLE table_name DROP SUBPARTITION subpartition_name;
```

Parameters

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`subpartition_name`

The name of the subpartition to be deleted.

Description

The ALTER TABLE... DROP SUBPARTITION command deletes a subpartition, and the data stored in that subpartition. To use the DROP SUBPARTITION clause, you must be the owner of the partitioning root, a member of a group that owns the table, or have superuser or administrative privileges.

10.3.11.1 Example - Deleting a Subpartition

The example that follows deletes a subpartition of the sales table. Use the following command to create the sales table:

```
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
    date date,
    amount number
)
PARTITION BY RANGE(date)
    SUBPARTITION BY LIST (country)
    (PARTITION first_half_2012 VALUES LESS THAN ('01-JUL-2012')
    (SUBPARTITION europe VALUES ('ITALY', 'FRANCE'),
     SUBPARTITION americas VALUES ('CANADA', 'US'),
```

...
SUBPARTITION asia VALUES ('PAKISTAN', 'INDIA')
,
PARTITION second_half_2012 VALUES LESS THAN('01-JAN-2013')
);

Querying the ALL_TAB_SUBPARTITIONS view displays the subpartition names:

```
acctg=# SELECT subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;
subpartition_name |             high_value
-------------------|-------------------------------------
 ASIA              | FOR VALUES IN ('PAKISTAN', 'INDIA')
 AMERICAS          | FOR VALUES IN ('CANADA', 'US')
 EUROPE            | FOR VALUES IN ('ITALY', 'FRANCE')
 SYS0101           | DEFAULT
(4 rows)
```

To delete the americas subpartition from the sales table, invoke the following command:

```
ALTER TABLE sales DROP SUBPARTITION americas;
```

Querying the ALL_TAB_SUBPARTITIONS view demonstrates that the subpartition has been successfully deleted:

```
acctg=# SELECT subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;
subpartition_name |             high_value
-------------------|-------------------------------------
 ASIA              | FOR VALUES IN ('PAKISTAN', 'INDIA')
 EUROPE            | FOR VALUES IN ('ITALY', 'FRANCE')
 SYS0101           | DEFAULT
(3 rows)
```
10.3.12 TRUNCATE TABLE

Use the TRUNCATE TABLE command to remove the contents of a table, while preserving the table definition. When you truncate a table, any partitions or subpartitions of that table are also truncated. The syntax is:

   TRUNCATE TABLE table_name

Description

The TRUNCATE TABLE command removes an entire table, and the data that resides in that table. When you delete a table, any partitions or subpartitions (of that table) are deleted as well.

To use the TRUNCATE TABLE command, you must be the owner of the partitioning root, a member of a group that owns the table, the schema owner, or a database superuser.

Parameters

table_name

   The name (optionally schema-qualified) of the partitioned table.

10.3.12.1 Example - Emptying a Table

The example that follows removes the data from the sales table. Use the following command to create the sales table:

   CREATE TABLE sales
   (    dept_no number,
    part_no   varchar2,
    country   varchar2(20),
    date      date,
    amount    number
   )
PARTITION BY LIST(country)
   (    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia    VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA')
   );
Populate the *sales* table with the command:

```
INSERT INTO sales VALUES
    (10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
    (20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
    (40, '9519b', 'US', '12-Apr-2012', '145000'),
    (20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
    (40, '4577b', 'US', '11-Nov-2012', '25000'),
    (30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
    (30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
    (30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
    (20, '3788a', 'US', '12-May-2012', '4950'),
    (10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
    (10, '9519a', 'FRANCE', '18-Aug-2012', '65000'),
    (20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
    (40, '4788a', 'US', '23-Sept-2012', '4950'),
    (40, '4788b', 'US', '09-Oct-2012', '15000'),
    (20, '4519a', 'INDIA', '18-Oct-2012', '65000'),
    (20, '4519b', 'INDIA', '2-Dec-2012', '5090');
```

Querying the *sales* table shows that the partitions are populated with data:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12</td>
<td>25000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12</td>
<td>50000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12</td>
<td>75000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12</td>
<td>120000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-SEP-12</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>09-OCT-12</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12</td>
<td>650000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12</td>
<td>37500</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>21-SEP-12</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12</td>
<td>5090</td>
</tr>
</tbody>
</table>

(17 rows)

To delete the contents of the *sales* table, invoke the following command:

```
TRUNCATE TABLE sales;
```

Now, querying the *sales* table shows that the data has been removed but the structure is intact:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
</table>

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For more information about the TRUNCATE TABLE command, please see the PostgreSQL documentation at:

https://www.postgresql.org/docs/10/static/sql-truncate.html
10.3.13  **ALTER TABLE... TRUNCATE PARTITION**

Use the `ALTER TABLE...TRUNCATE PARTITION` command to remove the data from the specified partition, leaving the partition structure intact. The syntax:

```
ALTER TABLE table_name TRUNCATE PARTITION partition_name
[{DROP|REUSE} STORAGE]
```

**Description**

Use the `ALTER TABLE...TRUNCATE PARTITION` command to remove the data from the specified partition, leaving the partition structure intact. When you truncate a partition, any subpartitions of that partition are also truncated.

`ALTER TABLE...TRUNCATE PARTITION` will not cause ON DELETE triggers that might exist for the table to fire, but it will fire ON TRUNCATE triggers. If an ON TRUNCATE trigger is defined for the partition, all BEFORE TRUNCATE triggers are fired before any truncation happens, and all AFTER TRUNCATE triggers are fired after the last truncation occurs.

You must have the TRUNCATE privilege on a table to invoke `ALTER TABLE...TRUNCATE PARTITION`.

**Parameters**

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`partition_name`

The name of the partition to be deleted.

`DROP STORAGE` and `REUSE STORAGE` are included for compatibility only; the clauses are parsed and ignored.

**10.3.13.1 Example - Emptying a Partition**

The example that follows removes the data from a partition of the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
```


```
(  
department no number,
part_no varchar2,
country varchar2(20),
date date,
amount number
)
PARTITION BY LIST(country)
(
  PARTITION europe VALUES('FRANCE', 'ITALY'),
  PARTITION asia VALUES('INDIA', 'PAKISTAN'),
  PARTITION americas VALUES('US', 'CANADA')
);

Populate the sales table with the command:

INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(30, '9519b', 'CANADA', '01-Feb-2012', '75000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2012', '4950'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(10, '9519a', 'FRANCE', '18-Aug-2012', '650000'),
(10, '9519b', 'FRANCE', '18-Aug-2012', '650000'),
(20, '3788b', 'INDIA', '21-Sept-2012', '5090'),
(40, '4788b', 'US', '09-Oct-2012', '15000'),
(20, '4519a', 'INDIA', '18-Oct-2012', '650000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');

Querying the sales table shows that the partitions are populated with data:
```

```sql
acctg=# SELECT tableoid::regclass, * FROM sales;
+-----------------+--------+-----------+----------+----------+--------+
| tableoid | dept_no | part_no   | country  | date     | amount |
|-----------+---------+-----------+----------+----------+--------|
| sales_americas | 40      | 9519b     | US       | 12-APR-12 00:00:00 | 145000 |
| sales_americas | 40      | 4577b     | US       | 11-NOV-12 00:00:00 | 25000  |
| sales_americas | 30      | 7588b     | CANADA   | 14-DEC-12 00:00:00 | 50000  |
| sales_americas | 30      | 9519b     | CANADA   | 01-FEB-12 00:00:00 | 75000  |
| sales_americas | 30      | 4519b     | CANADA   | 08-APR-12 00:00:00 | 120000 |
| sales_americas | 40      | 3788a     | US       | 12-MAY-12 00:00:00 | 4950   |
| sales_americas | 40      | 4788a     | US       | 09-OCT-12 00:00:00 | 4950   |
| sales_americas | 10      | 4519b     | FRANCE   | 17-JAN-12 00:00:00 | 45000  |
| sales_americas | 10      | 9519b     | ITALY    | 07-JUL-12 00:00:00 | 15000  |
| sales_americas | 10      | 9519a     | FRANCE   | 18-AUG-12 00:00:00 | 650000 |
| sales_americas | 10      | 9519b     | FRANCE   | 18-AUG-12 00:00:00 | 650000 |
| sales_asia    | 20      | 3788a     | INDIA    | 01-MAR-12 00:00:00 | 75000  |
| sales_asia    | 20      | 3788a     | PAKISTAN | 04-JUN-12 00:00:00 | 37500  |
```
To delete the contents of the `americas` partition, invoke the following command:

```
ALTER TABLE sales TRUNCATE PARTITION americas;
```

Now, querying the `sales` table shows that the content of the `americas` partition has been removed:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

```sql
<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>21-SEP-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
</tbody>
</table>
```

(9 rows)

While the rows have been removed, the structure of the `americas` partition is still intact:

```
acctg=# SELECT partition_name, high_value FROM ALL_TAB_PARTITIONS;
```

```sql
<table>
<thead>
<tr>
<th>partition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>FOR VALUES IN ('FRANCE', 'ITALY')</td>
</tr>
<tr>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
</tbody>
</table>
```

(3 rows)
10.3.14 ALTER TABLE... TRUNCATE SUBPARTITION

Use the `ALTER TABLE... TRUNCATE SUBPARTITION` command to remove all of the data from the specified subpartition, leaving the subpartition structure intact. The syntax is:

```
ALTER TABLE table_name
    TRUNCATE SUBPARTITION subpartition_name
    [{DROP|REUSE} STORAGE]
```

Description

The `ALTER TABLE... TRUNCATE SUBPARTITION` command removes all data from a specified subpartition, leaving the subpartition structure intact.

`ALTER TABLE... TRUNCATE SUBPARTITION` will not cause `ON DELETE` triggers that might exist for the table to fire, but it will fire `ON TRUNCATE` triggers. If an `ON TRUNCATE` trigger is defined for the subpartition, all `BEFORE TRUNCATE` triggers are fired before any truncation happens, and all `AFTER TRUNCATE` triggers are fired after the last truncation occurs.

You must have the `TRUNCATE` privilege on a table to invoke `ALTER TABLE... TRUNCATE SUBPARTITION`.

Parameters

`table_name`

The name (optionally schema-qualified) of the partitioned table.

`subpartition_name`

The name of the subpartition to be truncated.

The `DROP STORAGE` and `REUSE STORAGE` clauses are included for compatibility only; the clauses are parsed and ignored.

10.3.14.1 Example - Emptying a Subpartition

The example that follows removes the data from a subpartition of the `sales` table. Use the following command to create the `sales` table:

```
CREATE TABLE sales
```

Populate the `sales` table with the command:

```sql
INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2011', '45000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(40, '9519b', 'US', '12-Apr-2012', '145000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(40, '4577b', 'US', '11-Nov-2012', '25000'),
(30, '7588b', 'CANADA', '14-Dec-2011', '50000'),
(30, '4519b', 'CANADA', '08-Apr-2012', '120000'),
(40, '3788a', 'US', '12-May-2011', '4950'),
(20, '3788a', 'US', '04-Apr-2012', '37500'),
(40, '4577b', 'INDIA', '11-Jun-2011', '25000'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(20, '4519b', 'INDIA', '2-Dec-2012', '5090');
```

Querying the `sales` table shows that the rows have been distributed amongst the subpartitions:

```sql
acctg=# SELECT tableoid::regclass, * FROM sales;
tableoid       | dept_no | part_no | country  |        date        | amount
---------------------+--------+---------+----------+-------------------+-------
sales_americas_2011 |       30 | 7588b   | CANADA   | 14-Dec-11 00:00:00 | 50000
```

