UNIT-V

DBMS – TRANSACTION

A transaction can be defined as a group of tasks. A single task is the minimum processing unit which cannot be divided further.

TRANSACTION MANAGEMENT

A sequence of many actions which are considered to be one atomic unit of work. A transaction is a collection of operations involving data items in a database. There are four important properties of transactions that a DBMS must ensure to maintain data in the face concurrent access and system failures.

Let's take an example of a simple transaction. Suppose a bank employee transfers Rs 500 from A's account to B's account. This very simple and small transaction involves several low-level tasks.

A's Account

```
Open_Account(A)
Old_Balance = A.balance
New_Balance = Old_Balance - 500
A.balance = New_Balance
Close_Account(A)
```

B's Account

```
Open_Account(B)
Old_Balance = B.balance
New_Balance = Old_Balance + 500
B.balance = New_Balance
Close_Account(B)
```

ACID PROPERTIES

A transaction is a very small unit of a program and it may contain several lowlevel tasks. A transaction in a database system must maintain ***Atomicity, Consistency, Isolation, and Durability*** − commonly known as ACID properties − in order to ensure accuracy, completeness, and data integrity.

- **Atomicity** − this property states that a transaction must be treated as an atomic unit, that is, either all of its operations are executed or none. There must be no state in a database where a transaction is left partially completed. States should be defined either before the execution of the transaction or after the execution/abortion/failure of the transaction.
- **Consistency** − the database must remain in a consistent state after any transaction. No transaction should have any adverse effect on the data residing in the database. If the database was in a consistent state before the execution of a transaction, it must remain consistent after the execution of the transaction as well.

- **Durability** − the database should be durable enough to hold all its latest updates even if the system fails or restarts. If a transaction updates a chunk of data in a database and commits, then the database will hold the modified data. If a transaction commits but the system fails before the data could be written on to the disk, then that data will be updated once the system springs back into action.
- **Isolation** − In a database system where more than one transaction are being executed simultaneously and in parallel, the property of isolation states that all the transactions will be carried out and executed as if it is the only transaction in the system. No transaction will affect the existence of any other transaction.

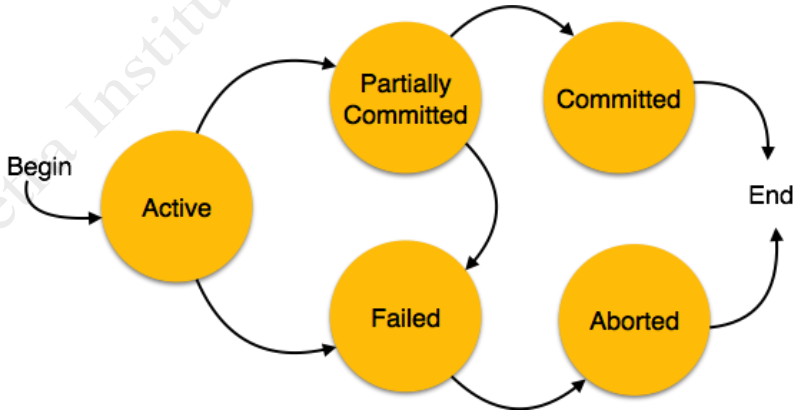
SERIALIZABILITY

When multiple transactions are being executed by the operating system in a multiprogramming environment, there are possibilities that instructions of one transactions are interleaved with some other transaction.

- **Schedule** − A chronological execution sequence of a transaction is called a schedule. A schedule can have many transactions in it, each comprising of a number of instructions/tasks.
- **Serial Schedule** − It is a schedule in which transactions are aligned in such a way that one transaction is executed first. When the first transaction completes its cycle, then the next transaction is executed. Transactions are ordered one after the other. This type of schedule is called a serial schedule, as transactions are executed in a serial manner.

STATES OF TRANSACTIONS

A transaction in a database can be in one of the following states −



- **Active** − in this state, the transaction is being executed. This is the initial state of every transaction.
- **Partially Committed** − When a transaction executes its final operation, it is said to be in a partially committed state.
- **Failed** − A transaction is said to be in a failed state if any of the checks made by the database recovery system fails. A failed transaction can no longer proceed further.

- **Aborted** − If any of the checks fails and the transaction has reached a failed state, then the recovery manager rolls back all its write operations on the database to bring the database back to its original state where it was prior to the execution of the transaction. Transactions in this state are called aborted. The database recovery module can select one of the two operations after a transaction aborts −
    - *Re-start the transaction*
    - *Kill the transaction*
- **Committed** − If a transaction executes all its operations successfully, it is said to be committed. All its effects are now permanently established on the database system.

DBMS - CONCURRENCY CONTROL

Concurrency Control: Process of managing simultaneous execution of transactions in a shared database, is known as **concurrency control**. Basically, concurrency control ensures that correct results for concurrent operations are generated, while getting those results as quickly as possible.

Concurrency control is the procedure in DBMS for managing simultaneous operations without conflicting with each another. Concurrent access is quite easy if all users are just reading data. There is no way they can interfere with one another. Though for any practical database, would have a mix of reading and WRITE operations and hence the concurrency is a challenge.

Concurrency control is used to address such conflicts which mostly occur with a multi-user system. It helps you to make sure that database transactions are performed concurrently without violating the data integrity of respective databases.Therefore, concurrency control is a most important element for the proper functioning of a system where two or multiple database transactions that require access to the same data, are executed simultaneously.

Potential problems of Concurrency

Here, are some issues which you will likely to face while using the Concurrency Control method:

- **Lost Updates** occur when multiple transactions select the same row and update the row based on the value selected
- Uncommitted dependency issues occur when the second transaction selects a row which is updated by another transaction (**dirty read**)
- **Non-Repeatable Read** occurs when a second transaction is trying to access the same row several times and reads different data each time.
- **Incorrect Summary issue** occurs when one transaction takes summary over the value of all the instances of a repeated data-item, and second transaction update few instances of that specific data-item. In that situation, the resulting summary does not reflect a correct result.

Why use Concurrency method?

Reasons for using Concurrency control method is DBMS:

- To apply Isolation through mutual exclusion between conflicting transactions
- To resolve read-write and write-write conflict issues
- To preserve database consistency through constantly preserving execution obstructions
- The system needs to control the interaction among the concurrent transactions. This control is achieved using concurrent-control schemes.
- Concurrency control helps to ensure serializability

Example

Assume that two people who go to electronic kiosks at the same time to buy a movie ticket for the same movie and the same show time.

However, there is only one seat left in for the movie show in that particular theatre. Without concurrency control, it is possible that both moviegoers will end up purchasing a ticket. However, concurrency control method does not allow this to happen. Both moviegoers can still access information written in the movie seating database. But concurrency control only provides a ticket to the buyer who has completed the transaction process first.

CONCURRENCY CONTROL PROTOCOLS

Different concurrency control protocols offer different benefits between the amount of concurrency they allow and the amount of overhead that they impose.

- ***Lock-Based Protocols***
- ***Two Phase***
- ***Timestamp-Based Protocols***
- ***Validation-Based Protocols***

Lock-based Protocols

A lock is a data variable which is associated with a data item. This lock signifies that operations that can be performed on the data item. Locks help synchronize access to the database items by concurrent transactions.

All lock requests are made to the concurrency-control manager. Transactions proceed only once the lock request is granted.

Binary Locks: A Binary lock on a data item can either locked or unlocked states.

Shared/exclusive: This type of locking mechanism separates the locks based on their uses. If a lock is acquired on a data item to perform a write operation, it is called an exclusive lock.

1. Shared Lock (S):

A shared lock is also called a Read-only lock. With the shared lock, the data item can be shared between transactions. This is because you will never have permission to update data on the data item.

For example, consider a case where two transactions are reading the account balance of a person. The database will let them read by placing a shared lock. However, if another transaction wants to update that account's balance, shared lock prevent it until the reading process is over.

2. Exclusive Lock (X):

With the Exclusive Lock, a data item can be read as well as written. This is exclusive and can't be held concurrently on the same data item. X-lock is requested using lock-x instruction. Transactions may unlock the data item after finishing the 'write' operation.

For example, when a transaction needs to update the account balance of a person. You can allows this transaction by placing X lock on it. Therefore, when the second transaction wants to read or write, exclusive lock prevent this operation.

STARVATION

Starvation is the situation when a transaction needs to wait for an indefinite period to acquire a lock.

Following are the reasons for Starvation:

- When waiting scheme for locked items is not properly managed
- In the case of resource leak
- The same transaction is selected as a victim repeatedly

DEADLOCK

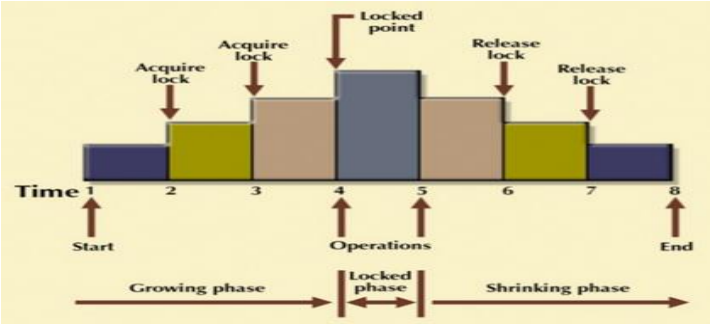
Deadlock refers to a specific situation where two or more processes are waiting for each other to release a resource or more than two processes are waiting for the resource in a circular chain.

Two Phase Locking (2PL) Protocol

Two-Phase locking protocol which is also known as a 2PL protocol. It is also called P2L. In this type of locking protocol, the transaction should acquire a lock after it releases one of its locks.

This locking protocol divides the execution phase of a transaction into three different parts.

- In the first phase, when the transaction begins to execute, it requires permission for the locks it needs.
- The second part is where the transaction obtains all the locks. When a transaction releases its first lock, the third phase starts.
- In this third phase, the transaction cannot demand any new locks. Instead, it only releases the acquired locks.



The Two-Phase Locking protocol allows each transaction to make a lock or unlock request in two steps:

- **Growing Phase**: In this phase transaction may obtain locks but may not release any locks.
- **Shrinking Phase**: In this phase, a transaction may release locks but not obtain any new lock

It is true that the 2PL protocol offers serializability. However, it does not ensure that deadlocks do not happen.

In the above-given diagram, you can see that local and global deadlock detectors are searching for deadlocks and solve them with resuming transactions to their initial states.

Strict Two-Phase Locking Method

Strict-Two phase locking system is almost similar to 2PL. The only difference is that Strict-2PL never releases a lock after using it. It holds all the locks until the commit point and releases all the locks at one go when the process is over.

Centralized 2PL

In Centralized 2 PL, a single site is responsible for lock management process. It has only one lock manager for the entire DBMS.

Primary copy 2PL

Primary copy 2PL mechanism, many lock managers are distributed to different sites. After that, a particular lock manager is responsible for managing the lock for a set of data items. When the primary copy has been updated, the change is propagated to the slaves.

Distributed 2PL

In this kind of two-phase locking mechanism, Lock managers are distributed to all sites. They are responsible for managing locks for data at that site. If no data is replicated, it is equivalent to primary copy 2PL. Communication costs of Distributed 2PL are quite higher than primary copy 2PL

Timestamp-based Protocols

The timestamp-based algorithm uses a timestamp to serialize the execution of concurrent transactions. This protocol ensures that every conflicting read and write operations are executed in timestamp order. The protocol uses the **System Time or Logical Count as** a Timestamp.

The older transaction is always given priority in this method. It uses system time to determine the time stamp of the transaction. This is the most commonly used concurrency protocol.

Lock-based protocols help you to manage the order between the conflicting transactions when they will execute. Timestamp-based protocols manage conflicts as soon as an operation is created.

Example:

Suppose there are there transactions T1, T2, and T3.
T1 has entered the system at time 0010
T2 has entered the system at 0020
T3 has entered the system at 0030
Priority will be given to transaction T1, then transaction T2 and lastly Transaction T3.

Advantages:

- Schedules are serializable just like 2PL protocols
- No waiting for the transaction, which eliminates the possibility of deadlocks!

Disadvantages:

Starvation is possible if the same transaction is restarted and continually aborted

Characteristics of Good Concurrency Protocol

An ideal concurrency control DBMS mechanism has the following objectives:

- Must be resilient to site and communication failures.
- It allows the parallel execution of transactions to achieve maximum concurrency.
- Its storage mechanisms and computational methods should be modest to minimize overhead.
- It must enforce some constraints on the structure of atomic actions of transactions.

PL/SQL SECURITY

Locks

- Locks are mechanisms used to ensure data integrity while allowing maximum concurrent access of data.
- Oracle locking is fully automatic & requires no user intervention.
- The oracle engine (server machine) locks table data while executing SQL stmt. This type of locking is called “implicit locking”.
- Oracle default locking strategy is implicit locking.
- Since the oracle engine has a fully automatic strategy ,it has to decide on two issues:-

  1) Types of lock to be applied.

  2) Level of lock to be applied.

Types of Lock

- ***Shared Locks***
- ***Exclusive Locks***

1) Shared Locks:-

a) Shared locks are placed on resource whenever a READ operation (select)is performed.

b) Multiple shared locks can be simultaneously set on a resource.