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To delete the contents of the 2012_americas partition, invoke the following command:

```
ALTER TABLE sales TRUNCATE SUBPARTITION "americas_2012";
```

Now, querying the sales table shows that the content of the americas_2012 partition has been removed:

```
acctg=# SELECT tableoid::regclass, * FROM sales;
```

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas_2011</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-11 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_americas_2011</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-11 00:00:00</td>
<td>49500</td>
</tr>
<tr>
<td>sales_europe_2011</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-11 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_asia_2011</td>
<td>40</td>
<td>4577b</td>
<td>INDIA</td>
<td>11-JUN-11 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_europe_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_asia_2012</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
</tbody>
</table>

(8 rows)

While the rows have been removed, the structure of the 2012_americas partition is still intact:

```
acctg=# SELECT subpartition_name, high_value FROM ALL_TAB_SUBPARTITIONS;
```

<table>
<thead>
<tr>
<th>subpartition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMERICAS_2011</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>ASIA_2011</td>
<td>FOR VALUES IN ('PAKISTAN', 'INDIA')</td>
</tr>
<tr>
<td>EUROPE_2011</td>
<td>FOR VALUES IN ('ITALY', 'FRANCE')</td>
</tr>
<tr>
<td>AMERICAS_2012</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>ASIA_2012</td>
<td>FOR VALUES IN ('PAKISTAN', 'INDIA')</td>
</tr>
<tr>
<td>EUROPE_2012</td>
<td>FOR VALUES IN ('ITALY', 'FRANCE')</td>
</tr>
<tr>
<td>AMERICAS_2013</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>ASIA_2013</td>
<td>FOR VALUES IN ('PAKISTAN', 'INDIA')</td>
</tr>
<tr>
<td>EUROPE_2013</td>
<td>FOR VALUES IN ('ITALY', 'FRANCE')</td>
</tr>
</tbody>
</table>

(9 rows)
10.4 Handling Stray Values in a LIST or RANGE Partitioned Table

A **DEFAULT** or **MAXVALUE** partition or subpartition will capture any rows that do not meet the other partitioning rules defined for a table.

**Defining a DEFAULT Partition**

A **DEFAULT** partition will capture any rows that do not fit into any other partition in a **LIST** partitioned (or subpartitioned) table. If you do not include a **DEFAULT** rule, any row that does not match one of the values in the partitioning constraints will result in an error. Each **LIST** partition or subpartition may have its own **DEFAULT** rule.

The syntax of a **DEFAULT** rule is:

```
PARTITION [partition_name] VALUES (DEFAULT)
```

Where `partition_name` specifies the name of the partition or subpartition that will store any rows that do not match the rules specified for other partitions.

The last example created a list partitioned table in which the server decided which partition to store the data based upon the value of the `country` column. If you attempt to add a row in which the value of the `country` column contains a value not listed in the rules, Advanced Server reports an error:

```
acctg=# INSERT INTO sales VALUES
acctg-#  (40, '3000x', 'IRELAND', '01-Mar-2012', '45000');
ERROR:  no partition of relation "sales_2012" found for row
DETAIL:  Partition key of the failing row contains (country) = (IRELAND).
```

The following example creates the same table, but adds a **DEFAULT** partition. The server will store any rows that do not match a value specified in the partitioning rules for `europe`, `asia`, or `americas` partitions in the **others** partition:

```
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    date        date,
    amount      number
)
PARTITION BY LIST(country)
(
    PARTITION europe VALUES('FRANCE', 'ITALY'),
    PARTITION asia VALUES('INDIA', 'PAKISTAN'),
    PARTITION americas VALUES('US', 'CANADA'),
    PARTITION others VALUES (DEFAULT)
);
```
To test the DEFAULT partition, add a row with a value in the country column that does not match one of the countries specified in the partitioning constraints:

```
INSERT INTO sales VALUES
(40, '3000x', 'IRELAND', '01-Mar-2012', '45000');
```

Querying the contents of the sales table confirms that the previously rejected row is now stored in the sales_others partition:

```
acctg=# SELECT tableoid::regclass, * FROM sales;

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-NOV-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-FEB-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-SEP-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_americas</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>09-OCT-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-AUG-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>21-SEP-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-OCT-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-DEC-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_others</td>
<td>40</td>
<td>3000x</td>
<td>IRELAND</td>
<td>01-MAR-12 00:00:00</td>
<td>45000</td>
</tr>
</tbody>
</table>

(18 rows)
```

Please note that Advanced Server does not have a way to re-assign the contents of a DEFAULT partition or subpartition:

- You cannot use the `ALTER TABLE ... ADD PARTITION` command to add a partition to a table with a DEFAULT rule, but you can use the `ALTER TABLE ... SPLIT PARTITION` command to split an existing partition. An example is shown following this bullet point list.

- You cannot use the `ALTER TABLE ... ADD SUBPARTITION` command to add a subpartition to a table with a DEFAULT rule, but you can use the `ALTER TABLE ... SPLIT SUBPARTITION` command to split an existing subpartition.

### Splitting a DEFAULT Partition

The following example splits a DEFAULT partition, redistributing the partition's content between two new partitions. The table was created with the `CREATE TABLE sales` command shown at the beginning of this section.