2) Exclusive Locks:-

a) Exclusive locks are placed on resource whenever WRITE operations (Insert, Update & Delete) are performed.

b) Only 1 exclusive lock can be placed on a resource at a time.

Level of Locks:-

A table can be decomposed into rows & a row can be further decomposed into fields.

1) Row Level
2) Page Level
3) Table Level

1) Row Level: If the Where clause evaluates to only one row in the table.

2) Page Level: If the Where clause evaluates to a set of data.

3) Table Level: If there is no Where clause (i.e. the query accesses the entire table).

Ex:-Two client machines client A & client B are recording the transaction performed in a bank for a particular account no. simultaneously.

- Client A fires the following select statement:
- Client A>select * from acct_mstr where acct_no='Sb9' for update;
- When the above select statement is fired the oracle engine locks the record 'sb9'. This lock is released when a commit or rollback is fired by client A
- Now client B fires a select stmt.,which points to record sb9

- Using Lock table stmt:-

Purpose:-

Use the LOCK TABLE statement to lock one or more tables, table partitions, or table sub partitions in a specified mode. This lock manually overrides automatic locking and permits or denies access to a table or view by other users for the duration of your operation .A LOCK is a mechanism that prevents destructive interaction between two simultaneous transactions or sessions trying to access the same database object.

Syntax:-

LOCK TABLE<TableName> IN lockmode

Example:

LOCK TABLE employees IN EXCLUSIVE MODE;

Output:-

Table Locked.

Releasing locks:-

All locks are released under the following circumstances:

1) The transaction is committed successfully.

2) A rollback is performed

3) A rollback to a save point will release locks set after the specified savepoint.

Note:-

COMMIT:-Save Work done.

SAVEPOINT: Identify a point in a transaction to which you can later rollback.

ROLLBACK: Restore database to original since the last COMMIT

GRANT/REVOKE: Grant or back permission to or from the oracle users.

Deadlock:-

A deadlock is a condition where two or more users are waiting for data locked by each other. Oracle automatically detects a deadlock and resolves them by rolling back one of the statements involved in the deadlock, thus releasing one set of data locked by that statement. Statement rolled back is usually the one which detects the deadlock.

A deadlock may occur if all the following conditions holds true.

Mutual exclusion condition: There must be at least one resource that cannot be used by more than one process at a time.

Hold and wait condition: A process that is holding a resource can request for additional resources that are being held by other processes in the system.

No pre-emption condition: A resource cannot be forcibly taken from a process. Only the process can release a resource that is being held by it.

Circular wait condition: A condition where one process is waiting for a resource that is being held by second process and second process is waiting for third process ….so on and the last process is waiting for the first process. Thus making a circular chain of waiting.

PL/SQL – OVERVIEW

SQL is the standard language to query a database.

PL SQL basically stands for "***Procedural Language extensions to SQL***." This is the extension of Structured Query Language (SQL) that is used in Oracle.

Difference between SQL and PL/SQL

SQL	PL/SQL
• SQL is a single query that is used to perform DML and DDL operations.	• PL/SQL is a block of codes that used to write the entire program blocks/ procedure/ function, etc.
• It is declarative, that defines what need to be done, rather than how things need to be done.	• PL/SQL is procedural that defines how the things needs to be done.
• Execute as a single statement.	• Execute as a whole block.
• Mainly used to manipulate data.	• Mainly used to create an application.
• Interaction with a Database server.	• No interaction with the database server.
• Cannot contain PL/SQL code in it.	• It is an extension of SQL, so that it can contain SQL inside it.

FEATURES OF PL/SQL

PL/SQL has the following features −

- PL/SQL is tightly integrated with SQL.
- It offers extensive error checking.
- It offers numerous data types.
- It offers a variety of programming structures.
- It supports structured programming through functions and procedures.
- It supports object-oriented programming.
- It supports the development of web applications and server pages.

ADVANTAGES OF PL/SQL

PL/SQL has the following advantages −

- SQL is the standard database language and PL/SQL is strongly integrated with SQL. PL/SQL supports both static and dynamic SQL. Static SQL supports DML operations and transaction control from PL/SQL block. In Dynamic SQL, SQL allows embedding DDL statements in PL/SQL blocks.
- PL/SQL allows sending an entire block of statements to the database at one time. This reduces network traffic and provides high performance for the applications.
- PL/SQL gives high productivity to programmers as it can query, transform, and update data in a database.
- PL/SQL saves time on design and debugging by strong features, such as exception handling, encapsulation, data hiding, and object-oriented data types.
- Applications written in PL/SQL are fully portable.
- PL/SQL provides high security level.
- PL/SQL provides access to predefined SQL packages.
- PL/SQL provides support for Object-Oriented Programming.
- PL/SQL provides support for developing Web Applications and Server Pages.

PL/SQL - BASIC SYNTAX

The Basic Syntax of PL/SQL which is a **block-structured** language; this means that the PL/SQL programs are divided and written in logical blocks of code. Each block consists of three sub-parts

S.No	Sections & Description
1	**Declarations** This section starts with the keyword **DECLARE**. It is an optional section and defines all variables, cursors, subprograms, and other elements to be used in the program.
2	**Executable Commands** This section is enclosed between the keywords **BEGIN** and **END** and it is a mandatory section. It consists of the executable PL/SQL statements of the program. It should have at least one executable line of code, which may be just a **NULL command** to indicate that nothing should be executed.
3	**Exception Handling**

	This section starts with the keyword **EXCEPTION**. This optional section contains **exception(s)** that handle errors in the program.

Every PL/SQL statement ends with a semicolon (;). PL/SQL blocks can be nested within other PL/SQL blocks using **BEGIN** and **END**.

Following is the basic structure of a PL/SQL block –

```
DECLARE
  <declarations section>
BEGIN
  <executable command(s)>
EXCEPTION
  <exception handling>
END;
```

The 'Hello World' Example

```
DECLARE
  message  varchar2(20):= 'Hello, World!';
BEGIN
  dbms_output.put_line(message);
END;
/
```

The **end;** line signals the end of the PL/SQL block. To run the code from the SQL command line, you may need to type / at the beginning of the first blank line after the last line of the code. When the above code is executed at the SQL prompt, it produces the following result −

```
Hello World

PL/SQL procedure successfully completed.
```

THE PL/SQL IDENTIFIERS

The identifiers consist of a letter optionally followed by more letters, numerals, dollar signs, underscores, and number signs and should not exceed 30 characters. By default, **identifiers are not case-sensitive**. So you can use **integer** or **INTEGER** to represent a numeric value. You cannot use a reserved keyword as an identifier.

THE PL/SQL DELIMITERS

A delimiter is a symbol with a special meaning. Following is the list of delimiters in PL/SQL −

Delimiter	Description
+, -, *, /	Addition, subtraction/negation, multiplication, division
%	Attribute indicator
'	Character string delimiter
.	Component selector
(,)	Expression or list delimiter
:	Host variable indicator
,	Item separator
"	Quoted identifier delimiter
=	Relational operator
@	Remote access indicator
;	Statement terminator
:=	Assignment operator
=>	Association operator
||	Concatenation operator
**	Exponentiation operator
<<, >>	Label delimiter (begin and end)
/*, */	Multi-line comment delimiter (begin and end)
--	Single-line comment indicator
..	Range operator
<, >, <=, >=	Relational operators
<>, '=, ~=, ^=	Different versions of NOT EQUAL

THE PL/SQL COMMENTS

Program comments are explanatory statements that can be included in the PL/SQL code that you write and helps anyone reading its source code. All programming languages allow some form of comments.

The PL/SQL supports single-line and multi-line comments. All characters available inside any comment are ignored by the PL/SQL compiler. The PL/SQL single-line comments start with the delimiter -- (double hyphen) and multi-line comments are enclosed by /* and */.

```
DECLARE
  -- variable declaration
  message  varchar2(20):= 'Hello, World!';
BEGIN
  /*
  *  PL/SQL executable statement(s)
  */
  dbms_output.put_line(message);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Hello World


PL/SQL procedure successfully completed.
```

PL/SQL - DATA TYPES

In this chapter, we will discuss the Data Types in PL/SQL. The PL/SQL variables, constants and parameters must have a valid data type, which specifies a storage format, constraints, and a valid range of values. We will focus on the **SCALAR** and the **LOB** data types in this chapter. The other two data types will be covered in other chapters.

S.No	Category & Description
1	**Scalar** Single values with no internal components, such as a **NUMBER, DATE,** or **BOOLEAN**.
2	**Large Object (LOB)** Pointers to large objects that are stored separately from other data items, such as text, graphic images, video clips, and sound waveforms.
3	**Composite** Data items that have internal components that can be accessed individually. For example, collections and records.
4	**Reference** Pointers to other data items.

PL/SQL Scalar Data Types and Subtypes

PL/SQL Scalar Data Types and Subtypes come under the following categories –

S.No	Date Type & Description
1	**Numeric** Numeric values on which arithmetic operations are performed.
2	**Character** Alphanumeric values that represent single characters or strings of characters.
3	**Boolean** Logical values on which logical operations are performed.
4	**Datetime** Dates and times.

PL/SQL provides subtypes of data types. For example, the data type NUMBER has a subtype called INTEGER. You can use the subtypes in your PL/SQL program to make the data types compatible with data types in other programs while embedding the PL/SQL code in another program, such as a Java program.

PL/SQL Numeric Data Types and Subtypes

Following table lists out the PL/SQL pre-defined numeric data types and their sub-types −

S.No	Data Type & Description
1	**PLS_INTEGER** Signed integer in range -2,147,483,648 through 2,147,483,647, represented in 32 bits
2	**BINARY_INTEGER** Signed integer in range -2,147,483,648 through 2,147,483,647, represented in 32 bits
3	**BINARY_FLOAT** Single-precision IEEE 754-format floating-point number
4	**BINARY_DOUBLE** Double-precision IEEE 754-format floating-point number
5	**NUMBER(prec, scale)** Fixed-point or floating-point number with absolute value in range 1E-130 to (but not including) 1.0E126. A NUMBER variable can also represent 0
6	**DEC(prec, scale)** ANSI specific fixed-point type with maximum precision of 38 decimal digits
7	**DECIMAL(prec, scale)** IBM specific fixed-point type with maximum precision of 38 decimal digits
8	**NUMERIC(pre, secale)** Floating type with maximum precision of 38 decimal digits
9	**DOUBLE PRECISION** ANSI specific floating-point type with maximum precision of 126 binary digits (approximately 38 decimal digits)
10	**FLOAT**

	ANSI and IBM specific floating-point type with maximum precision of 126 binary digits (approximately 38 decimal digits)
11	**INT** ANSI specific integer type with maximum precision of 38 decimal digits
12	**INTEGER** ANSI and IBM specific integer type with maximum precision of 38 decimal digits
13	**SMALLINT** ANSI and IBM specific integer type with maximum precision of 38 decimal digits
14	**REAL** Floating-point type with maximum precision of 63 binary digits (approximately 18 decimal digits)

Following is a valid declaration −

```
DECLARE
  num1 INTEGER;
  num2 REAL;
  num3 DOUBLE PRECISION;
BEGIN
  null;
END;
/
```

When the above code is compiled and executed, it produces the following result −

```
PL/SQL procedure successfully completed
```

PL/SQL Character Data Types and Subtypes

Following is the detail of PL/SQL pre-defined character data types and their sub-types −

S.No	Data Type & Description
1	**CHAR** Fixed-length character string with maximum size of 32,767 bytes

2	**VARCHAR2** Variable-length character string with maximum size of 32,767 bytes
3	**RAW** Variable-length binary or byte string with maximum size of 32,767 bytes, not interpreted by PL/SQL
4	**NCHAR** Fixed-length national character string with maximum size of 32,767 bytes
5	**NVARCHAR2** Variable-length national character string with maximum size of 32,767 bytes
6	**LONG** Variable-length character string with maximum size of 32,760 bytes
7	**LONG RAW** Variable-length binary or byte string with maximum size of 32,760 bytes, not interpreted by PL/SQL
8	**ROWID** Physical row identifier, the address of a row in an ordinary table
9	**UROWID** Universal row identifier (physical, logical, or foreign row identifier)

PL/SQL Boolean Data Types

The **BOOLEAN** data type stores logical values that are used in logical operations. The logical values are the Boolean values **TRUE** and **FALSE** and the value **NULL**.

However, SQL has no data type equivalent to BOOLEAN. Therefore, Boolean values cannot be used in –

- SQL statements
- Built-in SQL functions (such as **TO_CHAR**)
- PL/SQL functions invoked from SQL statements

PL/SQL Date time and Interval Types

The **DATE** datatype is used to store fixed-length datetimes, which include the time of day in seconds since midnight. Valid dates range from January 1, 4712 BC to December 31, 9999 AD.

The default date format is set by the Oracle initialization parameter NLS_DATE_FORMAT. For example, the default might be 'DD-MON-YY', which includes a two-digit number for the day of the month, an abbreviation of the month name, and the last two digits of the year. For example, 01-OCT-12.

Each DATE includes the century, year, month, day, hour, minute, and second. The following table shows the valid values for each field −

Field Name	Valid Datetime Values	Valid Interval Values
YEAR	-4712 to 9999 (excluding year 0)	Any nonzero integer
MONTH	01 to 12	0 to 11
DAY	01 to 31 (limited by the values of MONTH and YEAR, according to the rules of the calendar for the locale)	Any nonzero integer
HOUR	00 to 23	0 to 23
MINUTE	00 to 59	0 to 59
SECOND	00 to 59.9(n), where 9(n) is the precision of time fractional seconds	0 to 59.9(n), where 9(n) is the precision of interval fractional seconds
TIMEZONE_HOUR	-12 to 14 (range accommodates daylight savings time changes)	Not applicable
TIMEZONE_MINUTE	00 to 59	Not applicable
TIMEZONE_REGION	Found in the dynamic performance view V$TIMEZONE_NAMES	Not applicable
TIMEZONE_ABBR	Found in the dynamic performance view V$TIMEZONE_NAMES	Not applicable

PL/SQL Large Object (LOB) Data Types

Large Object (LOB) data types refer to large data items such as text, graphic images, video clips, and sound waveforms. LOB data types allow efficient, random, piecewise access to this data. Following are the predefined PL/SQL LOB data types –

Data Type	Description	Size
BFILE	Used to store large binary objects in operating system files outside the database.	System-dependent. Cannot exceed 4 gigabytes (GB).
BLOB	Used to store large binary objects in the database.	8 to 128 terabytes (TB)
CLOB	Used to store large blocks of character data in the database.	8 to 128 TB
NCLOB	Used to store large blocks of NCHAR data in the database.	8 to 128 TB

PL/SQL User-Defined Subtypes

A subtype is a subset of another data type, which is called its base type. A subtype has the same valid operations as its base type, but only a subset of its valid values.

PL/SQL predefines several subtypes in package **STANDARD**. For example, PL/SQL predefines the subtypes **CHARACTER** and **INTEGER** as follows −

```
SUBTYPE CHARACTER IS CHAR;
SUBTYPE INTEGER IS NUMBER(38,0);
```

You can define and use your own subtypes. The following program illustrates defining and using a user-defined subtype −

```
DECLARE
  SUBTYPE name IS char(20);
  SUBTYPE message IS varchar2(100);
  salutation name;
  greetings message;
BEGIN
  salutation := 'Reader ';
  greetings := 'Welcome to the World of PL/SQL';
  dbms_output.put_line('Hello ' || salutation || greetings);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Hello Reader Welcome to the World of PL/SQL

PL/SQL procedure successfully completed.
```

NULLs in PL/SQL

PL/SQL NULL values represent **missing** or **unknown data** and they are not an integer, a character, or any other specific data type. Note that **NULL** is not the same as an empty data string or the null character value **'\0'**. A null can be assigned but it cannot be equated with anything, including itself.

PL/SQL - VARIABLES

A variable is nothing but a name given to a storage area that our programs can manipulate. Each variable in PL/SQL has a specific data type, which determines the size and the layout of the variable's memory; the range of values that can be stored within that memory and the set of operations that can be applied to the variable.

The name of a PL/SQL variable consists of a letter optionally followed by more letters, numerals, dollar signs, underscores, and number signs and should not exceed 30 characters. By default, variable names are not case-sensitive. You cannot use a reserved PL/SQL keyword as a variable name.

PL/SQL programming language allows to define various types of variables, such as date time data types, records, collections, etc. which we will cover in subsequent chapters. For this chapter, let us study only basic variable types.

Variable Declaration in PL/SQL

PL/SQL variables must be declared in the declaration section or in a package as a global variable. When you declare a variable, PL/SQL allocates memory for the variable's value and the storage location is identified by the variable name.

The syntax for declaring a variable is −

```
variable_name [CONSTANT] datatype [NOT NULL] [:= | DEFAULT initial_value]
```

Where, *variable_name* is a valid identifier in PL/SQL, *datatype* must be a valid PL/SQL data type or any user defined data type which we already have discussed in the last chapter. Some valid variable declarations along with their definition are shown below −

```
sales number(10, 2);
pi CONSTANT double precision := 3.1415;
name varchar2(25);
address varchar2(100);
```

When you provide a size, scale or precision limit with the data type, it is called a **constrained declaration**. Constrained declarations require less memory than unconstrained declarations.

For example −

```
sales number(10, 2);
name varchar2(25);
address varchar2(100);
```

Initializing Variables in PL/SQL

Whenever you declare a variable, PL/SQL assigns it a default value of NULL. If you want to initialize a variable with a value other than the NULL value, you can do so during the declaration, using either of the following −

- The **DEFAULT** keyword
- The **assignment** operator

For example −

```
counter binary_integer := 0;
greetings varchar2(20) DEFAULT 'Have a Good Day';
```

You can also specify that a variable should not have a **NULL** value using the **NOT NULL** constraint. If you use the NOT NULL constraint, you must explicitly assign an initial value for that variable.It is a good programming practice to initialize variables properly otherwise, sometimes programs would produce unexpected results. Try the following example which makes use of various types of variables −

```
DECLARE
   a integer := 10;
   b integer := 20;
   c integer;
   f real;
BEGIN
   c := a + b;
   dbms_output.put_line('Value of c: ' || c);
   f := 70.0/3.0;
```

```
   dbms_output.put_line('Value of f: ' || f);
END;
/
```

When the above code is executed, it produces the following result −

```
Value of c: 30
Value of f: 23.333333333333333

PL/SQL procedure successfully completed.
```

Variable Scope in PL/SQL

PL/SQL allows the nesting of blocks, i.e., each program block may contain another inner block. If a variable is declared within an inner block, it is not accessible to the outer block. However, if a variable is declared and accessible to an outer block, it is also accessible to all nested inner blocks. There are two types of variable scope −

- **Local variables** − Variables declared in an inner block and not accessible to outer blocks.
- **Global variables** − Variables declared in the outermost block or a package.

Following example shows the usage of **Local** and **Global** variables in its simple form −

```
DECLARE
   -- Global variables
   num1 number := 95;
   num2 number := 85;
BEGIN
   dbms_output.put_line('Outer Variable num1: ' || num1);
   dbms_output.put_line('Outer Variable num2: ' || num2);
   DECLARE
      -- Local variables
      num1 number := 195;
      num2 number := 185;
   BEGIN
      dbms_output.put_line('Inner Variable num1: ' || num1);
```

```
    dbms_output.put_line('Inner Variable num2: ' || num2);
  END;
```

```
END;
/
```

When the above code is executed, it produces the following result −

```
Outer Variable num1: 95
Outer Variable num2: 85
Inner Variable num1: 195
Inner Variable num2: 185

PL/SQL procedure successfully completed.
```

Assigning SQL Query Results to PL/SQL Variables

You can use the **SELECT INTO** statement of SQL to assign values to PL/SQL variables. For each item in the **SELECT list**, there must be a corresponding, type-compatible variable in the **INTO list**. The following example illustrates the concept. Let us create a table named CUSTOMERS −

(**For SQL statements, please refer to the** SQL tutorial)

```
CREATE TABLE CUSTOMERS(
  ID   INT NOT NULL,
  NAME VARCHAR (20) NOT NULL,
  AGE INT NOT NULL,
  ADDRESS CHAR (25),
  SALARY   DECIMAL (18, 2),
  PRIMARY KEY (ID)
);

Table Created
```

Let us now insert some values in the table −

```
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (1, 'Ramesh', 32, 'Ahmedabad', 2000.00 );
```

```
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (2, 'Khilan', 25, 'Delhi', 1500.00 );
```

```
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (3, 'kaushik', 23, 'Kota', 2000.00 );

INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (4, 'Chaitali', 25, 'Mumbai', 6500.00 );

INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (5, 'Hardik', 27, 'Bhopal', 8500.00 );

INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)
VALUES (6, 'Komal', 22, 'MP', 4500.00 );
```

The following program assigns values from the above table to PL/SQL variables using the **SELECT INTO clause** of SQL −

```
DECLARE
   c_id customers.id%type := 1;
   c_name  customers.name%type;
   c_addr customers.address%type;
   c_sal  customers.salary%type;
BEGIN
   SELECT name, address, salary INTO c_name, c_addr, c_sal
   FROM customers
   WHERE id = c_id;
   dbms_output.put_line
   ('Customer ' ||c_name || ' from ' || c_addr || ' earns ' || c_sal);
END;

/
```

When the above code is executed, it produces the following result −

```
Customer Ramesh from Ahmedabad earns 2000

PL/SQL procedure completed successfully
```

PL/SQL - CONSTANTS AND LITERALS

A constant holds a value that once declared, does not change in the program. A constant declaration specifies its name, data type, and value, and allocates storage for it. The declaration can also impose the **NOT NULL constraint**.

Declaring a Constant

A constant is declared using the **CONSTANT** keyword. It requires an initial value and does not allow that value to be changed. For example −

```
PI CONSTANT NUMBER := 3.141592654;
DECLARE
   -- constant declaration
   pi constant number := 3.141592654;
   -- other declarations
   radius number(5,2);
   dia number(5,2);
   circumference number(7, 2);
   area number (10, 2);
BEGIN
   -- processing
   radius := 9.5;
   dia := radius * 2;
   circumference := 2.0 * pi * radius;
   area := pi * radius * radius;
   -- output
   dbms_output.put_line('Radius: ' || radius);
   dbms_output.put_line('Diameter: ' || dia);
   dbms_output.put_line('Circumference: ' || circumference);
   dbms_output.put_line('Area: ' || area);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Radius: 9.5
Diameter: 19
Circumference: 59.69
Area: 283.53

Pl/SQL procedure successfully completed.
```

THE PL/SQL LITERALS

A literal is an explicit numeric, character, string, or Boolean value not represented by an identifier. For example, TRUE, 786, NULL, 'tutorialspoint' are all literals of type Boolean, number, or string. PL/SQL, literals are case-sensitive. PL/SQL supports the following kinds of literals −

- *Numeric Literals*
- *Character Literals*
- *String Literals*
- *BOOLEAN Literals*
- *Date and Time Literals*

The following table provides examples from all these categories of literal values.

S.No	Literal Type & Example
1	**Numeric Literals** 050 78 -14 0 +32767 6.6667 0.0 -12.0 3.14159 +7800.00 6E5 1.0E-8 3.14159e0 -1E38 -9.5e-3
2	**Character Literals** 'A' '%' '9' ' ' 'z' '('
3	**String Literals** 'Hello, world!' 'Tutorials Point' '19-NOV-12'
4	**BOOLEAN Literals** TRUE, FALSE, and NULL.
5	**Date and Time Literals** DATE '1978-12-25'; TIMESTAMP '2012-10-29 12:01:01';

To embed single quotes within a string literal, place two single quotes next to each other as shown in the following program −

```
DECLARE
  message  varchar2(30):= 'That''s tutorialspoint.com!';
BEGIN
  dbms_output.put_line(message);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
That's tutorialspoint.com!
```

PL/SQL - OPERATORS

In this chapter, we will discuss operators in PL/SQL. An operator is a symbol that tells the compiler to perform specific mathematical or logical manipulation. PL/SQL language is rich in built-in operators and provides the following types of operators −

- *Arithmetic operators*
- *Relational operators*
- *Comparison operators*
- *Logical operators*
- *String operators*

Here, we will understand the arithmetic, relational, comparison and logical operators one by one. The String operators will be discussed in a later chapter − **PL/SQL - Strings**.

Arithmetic Operators

Following table shows all the arithmetic operators supported by PL/SQL. Let us assume **variable A** holds 10 and **variable B** holds 5, then −

Show Examples

Operator	Description	Example
+	Adds two operands	A + B will give 15
-	Subtracts second operand from the first	A - B will give 5
*	Multiplies both operands	A * B will give 50
/	Divides numerator by de-numerator	A / B will give 2
**	Exponentiation operator, raises one operand to the power of other	A ** B will give 100000

RELATIONAL OPERATORS

Relational operators compare two expressions or values and return a Boolean result. Following table shows all the relational operators supported by PL/SQL. Let us assume **variable A** holds 10 and **variable B** holds 20, then −

Show Examples

Operator	Description	Example
=	Checks if the values of two operands are equal or not, if yes then condition becomes true.	(A = B) is not true.

!= <> ~=	Checks if the values of two operands are equal or not, if values are not equal then condition becomes true.	(A != B) is true.
>	Checks if the value of left operand is greater than the value of right operand, if yes then condition becomes true.	(A > B) is not true.
<	Checks if the value of left operand is less than the value of right operand, if yes then condition becomes true.	(A < B) is true.
>=	Checks if the value of left operand is greater than or equal to the value of right operand, if yes then condition becomes true.	(A >= B) is not true.
<=	Checks if the value of left operand is less than or equal to the value of right operand, if yes then condition becomes true.	(A <= B) is true

COMPARISON OPERATORS

Comparison operators are used for comparing one expression to another. The result is always either **TRUE, FALSE** or **NULL**.