The following inserts rows into the table including rows into the DEFAULT partition:
Database Compatibility for Oracle® Developers Guide

INSERT INTO sales VALUES
(10, '4519b', 'FRANCE', '17-Jan-2012', '45000'),
(10, '9519b', 'ITALY', '07-Jul-2012', '15000'),
(20, '3788a', 'INDIA', '01-Mar-2012', '75000'),
(20, '3788a', 'PAKISTAN', '04-Jun-2012', '37500'),
(30, '9519b', 'US', '12-Apr-2012', '145000'),
(30, '7588b', 'CANADA', '14-Dec-2012', '50000'),
(40, '4519b', 'SOUTH AFRICA', '08-Apr-2012', '120000'),
(40, '4519b', 'KENYA', '08-Apr-2012', '120000'),
(50, '3788a', 'CHINA', '12-May-2012', '4950');

The partitions include the DEFAULT others partition:

<table>
<thead>
<tr>
<th>partition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>FOR VALUES IN ('FRANCE', 'ITALY')</td>
</tr>
<tr>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>OTHERS</td>
<td>DEFAULT</td>
</tr>
</tbody>
</table>

The following shows the rows distributed amongst the partitions:

<table>
<thead>
<tr>
<th>tableoid::regclass::regclass</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12</td>
<td>50000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12</td>
<td>15000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12</td>
<td>37500</td>
</tr>
<tr>
<td>sales_others</td>
<td>40</td>
<td>4519b</td>
<td>SOUTH AFRICA</td>
<td>08-APR-12</td>
<td>120000</td>
</tr>
<tr>
<td>sales_others</td>
<td>40</td>
<td>4519b</td>
<td>KENYA</td>
<td>08-APR-12</td>
<td>120000</td>
</tr>
<tr>
<td>sales_others</td>
<td>40</td>
<td>3788a</td>
<td>CHINA</td>
<td>12-MAY-12</td>
<td>4950</td>
</tr>
</tbody>
</table>

The following command splits the DEFAULT others partition into two partitions named africa and others:

ALTER TABLE sales SPLIT PARTITION others VALUES ('SOUTH AFRICA', 'KENYA')
INTO (PARTITION africa, PARTITION others);

The partitions now include the africa partition along with the DEFAULT others partition:

<table>
<thead>
<tr>
<th>partition_name</th>
<th>high_value</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUROPE</td>
<td>FOR VALUES IN ('FRANCE', 'ITALY')</td>
</tr>
<tr>
<td>ASIA</td>
<td>FOR VALUES IN ('INDIA', 'PAKISTAN')</td>
</tr>
<tr>
<td>AMERICAS</td>
<td>FOR VALUES IN ('US', 'CANADA')</td>
</tr>
<tr>
<td>AFRICA</td>
<td>FOR VALUES IN ('SOUTH AFRICA', 'KENYA')</td>
</tr>
<tr>
<td>OTHERS</td>
<td>DEFAULT</td>
</tr>
</tbody>
</table>
The following shows that the rows have been redistributed across the new partitions:

```
<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>9519b</td>
<td>US</td>
<td>12-APR-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_americas</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-DEC-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-JAN-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_europe</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-JUL-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-MAR-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_asia</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-JUN-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_africa</td>
<td>40</td>
<td>4519b</td>
<td>SOUTH AFRICA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_africa</td>
<td>40</td>
<td>4519b</td>
<td>KENYA</td>
<td>08-APR-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_others_1</td>
<td>50</td>
<td>3788a</td>
<td>CHINA</td>
<td>12-MAY-12 00:00:00</td>
<td>4950</td>
</tr>
</tbody>
</table>
```

**Defining a MAXVALUE Partition**

A **MAXVALUE** partition (or subpartition) will capture any rows that do not fit into any other partition in a range-partitioned (or subpartitioned) table. If you do not include a **MAXVALUE** rule, any row that exceeds the maximum limit specified by the partitioning rules will result in an error. Each partition or subpartition may have its own **MAXVALUE** partition.

The syntax of a **MAXVALUE** rule is:

```
PARTITION [partition_name] VALUES LESS THAN (MAXVALUE)
```

Where `partition_name` specifies the name of the partition that will store any rows that do not match the rules specified for other partitions.

The last example created a range-partitioned table in which the data was partitioned based upon the value of the `date` column. If you attempt to add a row with a `date` that exceeds a date listed in the partitioning constraints, Advanced Server reports an error:

```
acctg=# INSERT INTO sales VALUES
acctg-#   (40, '3000x', 'IRELAND', '01-Mar-2013', '45000');
ERROR: no partition of relation "sales" found for row
DETAIL: Partition key of the failing row contains (date) = (01-MAR-13 00:00:00).
```

The following **CREATE TABLE** command creates the same table, but with a **MAXVALUE** partition. Instead of throwing an error, the server will store any rows that do not match the previous partitioning constraints in the `others` partition:

```
CREATE TABLE sales
(
    dept_no number,
    part_no varchar2,
    country varchar2(20),
);```
To test the `MAXVALUE` partition, add a row with a value in the `date` column that exceeds the last date value listed in a partitioning rule. The server will store the row in the `others` partition:

```sql
INSERT INTO sales VALUES
(40, '3000x', 'IRELAND', '01-Mar-2013', '45000');
```

Querying the contents of the `sales` table confirms that the previously rejected row is now stored in the `sales_others` partition:

```sql
acctg=# SELECT tableoid::regclass, * FROM sales;