Show Examples

Operator	Description	Example
LIKE	The LIKE operator compares a character, string, or CLOB value to a pattern and returns TRUE if the value matches the pattern and FALSE if it does not.	If 'Zara Ali' like 'Z% A_i' returns a Boolean true, whereas, 'Nuha Ali' like 'Z% A_i' returns a Boolean false.
BETWEEN	The BETWEEN operator tests whether a value lies in a specified range. x BETWEEN a AND b means that x >= a and x <= b.	If x = 10 then, x between 5 and 20 returns true, x between 5 and 10 returns true, but x between 11 and 20 returns false.
IN	The IN operator tests set membership. x IN (set) means that x is equal to any member of set.	If x = 'm' then, x in ('a', 'b', 'c') returns Boolean false but x in ('m', 'n', 'o') returns Boolean true.
IS NULL	The IS NULL operator returns the BOOLEAN value TRUE if its operand is NULL or FALSE if it is not NULL. Comparisons involving NULL values always yield NULL.	If x = 'm', then 'x is null' returns Boolean false.

LOGICAL OPERATORS

Following table shows the Logical operators supported by PL/SQL. All these operators work on Boolean operands and produce Boolean results. Let us assume **variable A** holds true and **variable B** holds false, then −

Show Examples

Operator	Description	Examples
and	Called the logical AND operator. If both the operands are true then condition becomes true.	(A and B) is false.
or	Called the logical OR Operator. If any of the two operands is true then condition becomes true.	(A or B) is true.
not	Called the logical NOT Operator. Used to reverse the logical state of its operand. If a condition is true then Logical NOT operator will make it false.	not (A and B) is true.

PL/ SQL - String Functions

String functions are used to perform an operation on input string and return an output string.

Following are the string functions defined in SQL:

ASCII(): This function is used to find the ASCII value of a character.

Syntax: SELECT ascii('t');

Output: 116

CHAR_LENGTH(): This function is used to find the length of a word.

Syntax: SELECT char_length('Hello!');

Output: 6

CHARACTER_LENGTH(): This function is used to find the length of a line.

Syntax: SELECT CHARACTER_LENGTH('geeks for geeks');

Output: 15

CONCAT(): This function is used to add two words or strings.

Syntax: SELECT 'Geeks' || ' ' || 'forGeeks' FROM dual;

Output: 'GeeksforGeeks'

LCASE(): This function is used to convert the given string into lower case.

Syntax: LCASE ("GeeksFor Geeks To Learn");

Output: geeksforgeeks to learn

LEFT(): This function is used to SELECT a sub string from the left of given size or characters.

Syntax: SELECT LEFT('geeksforgeeks.org', 5);

Output: geeks

LENGTH(): This function is used to find the length of a word.

Syntax: LENGTH('GeeksForGeeks');

Output: 13

LOWER(): This function is used to convert the upper case string into lower case.

Syntax: SELECT LOWER('GEEKSFORGEEKS.ORG');

Output: geeksforgeeks.org

LTRIM(): This function is used to cut the given sub string from the original string.

Syntax: LTRIM('123123geeks', '123');

Output: geeks

REPEAT(): This function is used to write the given string again and again till the number of times mentioned.

Syntax: SELECT REPEAT('geeks', 2);

Output: geeksgeeks

REPLACE(): This function is used to cut the given string by removing the given sub string.

Syntax: REPLACE('123geeks123', '123');

Output: geeks

REVERSE(): This function is used to reverse a string.

Syntax: SELECT REVERSE('geeksforgeeks.org');

Output: 'gro.skeegrofskeeg'

RTRIM(): This function is used to cut the given sub string from the original string.

Syntax: RTRIM('geeksxyxzyyy', 'xyz');

Output: 'geeks'

STRCMP(): This function is used to compare 2 strings.

If string1 and string2 are the same, the STRCMP function will return 0.

If string1 is smaller than string2, the STRCMP function will return -1.

If string1 is larger than string2, the STRCMP function will return 1.

Syntax: SELECT STRCMP('google.com', 'geeksforgeeks.com');

Output: -1

SUBSTRING(): This function is used to find an alphabet from the mentioned size and the given string.

Syntax: SELECT SUBSTRING('GeeksForGeeks.org', 9, 1);

Output: 'G'

TRIM(): This function is used to cut the given symbol from the string.

Syntax: TRIM(LEADING '0' FROM '000123');

Output: 123

UCASE(): This function is used to make the string in upper case.

Syntax: UCASE ("GeeksForGeeks");

Output:

GEEKSFORGEEKS

PL/SQL OPERATOR PRECEDENCE

Operator precedence determines the grouping of terms in an expression. This affects how an expression is evaluated. Certain operators have higher precedence than others; for example, the multiplication operator has higher precedence than the addition operator.

For example, **x = 7 + 3 * 2**; here, **x** is assigned **13**, not 20 because operator * has higher precedence than +, so it first gets multiplied with **3*2** and then adds into **7**.

Here, operators with the highest precedence appear at the top of the table, those with the lowest appear at the bottom. Within an expression, higher precedence operators will be evaluated first.

The precedence of operators goes as follows: =, <, >, <=, >=, <>, !=, ~=, ^=, IS NULL, LIKE, BETWEEN, IN.

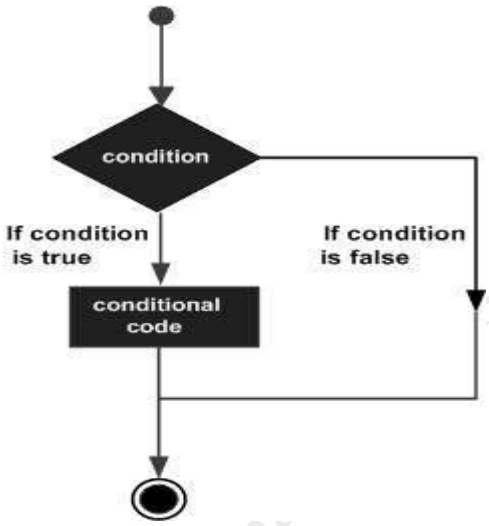
Show Examples

Operator	Operation
**	exponentiation
+, -	identity, negation
*, /	multiplication, division
+, -, ||	addition, subtraction, concatenation
comparison	
NOT	logical negation
AND	conjunction
OR	inclusion

PL/SQL – CONDITIONS- (Decision-Making Structures)

Decision-making structures require that the programmer specify one or more conditions to be evaluated or tested by the program, along with a statement or statements to be executed if the condition is determined to be true, and optionally, other statements to be executed if the condition is determined to be false.

Following is the general form of a typical conditional (i.e., decision making) structure found in most of the programming languages −



PL/SQL programming language provides following types of decision-making statements.

S.No	Statement & Description
1	**IF - THEN statement** The **IF statement** associates a condition with a sequence of statements enclosed by the keywords **THEN** and **END IF**. If the condition is true, the statements get executed and if the condition is false or NULL then the IF statement does nothing.
2	**IF-THEN-ELSE statement** **IF statement** adds the keyword **ELSE** followed by an alternative sequence of statement. If the condition is false or NULL, then only the alternative sequence of statements get executed. It ensures that either of the sequence of statements is executed.
3	**IF-THEN-ELSIF statement** It allows you to choose between several alternatives.
4	**Case statement** Like the IF statement, the **CASE statement** selects one sequence of statements to execute.

	However, to select the sequence, the CASE statement uses a selector rather than multiple Boolean expressions. A selector is an expression whose value is used to select one of several alternatives.
5	**Searched CASE statement** The searched CASE statement **has no selector**, and it's WHEN clauses contain search conditions that yield Boolean values.
6	**nested IF-THEN-ELSE** You can use one **IF-THEN** or **IF-THEN-ELSIF** statement inside another **IF-THEN** or **IF-THEN-ELSIF** statement(s).

PL/SQL - IF-THEN STATEMENT

It is the simplest form of the **IF** control statement, frequently used in decision-making and changing the control flow of the program execution.

The **IF statement** associates a condition with a sequence of statements enclosed by the keywords **THEN** and **END IF**.

If the condition is **TRUE**, the statements get executed, and if the condition is **FALSE** or **NULL**, then the **IF**statement does nothing.

Syntax

Syntax for **IF-THEN** statement is −

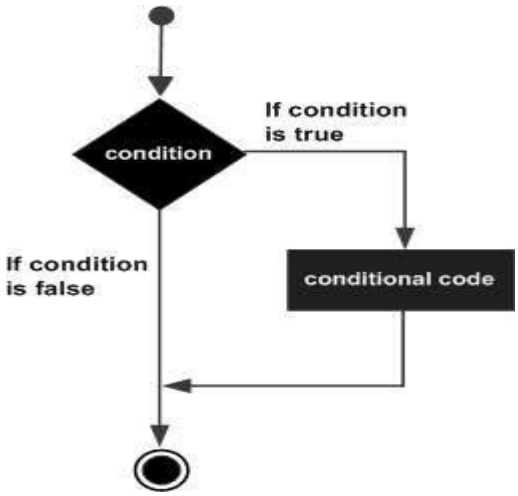
```
IF condition THEN
   S;
END IF;
```

Where *condition* is a Boolean or relational condition and S is a simple or compound statement. Following is an example of the IF-THEN statement −

```
IF (a <= 20) THEN

   c:= c+1;

END IF;
```

If the Boolean expression condition evaluates to true, then the block of code inside the **if statement** will be executed. If the Boolean expression evaluates to false, then the first set of code after the end of the **if statement** (after the closing end if) will be executed.

Flow Diagram



Example 1

Let us try an example that will help you understand the concept −

```
DECLARE
  a number(2) := 10;
BEGIN
  a:= 10;
 -- check the boolean condition using if statement
  IF( a < 20 ) THEN
    -- if condition is true then print the following
    dbms_output.put_line('a is less than 20 ' );
  END IF;
  dbms_output.put_line('value of a is : ' || a);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
a is less than 20
value of a is : 10

PL/SQL procedure successfully completed.
```

PL/SQL - IF-THEN-ELSE Statement

A sequence of **IF-THEN** statements can be followed by an optional sequence of **ELSE** statements, which execute when the condition is **FALSE**.

Syntax

Syntax for the IF-THEN-ELSE statement is −

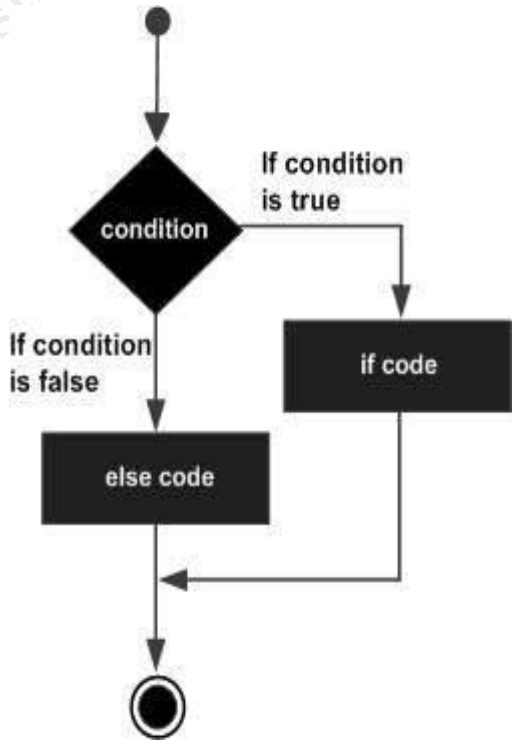
```
IF condition THEN
   S1;
ELSE
   S2;
END IF;
```

Where, *S1* and *S2* are different sequence of statements. In the **IF-THEN-ELSE statements**, when the test condition is TRUE, the statement *S1* is executed and *S2* is skipped; when the test condition is FALSE, then *S1* is bypassed and statement *S2* is executed. For example −

```
IF color = red THEN

  dbms_output.put_line('You have chosen a red car')

ELSE

  dbms_output.put_line('Please choose a color for your car');

END IF;
```

If the Boolean expression condition evaluates to true, then the **if-then block of code** will be executed otherwise the else block of code will be executed.

Flow Diagram



Example

Let us try an example that will help you understand the concept −

```
DECLARE
  a number(3) := 100;
BEGIN
  -- check the boolean condition using if statement
  IF( a < 20 ) THEN
    -- if condition is true then print the following
    dbms_output.put_line('a is less than 20 ' );
  ELSE
    dbms_output.put_line('a is not less than 20 ' );
  END IF;
  dbms_output.put_line('value of a is : ' || a);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
a is not less than 20
value of a is : 100

PL/SQL procedure successfully completed.
```

PL/SQL - IF-THEN-ELSIF Statement

The **IF-THEN-ELSIF** statement allows you to choose between several alternatives. An **IF-THEN** statement can be followed by an optional **ELSIF...ELSE** statement. The **ELSIF** clause lets you add additional conditions.

When using **IF-THEN-ELSIF** statements there are a few points to keep in mind.

- It's ELSIF, not ELSEIF.
- An IF-THEN statement can have zero or one ELSE's and it must come after any ELSIF's.
- An IF-THEN statement can have zero to many ELSIF's and they must come before the ELSE.
- Once an ELSIF succeeds, none of the remaining ELSIF's or ELSE's will be tested.

Syntax

The syntax of an **IF-THEN-ELSIF** Statement in PL/SQL programming language is −

```
IF(boolean_expression 1)THEN
   S1; -- Executes when the boolean expression 1 is true
ELSIF( boolean_expression 2) THEN
   S2;  -- Executes when the boolean expression 2 is true
ELSIF( boolean_expression 3) THEN
   S3; -- Executes when the boolean expression 3 is true
ELSE
   S4; -- executes when the none of the above condition is true
END IF;
```

Example

```
DECLARE
   a number(3) := 100;
BEGIN
   IF ( a = 10 ) THEN
      dbms_output.put_line('Value of a is 10' );
   ELSIF ( a = 20 ) THEN
      dbms_output.put_line('Value of a is 20' );
   ELSIF ( a = 30 ) THEN
      dbms_output.put_line('Value of a is 30' );
   ELSE
       dbms_output.put_line('None of the values is matching');
   END IF;
   dbms_output.put_line('Exact value of a is: '|| a );
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
None of the values is matching
Exact value of a is: 100
```

```
PL/SQL procedure successfully completed.
```

PL/SQL - CASE Statement

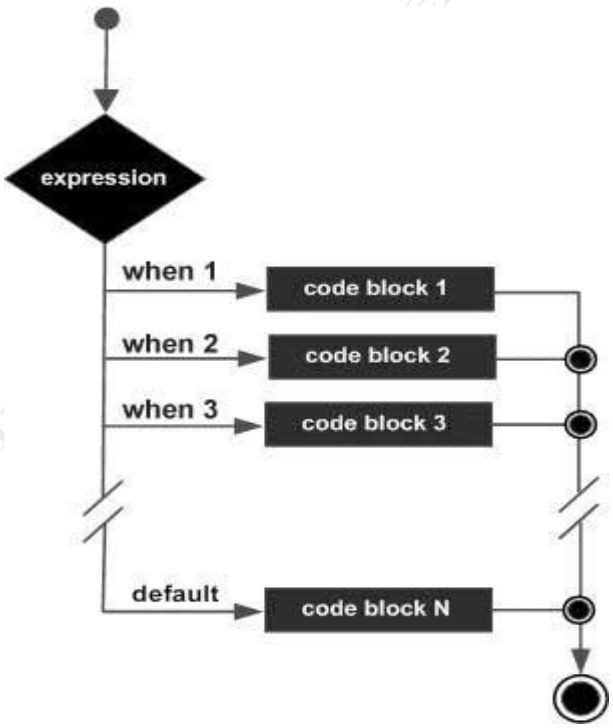
Like the **IF** statement, the **CASE statement** selects one sequence of statements to execute. However, to select the sequence, the **CASE** statement uses a selector rather than multiple Boolean expressions. A selector is an expression, the value of which is used to select one of several alternatives.

Syntax

The syntax for the case statement in PL/SQL is −

```
CASE selector
   WHEN 'value1' THEN S1;
   WHEN 'value2' THEN S2;
   WHEN 'value3' THEN S3;
   ...
   ELSE Sn;  -- default case
END CASE;
```

Flow Diagram



Example

```
DECLARE
   grade char(1) := 'A';
BEGIN
   CASE grade
```

```
    when 'A' then dbms_output.put_line('Excellent');
    when 'B' then dbms_output.put_line('Very good');
    when 'C' then dbms_output.put_line('Well done');
    when 'D' then dbms_output.put_line('You passed');
    when 'F' then dbms_output.put_line('Better try again');
    else dbms_output.put_line('No such grade');
  END CASE;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

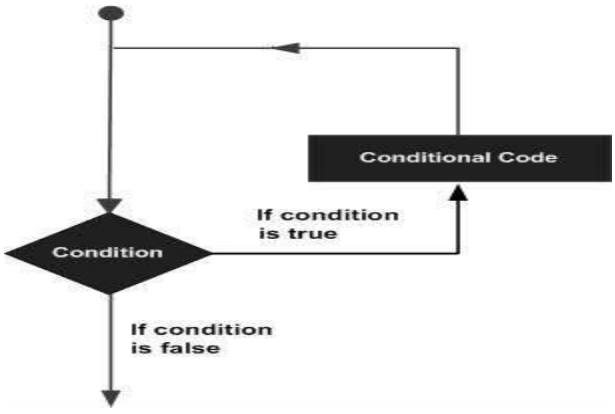
```
Excellent

PL/SQL procedure successfully completed.
```

L/SQL - Loops

There may be a situation when you need to execute a block of code several number of times. In general, statements are executed sequentially: The first statement in a function is executed first, followed by the second, and so on.

Programming languages provide various control structures that allow for more complicated execution paths.

A loop statement allows us to execute a statement or group of statements multiple times and following is the general form of a loop statement in most of the programming languages −



PL/SQL provides the following types of loop to handle the looping requirements.

S.No	Loop Type & Description
1	**PL/SQL Basic LOOP**

	In this loop structure, sequence of statements is enclosed between the LOOP and the END LOOP statements. At each iteration, the sequence of statements is executed and then control resumes at the top of the loop.
2	**PL/SQL WHILE LOOP** Repeats a statement or group of statements while a given condition is true. It tests the condition before executing the loop body.
3	**PL/SQL FOR LOOP** Execute a sequence of statements multiple times and abbreviates the code that manages the loop variable.
4	**Nested loops in PL/SQL** You can use one or more loop inside any another basic loop, while, or for loop.

Labeling a PL/SQL Loop

PL/SQL loops can be labeled. The label should be enclosed by double angle brackets (<< and >>) and appear at the beginning of the LOOP statement. The label name can also appear at the end of the LOOP statement. You may use the label in the EXIT statement to exit from the loop.

The following program illustrates the concept −

```
DECLARE
  i number(1);
  j number(1);
BEGIN
  << outer_loop >>
  FOR i IN 1..3 LOOP
    << inner_loop >>
    FOR j IN 1..3 LOOP
      dbms_output.put_line('i is: '|| i || ' and j is: ' || j);
    END loop inner_loop;
  END loop outer_loop;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
i is: 1 and j is: 1
i is: 1 and j is: 2
i is: 1 and j is: 3
i is: 2 and j is: 1
i is: 2 and j is: 2
```

```
i is: 2 and j is: 3
i is: 3 and j is: 1
i is: 3 and j is: 2
i is: 3 and j is: 3

PL/SQL procedure successfully completed.
```

The Loop Control Statements

Loop control statements change execution from its normal sequence. When execution leaves a scope, all automatic objects that were created in that scope are destroyed.

PL/SQL supports the following control statements. Labeling loops also help in taking the control outside a loop. Click the following links to check their details.

S.No	Control Statement & Description
1	**EXIT statement** The Exit statement completes the loop and control passes to the statement immediately after the END LOOP.
2	**CONTINUE statement** Causes the loop to skip the remainder of its body and immediately retest its condition prior to reiterating.
3	**GOTO statement** Transfers control to the labeled statement. Though it is not advised to use the GOTO statement in your program.

PL/SQL - Basic Loop Statement

Basic loop structure encloses sequence of statements in between the **LOOP**and **END LOOP** statements. With each iteration, the sequence of statements is executed and then control resumes at the top of the loop.

Syntax

The syntax of a basic loop in PL/SQL programming language is −

```
LOOP
   Sequence of statements;
END LOOP;
```

Here, the sequence of statement(s) may be a single statement or a block of statements. An **EXIT statement** or an **EXIT WHEN statement** is required to break the loop.

Example

```
DECLARE
```

```
x number := 10;
BEGIN
  LOOP
    dbms_output.put_line(x);
    x := x + 10;
    IF x > 50 THEN
      exit;
    END IF;
  END LOOP;
  -- after exit, control resumes here
  dbms_output.put_line('After Exit x is: ' || x);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
10
20
30
40
50
After Exit x is: 60

PL/SQL procedure successfully completed.
```

You can use the **EXIT WHEN** statement instead of the **EXIT** statement −

```
DECLARE
  x number := 10;
BEGIN
  LOOP
    dbms_output.put_line(x);
    x := x + 10;
    exit WHEN x > 50;
  END LOOP;
  -- after exit, control resumes here
```

```
  dbms_output.put_line('After Exit x is: ' || x);

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
10
20
30
40
50
After Exit x is: 60

PL/SQL procedure successfully completed.
```

PL/SQL - WHILE LOOP Statement

A **WHILE LOOP** statement in PL/SQL programming language repeatedly executes a target statement as long as a given condition is true.

Syntax

```
WHILE condition LOOP
   sequence_of_statements
END LOOP;
```

Example

```
DECLARE
  a number(2) := 10;

BEGIN
  WHILE a < 20 LOOP
    dbms_output.put_line('value of a: ' || a);
    a := a + 1;
  END LOOP;

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 10
value of a: 11
```

```
value of a: 12
value of a: 13
value of a: 14
value of a: 15
value of a: 16
value of a: 17
value of a: 18
value of a: 19

PL/SQL procedure successfully completed.
```

PL/SQL - FOR LOOP Statement

A **FOR LOOP** is a repetition control structure that allows you to efficiently write a loop that needs to execute a specific number of times.

Syntax

```
FOR counter IN initial_value .. final_value LOOP
  sequence_of_statements;
END LOOP;
```

Following is the flow of control in a **For Loop** −

- The initial step is executed first, and only once. This step allows you to declare and initialize any loop control variables.
- Next, the condition, i.e., *initial_value .. final_value* is evaluated. If it is TRUE, the body of the loop is executed. If it is FALSE, the body of the loop does not execute and the flow of control jumps to the next statement just after the for loop.
- After the body of the for loop executes, the value of the counter variable is increased or decreased.
- The condition is now evaluated again. If it is TRUE, the loop executes and the process repeats itself (body of loop, then increment step, and then again condition). After the condition becomes FALSE, the FOR-LOOP terminates.

Following are some special characteristics of PL/SQL for loop −

- The *initial_value* and *final_value* of the loop variable or counter can be literals, variables, or expressions but must evaluate to numbers. Otherwise, PL/SQL raises the predefined exception VALUE_ERROR.
- The *initial_value* need not be 1; however, the **loop counter increment (or decrement) must be 1**.
- PL/SQL allows the determination of the loop range dynamically at run time.

Example

```
DECLARE
   a number(2);
BEGIN
   FOR a in 10 .. 20 LOOP
      dbms_output.put_line('value of a: ' || a);
  END LOOP;
END;

/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 15
value of a: 16
value of a: 17
value of a: 18
value of a: 19
value of a: 20

PL/SQL procedure successfully completed.
```

Reverse FOR LOOP Statement

By default, iteration proceeds from the initial value to the final value, generally upward from the lower bound to the higher bound. You can reverse this order by using the **REVERSE** keyword. In such case, iteration proceeds the other way. After each iteration, the loop counter is decremented.

However, you must write the range bounds in ascending (not descending) order. The following program illustrates this −

```
DECLARE
   a number(2) ;
BEGIN
   FOR a IN REVERSE 10 .. 20 LOOP
      dbms_output.put_line('value of a: ' || a);
   END LOOP;
END;
```

```
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 20
value of a: 19
value of a: 18
value of a: 17
value of a: 16
value of a: 15
value of a: 14
value of a: 13
value of a: 12
value of a: 11
value of a: 10

PL/SQL procedure successfully completed.
```

PL/SQL - Nested Loops

PL/SQL allows using one loop inside another loop. Following section shows a few examples to illustrate the concept.

The **syntax** for a nested basic LOOP statement in PL/SQL is as follows −

```
LOOP
  Sequence of statements1
  LOOP
    Sequence of statements2
  END LOOP;
END LOOP;
```

The syntax for a nested FOR LOOP statement in PL/SQL is as follows −

```
FOR counter1 IN initial_value1 .. final_value1 LOOP
  sequence_of_statements1
  FOR counter2 IN initial_value2 .. final_value2 LOOP
    sequence_of_statements2
  END LOOP;
END LOOP;
```

The syntax for a nested WHILE LOOP statement in Pascal is as follows −

```
WHILE condition1 LOOP
  sequence_of_statements1
```

```
   WHILE condition2 LOOP
      sequence_of_statements2
   END LOOP;
END LOOP;
```

Example

The following program uses a nested basic loop to find the prime numbers from 2 to 100 −

```
DECLARE
  i number(3);
  j number(3);
BEGIN
  i := 2;
  LOOP
    j:= 2;
    LOOP
      exit WHEN ((mod(i, j) = 0) or (j = i));
      j := j +1;
    END LOOP;
  IF (j = i ) THEN
    dbms_output.put_line(i || ' is prime');
  END IF;
  i := i + 1;
  exit WHEN i = 50;
  END LOOP;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
2 is prime
3 is prime
5 is prime
7 is prime
```

```
11 is prime
13 is prime
```

```
17 is prime
19 is prime
23 is prime
29 is prime
31 is prime
37 is prime
41 is prime
43 is prime
47 is prime