<table>
<thead>
<tr>
<th>tableoid</th>
<th>dept_no</th>
<th>part_no</th>
<th>country</th>
<th>date</th>
<th>amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>sales_q1_2012</td>
<td>10</td>
<td>4519b</td>
<td>FRANCE</td>
<td>17-Jan-12 00:00:00</td>
<td>45000</td>
</tr>
<tr>
<td>sales_q1_2012</td>
<td>20</td>
<td>3788a</td>
<td>INDIA</td>
<td>01-Mar-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_q1_2012</td>
<td>30</td>
<td>9519b</td>
<td>CANADA</td>
<td>01-Feb-12 00:00:00</td>
<td>75000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>40</td>
<td>9519b</td>
<td>US</td>
<td>12-Apr-12 00:00:00</td>
<td>145000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>20</td>
<td>3788a</td>
<td>PAKISTAN</td>
<td>04-Jun-12 00:00:00</td>
<td>37500</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>30</td>
<td>4519b</td>
<td>CANADA</td>
<td>08-Apr-12 00:00:00</td>
<td>120000</td>
</tr>
<tr>
<td>sales_q2_2012</td>
<td>40</td>
<td>3788a</td>
<td>US</td>
<td>12-May-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519b</td>
<td>ITALY</td>
<td>07-Jul-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519a</td>
<td>FRANCE</td>
<td>18-Aug-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>10</td>
<td>9519b</td>
<td>FRANCE</td>
<td>18-Aug-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>20</td>
<td>3788b</td>
<td>INDIA</td>
<td>21-Sep-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_q3_2012</td>
<td>40</td>
<td>4788a</td>
<td>US</td>
<td>23-Sep-12 00:00:00</td>
<td>4950</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>40</td>
<td>4577b</td>
<td>US</td>
<td>11-Nov-12 00:00:00</td>
<td>25000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>30</td>
<td>7588b</td>
<td>CANADA</td>
<td>14-Dec-12 00:00:00</td>
<td>50000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>40</td>
<td>4788b</td>
<td>US</td>
<td>09-Oct-12 00:00:00</td>
<td>15000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>20</td>
<td>4519a</td>
<td>INDIA</td>
<td>18-Oct-12 00:00:00</td>
<td>650000</td>
</tr>
<tr>
<td>sales_q4_2012</td>
<td>20</td>
<td>4519b</td>
<td>INDIA</td>
<td>02-Dec-12 00:00:00</td>
<td>5090</td>
</tr>
<tr>
<td>sales_others</td>
<td>40</td>
<td>3000x</td>
<td>IRELAND</td>
<td>01-Mar-13 00:00:00</td>
<td>45000</td>
</tr>
</tbody>
</table>
```

(18 rows)

Please note that Advanced Server does not have a way to re-assign the contents of a `MAXVALUE` partition or subpartition:

- You cannot use the `ALTER TABLE...ADD PARTITION` statement to add a partition to a table with a `MAXVALUE` rule, but you can use the `ALTER TABLE...SPLIT PARTITION` statement to split an existing partition.
- You cannot use the `ALTER TABLE ... ADD SUBPARTITION` statement to add a subpartition to a table with a `MAXVALUE` rule, but you can split an existing subpartition with the `ALTER TABLE ... SPLIT SUBPARTITION` statement.
10.5 Specifying Multiple Partitioning Keys in a RANGE Partitioned Table

You can often improve performance by specifying multiple key columns for a RANGE partitioned table. If you often select rows using comparison operators (based on a greater-than or less-than value) on a small set of columns, consider using those columns in RANGE partitioning rules.

Specifying Multiple Keys in a Range-Partitioned Table

Range-partitioned table definitions may include multiple columns in the partitioning key. To specify multiple partitioning keys for a range-partitioned table, include the column names in a comma-separated list after the PARTITION BY RANGE clause:

```
CREATE TABLE sales
(
    dept_no     number,
    part_no     varchar2,
    country     varchar2(20),
    sale_year    number,
    sale_month   number,
    sale_day     number,
    amount      number
)
PARTITION BY RANGE(sale_year, sale_month)
(
    PARTITION q1_2012
        VALUES LESS THAN(2012, 4),
    PARTITION q2_2012
        VALUES LESS THAN(2012, 7),
    PARTITION q3_2012
        VALUES LESS THAN(2012, 10),
    PARTITION q4_2012
        VALUES LESS THAN(2013, 1)
);
```

If a table is created with multiple partitioning keys, you must specify multiple key values when querying the table to take full advantage of partition pruning:

```
acctg=# EXPLAIN SELECT * FROM sales WHERE sale_year = 2012 AND sale_month = 8;
```

```
QUERY PLAN
---------------------------------------------------------------------------------
Append  (cost=0.00..14.35 rows=1 width=250)
   ->  Seq Scan on sales_q3_2012  (cost=0.00..14.35 rows=1 width=250)
         Filter: ((sale_year = '2012'::numeric) AND (sale_month = '8'::numeric))
(3 rows)
```

Since all rows with a value of 8 in the sale_month column and a value of 2012 in the sale_year column will be stored in the q3_2012 partition, Advanced Server searches only that partition.
10.6 Retrieving Information about a Partitioned Table

Advanced Server provides five system catalog views that you can use to view information about the structure of partitioned tables.

Querying the Partitioning Views

You can query the following views to retrieve information about partitioned and subpartitioned tables:

- ALL_PART_TABLES
- ALL_TAB_PARTITIONS
- ALL_TAB_SUBPARTITIONS
- ALL_PART_KEY_COLUMNS
- ALL_SUBPART_KEY_COLUMNS

The structure of each view is explained in Section 10.6.1, Table Partitioning Views. If you are using the EDB-PSQL client, you can also discover the structure of a view by entering:

\d view_name

Where view_name specifies the name of the table partitioning view.

Querying a view can provide information about the structure of a partitioned or subpartitioned table. For example, the following code snippet displays the names of a subpartitioned table:

```sql
acctg=# SELECT subpartition_name, partition_name FROM ALL_TAB_SUBPARTITIONS;
subpartition_name | partition_name
--------------------|------------------
EUROPE_2011        | EUROPE
EUROPE_2012        | EUROPE
ASIA_2011          | ASIA
ASIA_2012          | ASIA
AMERICAS_2011      | AMERICAS
AMERICAS_2012      | AMERICAS
(6 rows)
```
10.6.1 Table Partitioning Views - Reference

Query the following catalog views, compatible with Oracle databases, to review detailed information about your partitioned tables.

10.6.1.1 ALL_PART_TABLES

The following table lists the information available in the `ALL_PART_TABLES` view:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>owner</td>
<td>name</td>
<td>The owner of the table.</td>
</tr>
<tr>
<td>schema_name</td>
<td>name</td>
<td>The schema in which the table resides.</td>
</tr>
<tr>
<td>table_name</td>
<td>name</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>partitioning_type</td>
<td>text</td>
<td>RANGE, LIST or HASH</td>
</tr>
<tr>
<td>subpartitioning_type</td>
<td>text</td>
<td>RANGE, LIST, HASH, or NONE</td>
</tr>
<tr>
<td>partition_count</td>
<td>bigint</td>
<td>The number of partitions.</td>
</tr>
<tr>
<td>def_subpartition_count</td>
<td>integer</td>
<td>The default subpartition count - this will always be 0.</td>
</tr>
<tr>
<td>partitioning_key_count</td>
<td>integer</td>
<td>The number of columns listed in the partition by clause.</td>
</tr>
<tr>
<td>subpartitioning_key_count</td>
<td>integer</td>
<td>The number of columns in the subpartition by clause.</td>
</tr>
<tr>
<td>status</td>
<td>character varying(8)</td>
<td>This column will always be VALID.</td>
</tr>
<tr>
<td>def_tablespace_name</td>
<td>character varying(30)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_pct_free</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_pct_used</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_init_trans</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_max_trans</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_initial_extent</td>
<td>character varying(40)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_next_extent</td>
<td>character varying(40)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_min_extents</td>
<td>character varying(40)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_max_extents</td>
<td>character varying(40)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_pct_increase</td>
<td>character varying(40)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_freeists</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_freeist_groups</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>def_logging</td>
<td>character varying(7)</td>
<td>This column will always be YES.</td>
</tr>
<tr>
<td>def_compression</td>
<td>character varying(8)</td>
<td>This column will always be NONE</td>
</tr>
<tr>
<td>def_buffer_pool</td>
<td>character varying(8)</td>
<td>This column will always be DEFAULT</td>
</tr>
<tr>
<td>ref_ptn_constraint_name</td>
<td>character varying(30)</td>
<td>This column will always be NULL</td>
</tr>
<tr>
<td>interval</td>
<td>character varying(1000)</td>
<td>This column will always be NULL</td>
</tr>
</tbody>
</table>
10.6.1.2 **ALL_TAB_PARTITIONS**

The following table lists the information available in the **ALL_TAB_PARTITIONS** view:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_owner</td>
<td>name</td>
<td>The owner of the table.</td>
</tr>
<tr>
<td>schema_name</td>
<td>name</td>
<td>The schema in which the table resides.</td>
</tr>
<tr>
<td>table_name</td>
<td>name</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>composite</td>
<td>text</td>
<td>YES if the table is subpartitioned; NO if it is not subpartitioned.</td>
</tr>
<tr>
<td>partition_name</td>
<td>name</td>
<td>The name of the partition.</td>
</tr>
<tr>
<td>subpartition_count</td>
<td>bigint</td>
<td>The number of subpartitions for this partition.</td>
</tr>
<tr>
<td>high_value</td>
<td>text</td>
<td>The partition limit for RANGE partitions, or the partition value for LIST partitions.</td>
</tr>
<tr>
<td>high_value_length</td>
<td>integer</td>
<td>The length of high_value.</td>
</tr>
<tr>
<td>partition_position</td>
<td>integer</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>tablespace_name</td>
<td>name</td>
<td>The tablespace in which this partition resides.</td>
</tr>
<tr>
<td>pct_free</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>pct_used</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>ini_trans</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>max_trans</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>initial_extent</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>next_extent</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>min_extent</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>max_extent</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>pct_increase</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>freelists</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>freelists_groups</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>logging</td>
<td>character varying(7)</td>
<td>This column will always be YES.</td>
</tr>
<tr>
<td>compression</td>
<td>character varying(8)</td>
<td>This column will always be NONE.</td>
</tr>
<tr>
<td>num_rows</td>
<td>numeric</td>
<td>The approx. number of rows in this partition.</td>
</tr>
<tr>
<td>blocks</td>
<td>integer</td>
<td>The approx. number of blocks in this partition.</td>
</tr>
<tr>
<td>empty_blocks</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>avg_space</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>chain_cnt</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>avg_row_len</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>sample_size</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>last_analyzed</td>
<td>timestamp without timezone</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>buffer_pool</td>
<td>character varying(7)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>global_stats</td>
<td>character varying(3)</td>
<td>This column will always be YES.</td>
</tr>
<tr>
<td>user_stats</td>
<td>character varying(3)</td>
<td>This column will always be NO.</td>
</tr>
<tr>
<td>backing_table</td>
<td>regclass</td>
<td>OID of the backing table for this partition.</td>
</tr>
</tbody>
</table>
### 10.6.1.3 **ALL_TAB_SUBPARTITIONS**

The following table lists the information available in the **ALL_TAB_SUBPARTITIONS** view:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table_owner</td>
<td>name</td>
<td>The name of the owner of the table.</td>
</tr>
<tr>
<td>schema_name</td>
<td>name</td>
<td>The name of the schema in which the table resides.</td>
</tr>
<tr>
<td>table_name</td>
<td>name</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>partition_name</td>
<td>name</td>
<td>The name of the partition.</td>
</tr>
<tr>
<td>subpartition_name</td>
<td>name</td>
<td>The name of the subpartition.</td>
</tr>
<tr>
<td>high_value</td>
<td>text</td>
<td>The subpartition limit for RANGE subpartitions, or the subpartition value for LIST subpartitions.</td>
</tr>
<tr>
<td>high_value_length</td>
<td>integer</td>
<td>The length of high_value.</td>
</tr>
<tr>