PL/SQL procedure successfully completed.
```

PL/SQL - EXIT Statement

The **EXIT** statement in PL/SQL programming language has the following two usages −

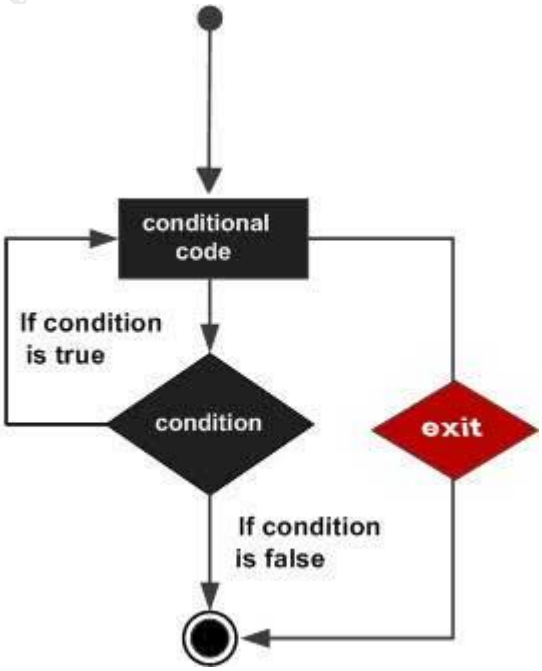
- When the EXIT statement is encountered inside a loop, the loop is immediately terminated and the program control resumes at the next statement following the loop.
- If you are using nested loops (i.e., one loop inside another loop), the EXIT statement will stop the execution of the innermost loop and start executing the next line of code after the block.

Syntax

The syntax for an EXIT statement in PL/SQL is as follows −

```
EXIT;
```

Flow Diagram



Example

```
DECLARE
  a number(2) := 10;
BEGIN
  -- while loop execution
  WHILE a < 20 LOOP
    dbms_output.put_line ('value of a: ' || a);
    a := a + 1;
    IF a > 15 THEN
      -- terminate the loop using the exit statement
      EXIT;
    END IF;
  END LOOP;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 15

PL/SQL procedure successfully completed.
```

The EXIT WHEN Statement

The **EXIT-WHEN** statement allows the condition in the WHEN clause to be evaluated. If the condition is true, the loop completes and control passes to the statement immediately after the END LOOP.

Following are the two important aspects for the EXIT WHEN statement −

- Until the condition is true, the EXIT-WHEN statement acts like a NULL statement, except for evaluating the condition, and does not terminate the loop.
- A statement inside the loop must change the value of the condition.

Syntax

The syntax for an EXIT WHEN statement in PL/SQL is as follows −

```
EXIT WHEN condition;
```

The EXIT WHEN statement **replaces a conditional statement like if-then**used with the EXIT statement.

Example

```
DECLARE
  a number(2) := 10;
BEGIN
  -- while loop execution
  WHILE a < 20 LOOP
    dbms_output.put_line ('value of a: ' || a);
    a := a + 1;
    -- terminate the loop using the exit when statement
  EXIT WHEN a > 15;
  END LOOP;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 15

PL/SQL procedure successfully completed.
```

PL/SQL - CONTINUE Statement

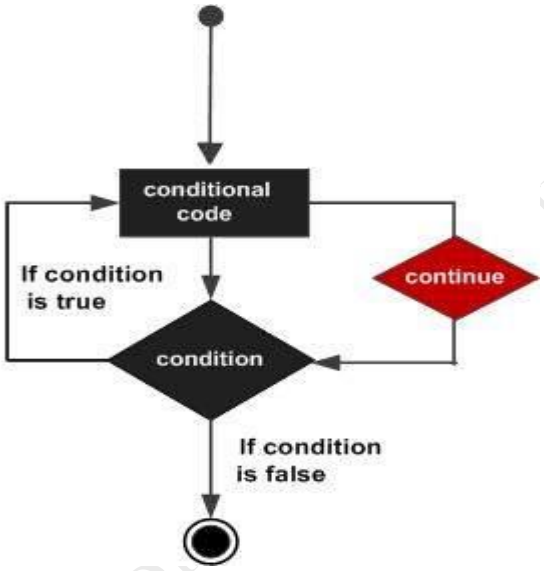
The **CONTINUE** statement causes the loop to skip the remainder of its body and immediately retest its condition prior to reiterating. In other words, it forces the next iteration of the loop to take place, skipping any code in between.

Syntax

The syntax for a CONTINUE statement is as follows −

```
CONTINUE;
```

Flow Diagram



Example

```
DECLARE
  a number(2) := 10;
BEGIN
  -- while loop execution
  WHILE a < 20 LOOP
    dbms_output.put_line ('value of a: ' || a);
    a := a + 1;
    IF a = 15 THEN
      -- skip the loop using the CONTINUE statement
      a := a + 1;
      CONTINUE;
    END IF;
  END LOOP;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 16
value of a: 17
value of a: 18
value of a: 19

PL/SQL procedure successfully completed.
```

PL/SQL - GOTO Statement

A **GOTO** statement in PL/SQL programming language provides an unconditional jump from the GOTO to a labeled statement in the same subprogram.

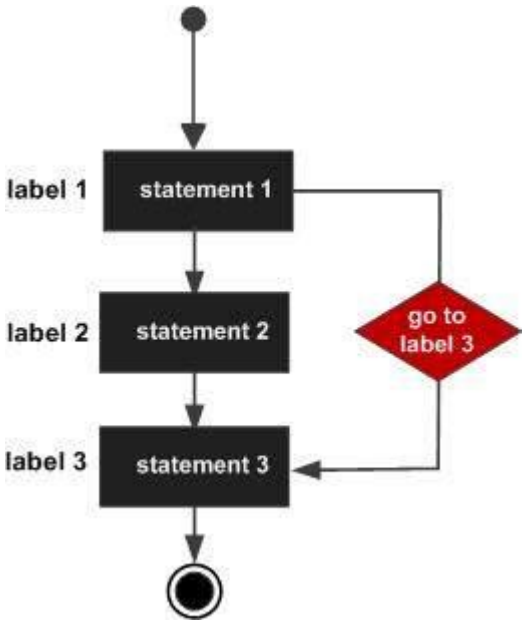
NOTE − The use of GOTO statement is not recommended in any programming language because it makes it difficult to trace the control flow of a program, making the program hard to understand and hard to modify. Any program that uses a GOTO can be rewritten so that it doesn't need the GOTO.

Syntax

The syntax for a GOTO statement in PL/SQL is as follows −

```
GOTO label;
..
..
<< label >>
statement;
```

Flow Diagram



Example

```
DECLARE
  a number(2) := 10;
BEGIN
  <<loopstart>>
  -- while loop execution
  WHILE a < 20 LOOP
  dbms_output.put_line ('value of a: ' || a);
    a := a + 1;
    IF a = 15 THEN
      a := a + 1;
      GOTO loopstart;
    END IF;
  END LOOP;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
value of a: 10
value of a: 11
value of a: 12
value of a: 13
value of a: 14
value of a: 16
value of a: 17
value of a: 18
value of a: 19

PL/SQL procedure successfully completed.
```

Restrictions with GOTO Statement

GOTO Statement in PL/SQL imposes the following restrictions −

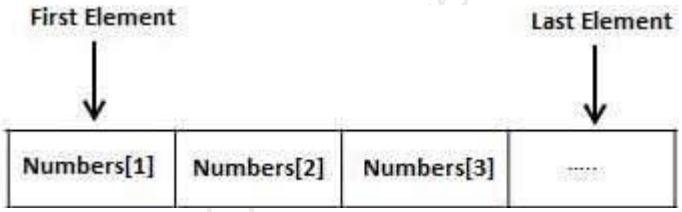
- A GOTO statement cannot branch into an IF statement, CASE statement, LOOP statement or sub-block.
- A GOTO statement cannot branch from one IF statement clause to another or from one CASE statement WHEN clause to another.

- A GOTO statement cannot branch from an outer block into a sub-block (i.e., an inner BEGIN-END block).
- A GOTO statement cannot branch out of a subprogram. To end a subprogram early, either use the RETURN statement or have GOTO branch to a place right before the end of the subprogram.
- A GOTO statement cannot branch from an exception handler back into the current BEGIN-END block. However, a GOTO statement can branch from an exception handler into an enclosing block.

PL/SQL - ARRAYS

The PL/SQL programming language provides a data structure called the **VARRAY**, which can store a fixed-size sequential collection of elements of the same type. A varray is used to store an ordered collection of data, however it is often better to think of an array as a collection of variables of the same type.

All varrays consist of contiguous memory locations. The lowest address corresponds to the first element and the highest address to the last element.



An array is a part of collection type data and it stands for variable-size arrays. We will study other collection types in a later chapter '**PL/SQL Collections**'.

Each element in a **varray** has an index associated with it. It also has a maximum size that can be changed dynamically.

Creating a Varray Type

A varray type is created with the **CREATE TYPE** statement. You must specify the maximum size and the type of elements stored in the varray.

The basic syntax for creating a VARRAY type at the schema level is −

```
CREATE OR REPLACE TYPE varray_type_name IS VARRAY(n) of <element_type>
```

Where,

- *varray_type_name* is a valid attribute name,
- *n* is the number of elements (maximum) in the varray,
- *element_type* is the data type of the elements of the array.

Maximum size of a varray can be changed using the **ALTER TYPE** statement.

For **example,**

```
CREATE Or REPLACE TYPE namearray AS VARRAY(3) OF VARCHAR2(10);
/

Type created.
```

The basic syntax for creating a VARRAY type within a PL/SQL block is −

```
TYPE varray_type_name IS VARRAY(n) of <element_type>
```

For example −

```
TYPE namearray IS VARRAY(5) OF VARCHAR2(10);
Type grades IS VARRAY(5) OF INTEGER;
```

Let us now work out on a few examples to understand the concept −

Example 1

The following program illustrates the use of varrays −

```
DECLARE
  type namesarray IS VARRAY(5) OF VARCHAR2(10);
  type grades IS VARRAY(5) OF INTEGER;
  names namesarray;
  marks grades;
  total integer;
BEGIN
  names := namesarray('Kavita', 'Pritam', 'Ayan', 'Rishav', 'Aziz');
  marks:= grades(98, 97, 78, 87, 92);
  total := names.count;
  dbms_output.put_line('Total '|| total || ' Students');
  FOR i in 1 .. total LOOP
    dbms_output.put_line('Student: ' || names(i) || '
     Marks: ' || marks(i));
  END LOOP;
END;
```

```
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Total 5 Students
Student: Kavita  Marks: 98
Student: Pritam  Marks: 97
Student: Ayan  Marks: 78
Student: Rishav  Marks: 87
Student: Aziz  Marks: 92

PL/SQL procedure successfully completed.
```

Please note −

- In Oracle environment, the starting index for varrays is always 1.
- You can initialize the varray elements using the constructor method of the varray type, which has the same name as the varray.
- Varrays are one-dimensional arrays.
- A varray is automatically NULL when it is declared and must be initialized before its elements can be referenced.

Example 2

Elements of a varray could also be a %ROWTYPE of any database table or %TYPE of any database table field. The following example illustrates the concept.

We will use the CUSTOMERS table stored in our database as −

```
Select * from customers;

+----+----------+-----+-----------+----------+
| ID | NAME     | AGE | ADDRESS   | SALARY   |
+----+----------+-----+-----------+----------+
|  1 | Ramesh   |  32 | Ahmedabad |  2000.00 |
|  2 | Khilan   |  25 | Delhi     |  1500.00 |
|  3 | kaushik  |  23 | Kota      |  2000.00 |
|  4 | Chaitali |  25 | Mumbai    |  6500.00 |
|  5 | Hardik   |  27 | Bhopal    |  8500.00 |
|  6 | Komal    |  22 | MP        |  4500.00 |
+----+----------+-----+-----------+----------+
```

Following example makes the use of **cursor**, which you will study in detail in a separate chapter.

```
DECLARE

   CURSOR c_customers is

   SELECT  name FROM customers;

   type c_list is varray (6) of customers.name%type;
```

```
   name_list c_list := c_list();
   counter integer :=0;
BEGIN
   FOR n IN c_customers LOOP
      counter := counter + 1;
      name_list.extend;
      name_list(counter)  := n.name;
      dbms_output.put_line('Customer('||counter ||'):'||name_list(counter));
   END LOOP;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Customer(1): Ramesh
Customer(2): Khilan
Customer(3): kaushik
Customer(4): Chaitali
Customer(5): Hardik
Customer(6): Komal


PL/SQL procedure successfully completed.
```

PL/SQL - PROCEDURES

A **subprogram** is a program unit/module that performs a particular task. These subprograms are combined to form larger programs. This is basically called the 'Modular design'. A subprogram can be invoked by another subprogram or program which is called the **calling program**.

A subprogram can be created −

- At the schema level
- Inside a package
- Inside a PL/SQL block

At the schema level, subprogram is a **standalone subprogram**. It is created with the CREATE PROCEDURE or the CREATE FUNCTION statement. It is stored in the database and can be deleted with the DROP PROCEDURE or DROP FUNCTION statement.

A subprogram created inside a package is a **packaged subprogram**. It is stored in the database and can be deleted only when the package is deleted with the DROP PACKAGE statement. We will discuss packages in the chapter **'PL/SQL - Packages'**.

PL/SQL subprograms are named PL/SQL blocks that can be invoked with a set of parameters. PL/SQL provides two kinds of subprograms −

- **Functions** − these subprograms return a single value; mainly used to compute and return a value.
- **Procedures** − these subprograms do not return a value directly; mainly used to perform an action.

This chapter is going to cover important aspects of a **PL/SQL procedure**. We will discuss **PL/SQL function** in the next chapter.

Parts of a PL/SQL Subprogram

Each PL/SQL subprogram has a name, and may also have a parameter list. Like anonymous PL/SQL blocks, the named blocks will also have the following three parts −

S.No	Parts & Description
1	**Declarative Part** It is an optional part. However, the declarative part for a subprogram does not start with the DECLARE keyword. It contains declarations of types, cursors, constants, variables, exceptions, and nested subprograms. These items are local to the subprogram and cease to exist when the subprogram completes execution.
2	**Executable Part** This is a mandatory part and contains statements that perform the designated action.
3	**Exception-handling** This is again an optional part. It contains the code that handles run-time errors.

Creating a Procedure

A procedure is created with the **CREATE OR REPLACE PROCEDURE**statement. The simplified syntax for the CREATE OR REPLACE PROCEDURE statement is as follows −

```
CREATE [OR REPLACE] PROCEDURE procedure_name
[(parameter_name [IN | OUT | IN OUT] type [, ...])]
{IS | AS}
BEGIN
 < procedure_body >
END procedure_name;
```

Where,

- *procedure-name* specifies the name of the procedure.
- [OR REPLACE] option allows the modification of an existing procedure.
- The optional parameter list contains name, mode and types of the parameters. **IN** represents the value that will be passed from outside and OUT represents the parameter that will be used to return a value outside of the procedure.
- *procedure-body* contains the executable part.
- The AS keyword is used instead of the IS keyword for creating a standalone procedure.

Example

The following example creates a simple procedure that displays the string 'Hello World!' on the screen when executed.

```
CREATE OR REPLACE PROCEDURE greetings
AS
BEGIN
  dbms_output.put_line('Hello World!');
END;
/
```

When the above code is executed using the SQL prompt, it will produce the following result −

```
Procedure created.
```

Executing a Standalone Procedure

A standalone procedure can be called in two ways −

- Using the **EXECUTE** keyword
- Calling the name of the procedure from a PL/SQL block

The above procedure named '**greetings**' can be called with the EXECUTE keyword as −

```
EXECUTE greetings;
```

The above call will display −

```
Hello World

PL/SQL procedure successfully completed.
```

The procedure can also be called from another PL/SQL block −

```
BEGIN
  greetings;
END;
/
```

The above call will display −

```
Hello World

PL/SQL procedure successfully completed.
```

Deleting a Standalone Procedure

A standalone procedure is deleted with the **DROP PROCEDURE** statement. Syntax for deleting a procedure is −

```
DROP PROCEDURE procedure-name;
```

You can drop the greetings procedure by using the following statement −

```
DROP PROCEDURE greetings;
```

Parameter Modes in PL/SQL Subprograms

The following table lists out the parameter modes in PL/SQL subprograms −

S.No	Parameter Mode & Description
1	**IN**

	An IN parameter lets you pass a value to the subprogram. **It is a read-only parameter**. Inside the subprogram, an IN parameter acts like a constant. It cannot be assigned a value. You can pass a constant, literal, initialized variable, or expression as an IN parameter. You can also initialize it to a default value; however, in that case, it is omitted from the subprogram call. **It is the default mode of parameter passing. Parameters are passed by reference**.
2	**OUT** An OUT parameter returns a value to the calling program. Inside the subprogram, an OUT parameter acts like a variable. You can change its value and reference the value after assigning it. **The actual parameter must be variable and it is passed by value**.
3	**IN OUT** An **IN OUT** parameter passes an initial value to a subprogram and returns an updated value to the caller. It can be assigned a value and the value can be read. The actual parameter corresponding to an IN OUT formal parameter must be a variable, not a constant or an expression. Formal parameter must be assigned a value. **Actual parameter is passed by value.**

IN & OUT Mode Example 1

This program finds the minimum of two values. Here, the procedure takes two numbers using the IN mode and returns their minimum using the OUT parameters.

```
DECLARE
  a number;
  b number;
  c number;
PROCEDURE findMin(x IN number, y IN number, z OUT number) IS
BEGIN
  IF x < y THEN
    z:= x;
  ELSE
    z:= y;
  END IF;
```

```
END;
BEGIN
  a:= 23;
  b:= 45;
  findMin(a, b, c);
  dbms_output.put_line(' Minimum of (23, 45) : ' || c);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Minimum of (23, 45) : 23
PL/SQL procedure successfully completed.
```

IN & OUT Mode Example 2

This procedure computes the square of value of a passed value. This example shows how we can use the same parameter to accept a value and then return another result.

```
DECLARE
  a number;
PROCEDURE squareNum(x IN OUT number) IS
BEGIN
 x := x * x;
END;
BEGIN
  a:= 23;
  squareNum(a);
  dbms_output.put_line(' Square of (23): ' || a);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Square of (23): 529
PL/SQL procedure successfully completed.
```

Methods for Passing Parameters

Actual parameters can be passed in three ways −

- Positional notation
- Named notation
- Mixed notation

Positional Notation

In positional notation, you can call the procedure as −

```
findMin(a, b, c, d);
```

In positional notation, the first actual parameter is substituted for the first formal parameter; the second actual parameter is substituted for the second formal parameter, and so on. So, **a** is substituted for **x, b** is substituted for **y, c** is substituted for **z** and **d** is substituted for **m**.

Named Notation

In named notation, the actual parameter is associated with the formal parameter using the **arrow symbol (=>)**. The procedure call will be like the following −

```
findMin(x => a, y => b, z => c, m => d);
```

Mixed Notation

In mixed notation, you can mix both notations in procedure call; however, the positional notation should precede the named notation.

The following call is legal −

```
findMin(a, b, c, m => d);
```

However, this is not legal:

```
findMin(x => a, b, c, d);
```

PL/SQL - FUNCTIONS

A function is same as a procedure except that it returns a value. Therefore, all the discussions of the previous chapter are true for functions too.

Creating a Function

A standalone function is created using the **CREATE FUNCTION** statement. The simplified syntax for the **CREATE OR REPLACE PROCEDURE** statement is as follows −

```
CREATE [OR REPLACE] FUNCTION function_name
[(parameter_name [IN | OUT | IN OUT] type [, ...])]
RETURN return_datatype
{IS | AS}
BEGIN
  < function_body >
END [function_name];
```

Where,

- *function-name* specifies the name of the function.
- [OR REPLACE] option allows the modification of an existing function.
- The optional parameter list contains name, mode and types of the parameters. IN represents the value that will be passed from outside and OUT represents the parameter that will be used to return a value outside of the procedure.
- The function must contain a **return** statement.
- The *RETURN* clause specifies the data type you are going to return from the function.
- *function-body* contains the executable part.
- The AS keyword is used instead of the IS keyword for creating a standalone function.

Example

The following example illustrates how to create and call a standalone function. This function returns the total number of CUSTOMERS in the customers table.

We will use the CUSTOMERS table, which we had created in the PL/SQL Variables chapter −

```
Select * from customers;

+----+----------+-----+-----------+----------+
| ID | NAME     | AGE | ADDRESS   | SALARY   |
+----+----------+-----+-----------+----------+
|  1 | Ramesh   |  32 | Ahmedabad |  2000.00 |
|  2 | Khilan   |  25 | Delhi     |  1500.00 |
|  3 | kaushik  |  23 | Kota      |  2000.00 |
```

```
| 4 | Chaitali |  25 | Mumbai    |  6500.00 |
| 5 | Hardik   |  27 | Bhopal    |  8500.00 |
| 6 | Komal    |  22 | MP        |  4500.00 |
+----+----------+-----+-----------+----------+
```

```
CREATE OR REPLACE FUNCTION totalCustomers

RETURN number IS

  total number(2) := 0;

BEGIN

  SELECT count(*) into total

  FROM customers;



  RETURN total;

END;

/
```

When the above code is executed using the SQL prompt, it will produce the following result −

```
Function created.
```

Calling a Function

While creating a function, you give a definition of what the function has to do. To use a function, you will have to call that function to perform the defined task. When a program calls a function, the program control is transferred to the called function.

A called function performs the defined task and when its return statement is executed or when the **last end statement** is reached, it returns the program control back to the main program.

To call a function, you simply need to pass the required parameters along with the function name and if the function returns a value, then you can store the returned value. Following program calls the function **totalCustomers** from an anonymous block −

```
DECLARE

  c number(2);

BEGIN

  c := totalCustomers();

  dbms_output.put_line('Total no. of Customers: ' || c);

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Total no. of Customers: 6

PL/SQL procedure successfully completed.
```

Example

The following example demonstrates Declaring, Defining, and Invoking a Simple PL/SQL Function that computes and returns the maximum of two values.

```
DECLARE
  a number;
  b number;
  c number;
FUNCTION findMax(x IN number, y IN number)  RETURN number
IS     z number;
BEGIN
  IF x > y THEN
     z:= x;
  ELSE
     Z:= y;
  END IF;
  RETURN z;
END;
BEGIN
  a:= 23;
  b:= 45;
  c := findMax(a, b);
  dbms_output.put_line(' Maximum of (23,45): ' || c);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Maximum of (23,45): 45

PL/SQL procedure successfully completed.
```

PL/SQL Recursive Functions

We have seen that a program or subprogram may call another subprogram. When a subprogram calls itself, it is referred to as a recursive call and the process is known as **recursion**.

To illustrate the concept, let us calculate the factorial of a number. Factorial of a number n is defined as −

```
n! = n*(n-1)!
  = n*(n-1)*(n-2)!
     ...
  = n*(n-1)*(n-2)*(n-3)... 1
```

The following program calculates the factorial of a given number by calling itself recursively −

```
DECLARE
  num number;
  factorial number;
  FUNCTION fact(x number) RETURN number  IS    f number;
BEGIN
  IF x=0 THEN
    f := 1;
  ELSE
    f := x * fact(x-1);
  END IF;
RETURN f;
END;
BEGIN
  num:= 6;
  factorial := fact(num);
  dbms_output.put_line(' Factorial '|| num || ' is ' || factorial);
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Factorial 6 is 720

PL/SQL procedure successfully completed.
```

PL/SQL - CURSORS

In this chapter, we will discuss the cursors in PL/SQL. Oracle creates a memory area, known as the context area, for processing an SQL statement, which contains all the information needed for processing the statement; for example, the number of rows processed, etc.

A **cursor** is a pointer to this context area. PL/SQL controls the context area through a cursor. A cursor holds the rows (one or more) returned by a SQL statement. The set of rows the cursor holds is referred to as the **active set**.

You can name a cursor so that it could be referred to in a program to fetch and process the rows returned by the SQL statement, one at a time. There are two types of cursors −

- ***Implicit cursors***
- ***Explicit cursors***

Implicit Cursors

Implicit cursors are automatically created by Oracle whenever an SQL statement is executed, when there is no explicit cursor for the statement. Programmers cannot control the implicit cursors and the information in it.

Whenever a DML statement (INSERT, UPDATE and DELETE) is issued, an implicit cursor is associated with this statement. For INSERT operations, the cursor holds the data that needs to be inserted. For UPDATE and DELETE operations, the cursor identifies the rows that would be affected.

In PL/SQL, you can refer to the most recent implicit cursor as the **SQL cursor**, which always has attributes such as **%FOUND, %ISOPEN, %NOTFOUND**, and **%ROWCOUNT**. The SQL cursor has additional attributes, **%BULK_ROWCOUNT** and **%BULK_EXCEPTIONS**, designed for use with the **FORALL** statement. The following table provides the description of the most used attributes –

S.No	Attribute & Description
1	**%FOUND** Returns TRUE if an INSERT, UPDATE, or DELETE statement affected one or more rows or a SELECT INTO statement returned one or more rows. Otherwise, it returns FALSE.

2	**%NOTFOUND** The logical opposite of %FOUND. It returns TRUE if an INSERT, UPDATE, or DELETE statement affected no rows, or a SELECT INTO statement returned no rows. Otherwise, it returns FALSE.
3	**%ISOPEN** Always returns FALSE for implicit cursors, because Oracle closes the SQL cursor automatically after executing its associated SQL statement.
4	**%ROWCOUNT** Returns the number of rows affected by an INSERT, UPDATE, or DELETE statement, or returned by a SELECT INTO statement.

Any SQL cursor attribute will be accessed as **sql%attribute_name** as shown below in the example.

Example

We will be using the CUSTOMERS table we had created and used in the previous chapters.