<td>subpartition_position</td>
<td>integer</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>tablespace_name</td>
<td>name</td>
<td>The tablespace in which this subpartition resides.</td>
</tr>
<tr>
<td>pct_free</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>pct_used</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>init_trans</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>max_trans</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>initial_extent</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>next_extent</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>min_extent</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>max_extent</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>pct_increase</td>
<td>numeric</td>
<td>This column will always be 0.</td>
</tr>
<tr>
<td>freelists</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>freelists_groups</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>logging</td>
<td>character varying(7)</td>
<td>This column will always be YES.</td>
</tr>
<tr>
<td>compression</td>
<td>character varying(8)</td>
<td>This column will always be NONE.</td>
</tr>
<tr>
<td>num_rows</td>
<td>numeric</td>
<td>The approx. number of rows in this subpartition.</td>
</tr>
<tr>
<td>blocks</td>
<td>integer</td>
<td>The approx. number of blocks in this subpartition.</td>
</tr>
<tr>
<td>empty_blocks</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>avg_space</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>chain_cnt</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>avg_row_len</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>sample_size</td>
<td>numeric</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>last_analyzed</td>
<td>timestamp without time zone</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>buffer_pool</td>
<td>character varying(7)</td>
<td>This column will always be NULL.</td>
</tr>
<tr>
<td>global_stats</td>
<td>character varying(3)</td>
<td>This column will always be YES.</td>
</tr>
<tr>
<td>user_stats</td>
<td>character varying(3)</td>
<td>This column will always be NO.</td>
</tr>
<tr>
<td>backing_table</td>
<td>regclass</td>
<td>OID of the backing table for this subpartition.</td>
</tr>
</tbody>
</table>
### 10.6.1.4 ALL_PART_KEY_COLUMNS

The following table lists the information available in the `ALL_PART_KEY_COLUMNS` view:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>owner</td>
<td>name</td>
<td>The name of the table owner.</td>
</tr>
<tr>
<td>schema_name</td>
<td>name</td>
<td>The name of the schema on which the table resides.</td>
</tr>
<tr>
<td>name</td>
<td>name</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>object_type</td>
<td>character(5)</td>
<td>This column will always be TABLE.</td>
</tr>
<tr>
<td>column_name</td>
<td>name</td>
<td>The name of the partitioning key column.</td>
</tr>
<tr>
<td>column_position</td>
<td>integer</td>
<td>The position of this column within the partitioning key (the first column has a column position of 1, the second column has a column position of 2...)</td>
</tr>
</tbody>
</table>

### 10.6.1.5 ALL_SUBPART_KEY_COLUMNS

The following table lists the information available in the `ALL_SUBPART_KEY_COLUMNS` view:

<table>
<thead>
<tr>
<th>Column</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>owner</td>
<td>name</td>
<td>The name of the table owner.</td>
</tr>
<tr>
<td>schema_name</td>
<td>name</td>
<td>The name of the schema on which the table resides.</td>
</tr>
<tr>
<td>name</td>
<td>name</td>
<td>The name of the table.</td>
</tr>
<tr>
<td>object_type</td>
<td>character(5)</td>
<td>This column will always be TABLE.</td>
</tr>
<tr>
<td>column_name</td>
<td>name</td>
<td>The name of the partitioning key column.</td>
</tr>
<tr>
<td>column_position</td>
<td>integer</td>
<td>The position of this column within the subpartitioning key (the first column has a column position of 1, the second column has a column position of 2...)</td>
</tr>
</tbody>
</table>
11 ECPGPlus

EnterpriseDB has enhanced ECPG (the PostgreSQL pre-compiler) to create ECPGPlus. ECPGPlus allows you to include embedded SQL commands in C applications; when you use ECPGPlus to compile an application that contains embedded SQL commands, the SQL code is syntax-checked and translated into C.

ECPGPlus supports Pro*C compatible syntax in C programs when connected to an Advanced Server database. ECPGPlus supports:

- Pro*C compatible anonymous blocks.
- A CALL statement compatible with Oracle databases.

As part of ECPGPlus' Pro*C compatibility, you do not need to include the BEGIN DECLARE SECTION and END DECLARE SECTION directives.

For more information about using ECPGPlus, please see the EDB Postgres Advanced Server ECPG Connector Guide available from the EnterpriseDB website at:

https://www.enterprisedb.com/resources/product-documentation
12 dblink_ora

dblink_ora provides an OCI-based database link that allows you to SELECT, INSERT, UPDATE or DELETE data stored on an Oracle system from within Advanced Server.

Connecting to an Oracle Database

To enable Oracle connectivity, download Oracle's freely available OCI drivers from their website, presently at:


For Linux, if the Oracle instant client that you've downloaded does not include the libclntsh.so library, you must create a symbolic link named libclntsh.so that points to the downloaded version. Navigate to the instant client directory and execute the following command:

ln -s libclntsh.so.version libclntsh.so

Where version is the version number of the libclntsh.so library. For example:

ln -s libclntsh.so.12.1 libclntsh.so

Before creating a link to an Oracle server, you must tell Advanced Server where to find the OCI driver.

Set the LD_LIBRARY_PATH environment variable on Linux (or PATH on Windows) to the lib directory of the Oracle client installation directory.

For Windows only, you can instead set the value of the oracle_home configuration parameter in the postgresql.conf file. The value specified in the oracle_home configuration parameter will override the Windows PATH environment variable.

The LD_LIBRARY_PATH environment variable on Linux (PATH environment variable or oracle_home configuration parameter on Windows) must be set properly each time you start Advanced Server.

When using a Linux service script to start Advanced Server, be sure LD_LIBRARY_PATH has been set within the service script so it is in effect when the script invokes the pg_ctl utility to start Advanced Server.

For Windows only: To set the oracle_home configuration parameter in the postgresql.conf file, edit the file, adding the following line:
oracle_home = 'lib_directory'

Substitute the name of the Windows directory that contains oci.dll for
lib_directory.

After setting the oracle_home configuration parameter, you must restart the server for
the changes to take effect. Restart the server from the Windows Services console.

12.1 dblink_ora Functions and Procedures

dblink_ora supports the following functions and procedures.

12.1.1 dblink_ora_connect()

The dblink_ora_connect() function establishes a connection to an Oracle database
with user-specified connection information. The function comes in two forms; the
signature of the first form is:

```
dblink_ora_connect(conn_name, server_name, service_name, 
user_name, password, port, asDBA)
```

Where:

- **conn_name** specifies the name of the link.
- **server_name** specifies the name of the host.
- **service_name** specifies the name of the service.
- **user_name** specifies the name used to connect to the server.
- **password** specifies the password associated with the username.
- **port** specifies the port number.
- **asDBA** is True if you wish to request SYSDBA privileges on the Oracle server.
  This parameter is optional; if omitted, the default value is FALSE.

The first form of dblink_ora_connect() returns a TEXT value.

The signature of the second form of the dblink_ora_connect() function is:

```
dblink_ora_connect(foreign_server_name, asDBA)
```
Where:

*foreign_server_name* specifies the name of a foreign server.

*asDBA* is True if you wish to request SYSDBA privileges on the Oracle server. This parameter is optional; if omitted, the default value is FALSE.

The second form of the `dblink_ora_connect()` function allows you to use the connection properties of a pre-defined foreign server when establishing a connection to the server.

Before invoking the second form of the `dblink_ora_connect()` function, use the `CREATE SERVER` command to store the connection properties for the link to a system table. When you call the `dblink_ora_connect()` function, substitute the server name specified in the `CREATE SERVER` command for the name of the link.

The second form of `dblink_ora_connect()` returns a TEXT value.

### 12.1.2 dblink_ora_status()

The `dblink_ora_status()` function returns the database connection status. The signature is:

```
   dblink_ora_status(conn_name)
```

Where:

*conn_name* specifies the name of the link.

If the specified connection is active, the function returns a TEXT value of OK.

### 12.1.3 dblink_ora_disconnect()

The `dblink_ora_disconnect()` function closes a database connection. The signature is:

```
   dblink_ora_disconnect(conn_name)
```

Where:

*conn_name* specifies the name of the link.
The function returns a **TEXT** value.

### 12.1.4 dblink_ora_record()

The `dblink_ora_record()` function retrieves information from a database. The signature is:

```
dlink_ora_record(conn_name, query_text)
```

Where:

- `conn_name` specifies the name of the link.
- `query_text` specifies the text of the SQL `SELECT` statement that will be invoked on the Oracle server.

The function returns a **SETOF** record.

### 12.1.5 dblink_ora_call()

The `dblink_ora_call()` function executes a non-`SELECT` statement on an Oracle database and returns a result set. The signature is:

```
dblink_ora_call(conn_name, command, iterations)
```

Where:

- `conn_name` specifies the name of the link.
- `command` specifies the text of the SQL statement that will be invoked on the Oracle server.
- `iterations` specifies the number of times the statement is executed.

The function returns a **SETOF** record.

### 12.1.6 dblink_ora_exec()

The `dblink_ora_exec()` procedure executes a DML or DDL statement in the remote database. The signature is:
dblink_ora_exec(conn_name, command)

Where:

conn_name specifies the name of the link.

command specifies the text of the `INSERT`, `UPDATE`, or `DELETE` SQL statement that will be invoked on the Oracle server.

The function returns a VOID.

### 12.1.7 dblink_ora_copy()

The `dblink_ora_copy()` function copies an Oracle table to an EnterpriseDB table. The `dblink_ora_copy()` function returns a BIGINT value that represents the number of rows copied. The signature is:

```c
dblink_ora_copy(conn_name, command, schema_name, table_name, truncate, count)
```

Where:

conn_name specifies the name of the link.

command specifies the text of the SQL `SELECT` statement that will be invoked on the Oracle server.

schema_name specifies the name of the target schema.

table_name specifies the name of the target table.

truncate specifies if the server should TRUNCATE the table prior to copying; specify `TRUE` to indicate that the server should TRUNCATE the table. `truncate` is optional; if omitted, the value is `FALSE`.

count instructs the server to report status information every `n` record, where `n` is the number specified. During the execution of the function, Advanced Server raises a notice of severity `INFO` with each iteration of the count. For example, if `FeedbackCount` is `10`, `dblink_ora_copy()` raises a notice every `10` records. `count` is optional; if omitted, the value is `0`. 
12.2 Calling dblink_ora Functions

The following command establishes a connection using the dblink_ora_connect() function:

```sql
SELECT dblink_ora_connect('acctg', 'localhost', 'xe', 'hr', 'pwd', 1521);
```

The example connects to a service named xe running on port 1521 (on the localhost) with a user name of hr and a password of pwd. You can use the connection name acctg to refer to this connection when calling other dblink_ora functions.

The following command uses the dblink_ora_copy() function over a connection named edb_conn to copy the empid and deptno columns from a table (on an Oracle server) named ora_acctg to a table located in the public schema on an instance of Advanced Server named as_acctg. The TRUNCATE option is enforced, and a feedback count of 3 is specified:

```sql
edb=# SELECT dblink_ora_copy('edb_conn','select empid, deptno FROM ora_acctg', 'public', 'as_acctg', true, 3);
```

The following SELECT statement uses dblink_ora_record() function and the acctg connection to retrieve information from the Oracle server:

```sql
SELECT * FROM dblink_ora_record( 'acctg', 'SELECT first_name from employees') AS t1(id VARCHAR);
```

The command retrieves a list that includes all of the entries in the first_name column of the employees table.
13 System Catalog Tables

The system catalog tables contain definitions of database objects that are available to Advanced Server; the layout of the system tables is subject to change. If you are writing an application that depends on information stored in the system tables, it would be prudent to use an existing catalog view, or create a catalog view to isolate the application from changes to the system table.

For detailed information about the system catalog tables, please see the Database Compatibility for Oracle® Developer’s Reference Guide, available at:

https://www.enterprisedb.com/resources/product-documentation
14 Acknowledgements

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