```
Select * from customers;

+----+----------+-----+-----------+----------+
| ID | NAME     | AGE | ADDRESS   | SALARY   |
+----+----------+-----+-----------+----------+
|  1 | Ramesh   |  32 | Ahmedabad |  2000.00 |
|  2 | Khilan   |  25 | Delhi     |  1500.00 |
|  3 | kaushik  |  23 | Kota      |  2000.00 |
|  4 | Chaitali |  25 | Mumbai    |  6500.00 |
|  5 | Hardik   |  27 | Bhopal    |  8500.00 |
|  6 | Komal    |  22 | MP        |  4500.00 |
+----+----------+-----+-----------+----------+
```

The following program will update the table and increase the salary of each customer by 500 and use the **SQL%ROWCOUNT** attribute to determine the number of rows affected −

```
DECLARE
  total_rows number(2);
BEGIN
  UPDATE customers
  SET salary = salary + 500;
  IF sql%notfound THEN
```

```
   dbms_output.put_line('no customers selected');
  ELSIF sql%found THEN
```

```
   total_rows := sql%rowcount;
   dbms_output.put_line( total_rows || ' customers selected ');
  END IF;
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
6 customers selected

PL/SQL procedure successfully completed.
```

If you check the records in customers table, you will find that the rows have been updated −

```
Select * from customers;

+----+----------+-----+-----------+----------+
| ID | NAME     | AGE | ADDRESS   | SALARY   |
+----+----------+-----+-----------+----------+
|  1 | Ramesh   |  32 | Ahmedabad |  2500.00 |
|  2 | Khilan   |  25 | Delhi     |  2000.00 |
|  3 | kaushik  |  23 | Kota      |  2500.00 |
|  4 | Chaitali |  25 | Mumbai    |  7000.00 |
|  5 | Hardik   |  27 | Bhopal    |  9000.00 |
|  6 | Komal    |  22 | MP        |  5000.00 |
+----+----------+-----+-----------+----------+
```

Explicit Cursors

Explicit cursors are programmer-defined cursors for gaining more control over the **context area**. An explicit cursor should be defined in the declaration section of the PL/SQL Block. It is created on a SELECT Statement which returns more than one row.

The syntax for creating an explicit cursor is −

```
CURSOR cursor_name IS select_statement;
```

Working with an explicit cursor includes the following steps −

- Declaring the cursor for initializing the memory
- Opening the cursor for allocating the memory
- Fetching the cursor for retrieving the data
- Closing the cursor to release the allocated memory

Declaring the Cursor

Declaring the cursor defines the cursor with a name and the associated SELECT statement. For example −

```
CURSOR c_customers IS
   SELECT id, name, address FROM customers;
```

Opening the Cursor

Opening the cursor allocates the memory for the cursor and makes it ready for fetching the rows returned by the SQL statement into it. For example, we will open the above defined cursor as follows −

```
OPEN c_customers;
```

Fetching the Cursor

Fetching the cursor involves accessing one row at a time. For example, we will fetch rows from the above-opened cursor as follows −

```
FETCH c_customers INTO c_id, c_name, c_addr;
```

Closing the Cursor

Closing the cursor means releasing the allocated memory. For example, we will close the above-opened cursor as follows −

```
CLOSE c_customers;
```

Example

Following is a complete example to illustrate the concepts of explicit cursors &minua;

```
DECLARE
   c_id customers.id%type;
   c_name customerS.No.ame%type;
   c_addr customers.address%type;
   CURSOR c_customers is
      SELECT id, name, address FROM customers;
BEGIN
   OPEN c_customers;
   LOOP
   FETCH c_customers into c_id, c_name, c_addr;
```

```
   EXIT WHEN c_customers%notfound;

   dbms_output.put_line(c_id || ' ' || c_name || ' ' || c_addr);
```

```
  END LOOP;

  CLOSE c_customers;

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
1 Ramesh Ahmedabad
2 Khilan Delhi
3 kaushik Kota
4 Chaitali Mumbai
5 Hardik Bhopal
6 Komal MP

PL/SQL procedure successfully completed.
```

PL/SQL - TRIGGERS

Triggers are stored programs, which are automatically executed or fired when some events occur. Triggers are, in fact, written to be executed in response to any of the following events −

- A **database manipulation (DML)** statement (DELETE, INSERT, or UPDATE)
- A **database definition (DDL)** statement (CREATE, ALTER, or DROP).
- A **database operation** (SERVERERROR, LOGON, LOGOFF, STARTUP, or SHUTDOWN).

Triggers can be defined on the table, view, schema, or database with which the event is associated.

Benefits of Triggers

Triggers can be written for the following purposes −

- Generating some derived column values automatically
- Enforcing referential integrity
- Event logging and storing information on table access
- Auditing
- Synchronous replication of tables
- Imposing security authorizations
- Preventing invalid transactions

Creating Triggers

The syntax for creating a trigger is −

```
CREATE [OR REPLACE ] TRIGGER trigger_name
{BEFORE | AFTER | INSTEAD OF }
{INSERT [OR] | UPDATE [OR] | DELETE}
[OF col_name]
ON table_name
[REFERENCING OLD AS o NEW AS n]
[FOR EACH ROW]
WHEN (condition)
DECLARE
  Declaration-statements
BEGIN
  Executable-statements
EXCEPTION
  Exception-handling-statements
END;
```

Where,

- CREATE [OR REPLACE] TRIGGER trigger_name − Creates or replaces an existing trigger with the *trigger_name*.
- {BEFORE | AFTER | INSTEAD OF} − This specifies when the trigger will be executed. The INSTEAD OF clause is used for creating trigger on a view.
- {INSERT [OR] | UPDATE [OR] | DELETE} − This specifies the DML operation.
- [OF col_name] − This specifies the column name that will be updated.
- [ON table_name] − This specifies the name of the table associated with the trigger.
- [REFERENCING OLD AS o NEW AS n] − This allows you to refer new and old values for various DML statements, such as INSERT, UPDATE, and DELETE.
- [FOR EACH ROW] − This specifies a row-level trigger, i.e., the trigger will be executed for each row being affected. Otherwise the trigger will execute just once when the SQL statement is executed, which is called a table level trigger.
- WHEN (condition) − This provides a condition for rows for which the trigger would fire. This clause is valid only for row-level triggers.

Example

To start with, we will be using the CUSTOMERS table we had created and used in the previous chapters −

```
Select * from customers;

+----+----------+-----+-----------+----------+
| ID | NAME     | AGE | ADDRESS   | SALARY   |
+----+----------+-----+-----------+----------+
|  1 | Ramesh   |  32 | Ahmedabad |  2000.00 |
|  2 | Khilan   |  25 | Delhi     |  1500.00 |
|  3 | kaushik  |  23 | Kota      |  2000.00 |
|  4 | Chaitali |  25 | Mumbai    |  6500.00 |
|  5 | Hardik   |  27 | Bhopal    |  8500.00 |
|  6 | Komal    |  22 | MP        |  4500.00 |
+----+----------+-----+-----------+----------+
```

The following program creates a **row-level** trigger for the customers table that would fire for INSERT or UPDATE or DELETE operations performed on the CUSTOMERS table. This trigger will display the salary difference between the old values and new values −

```
CREATE OR REPLACE TRIGGER display_salary_changes

BEFORE DELETE OR INSERT OR UPDATE ON customers

FOR EACH ROW

WHEN (NEW.ID > 0)

DECLARE

  sal_diff number;

BEGIN

  sal_diff := :NEW.salary  - :OLD.salary;

  dbms_output.put_line('Old salary: ' || :OLD.salary);

  dbms_output.put_line('New salary: ' || :NEW.salary);

  dbms_output.put_line('Salary difference: ' || sal_diff);

END;

/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Trigger created.
```

The following points need to be considered here −

- OLD and NEW references are not available for table-level triggers, rather you can use them for record-level triggers.
- If you want to query the table in the same trigger, then you should use the AFTER keyword, because triggers can query the table or change it again only after the initial changes are applied and the table is back in a consistent state.
- The above trigger has been written in such a way that it will fire before any DELETE or INSERT or UPDATE operation on the table, but you can write your trigger on a single or multiple operations, for example BEFORE DELETE, which will fire whenever a record will be deleted using the DELETE operation on the table.

Triggering a Trigger

Let us perform some DML operations on the CUSTOMERS table. Here is one INSERT statement, which will create a new record in the table −

```
INSERT INTO CUSTOMERS (ID,NAME,AGE,ADDRESS,SALARY)

VALUES (7, 'Kriti', 22, 'HP', 7500.00 );
```

When a record is created in the CUSTOMERS table, the above create trigger, **display_salary_changes** will be fired and it will display the following result −

```
Old salary:
New salary: 7500
Salary difference:
```

Because this is a new record, old salary is not available and the above result comes as null. Let us now perform one more DML operation on the CUSTOMERS table. The UPDATE statement will update an existing record in the table −

```
UPDATE customers

SET salary = salary + 500

WHERE id = 2;
```

When a record is updated in the CUSTOMERS table, the above create trigger, **display_salary_changes** will be fired and it will display the following result −

```
Old salary: 1500
New salary: 2000
Salary difference: 500
```

ERROR HANDLING PL/SQL – EXCEPTIONS

An exception is an error condition during a program execution. PL/SQL supports programmers to catch such conditions using **EXCEPTION** block in the program and an appropriate action is taken against the error condition. There are two types of exceptions −

- ***System-defined exceptions***
- ***User-defined exceptions***

Syntax for Exception Handling

The general syntax for exception handling is as follows. Here you can list down as many exceptions as you can handle. The default exception will be handled using ***WHEN others THEN*** −

```
DECLARE
  <declarations section>
BEGIN
  <executable command(s)>
EXCEPTION
  <exception handling goes here >
  WHEN exception1 THEN
    exception1-handling-statements
  WHEN exception2  THEN
    exception2-handling-statements
  WHEN exception3 THEN
    exception3-handling-statements
  ........
  WHEN others THEN
    exception3-handling-statements
END;
```

Example

Let us write a code to illustrate the concept. We will be using the CUSTOMERS table we had created and used in the previous chapters –

```
DECLARE
   c_id customers.id%type := 8;
   c_name customerS.Name%type;
   c_addr customers.address%type;
BEGIN
   SELECT  name, address INTO  c_name, c_addr
   FROM customers
   WHERE id = c_id;
   DBMS_OUTPUT.PUT_LINE ('Name: '||  c_name);
   DBMS_OUTPUT.PUT_LINE ('Address: ' || c_addr);

EXCEPTION
   WHEN no_data_found THEN
      dbms_output.put_line('No such customer!');
   WHEN others THEN
      dbms_output.put_line('Error!');
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
No such customer!

PL/SQL procedure successfully completed.
```

The above program displays the name and address of a customer whose ID is given. Since there is no customer with ID value 8 in our database, the program raises the run-time exception **NO_DATA_FOUND**, which is captured in the **EXCEPTION block**.

Raising Exceptions

Exceptions are raised by the database server automatically whenever there is any internal database error, but exceptions can be raised explicitly by the programmer by using the command **RAISE**. Following is the simple syntax for raising an exception −

```
DECLARE
   exception_name EXCEPTION;
BEGIN
```

```
  IF condition THEN
    RAISE exception_name;
  END IF;
EXCEPTION
  WHEN exception_name THEN
  statement;
END;
```

You can use the above syntax in raising the Oracle standard exception or any user-defined exception. In the next section, we will give you an example on raising a user-defined exception. You can raise the Oracle standard exceptions in a similar way.

User-defined Exceptions

PL/SQL allows you to define your own exceptions according to the need of your program. A user-defined exception must be declared and then raised explicitly, using either a RAISE statement or the procedure **DBMS_STANDARD.RAISE_APPLICATION_ERROR**.

The syntax for declaring an exception is −

```
DECLARE
  my-exception EXCEPTION;
```

Example

The following example illustrates the concept. This program asks for a customer ID, when the user enters an invalid ID, the exception **invalid_id** is raised.

```
DECLARE
  c_id customers.id%type := &cc_id;
  c_name customerS.Name%type;
  c_addr customers.address%type;
  -- user defined exception
  ex_invalid_id  EXCEPTION;
BEGIN
  IF c_id <= 0 THEN
    RAISE ex_invalid_id;
```

```
   ELSE
      SELECT  name, address INTO  c_name, c_addr
      FROM customers
      WHERE id = c_id;
      DBMS_OUTPUT.PUT_LINE ('Name: '||  c_name);
      DBMS_OUTPUT.PUT_LINE ('Address: ' || c_addr);
   END IF;

EXCEPTION
   WHEN ex_invalid_id THEN
      dbms_output.put_line('ID must be greater than zero!');
   WHEN no_data_found THEN
      dbms_output.put_line('No such customer!');
   WHEN others THEN
      dbms_output.put_line('Error!');
END;
/
```

When the above code is executed at the SQL prompt, it produces the following result −

```
Enter value for cc_id: -6 (let's enter a value -6)
old  2: c_id customers.id%type := &cc_id;
new  2: c_id customers.id%type := -6;
ID must be greater than zero!

PL/SQL procedure successfully completed.
```

Pre-defined Exceptions

PL/SQL provides many pre-defined exceptions, which are executed when any database rule is violated by a program. For example, the predefined exception NO_DATA_FOUND is raised when a SELECT INTO statement returns no rows. The following table lists few of the important pre-defined exceptions −

Exception	Oracle Error	SQLCODE	Description
ACCESS_INTO_NULL	06530	-6530	It is raised when a null object is automatically assigned a value.
CASE_NOT_FOUND	06592	-6592	It is raised when none of the choices in the WHEN clause of a CASE statement is selected, and there is no ELSE clause.
COLLECTION_IS_NULL	06531	-6531	It is raised when a program attempts to apply collection methods other than EXISTS to an uninitialized nested table or varray, or the program attempts to assign values to the elements of an uninitialized nested table or varray.
DUP_VAL_ON_INDEX	00001	-1	It is raised when duplicate values are attempted to be stored in a column with unique index.
INVALID_CURSOR	01001	-1001	It is raised when attempts are made to make a cursor operation that is not allowed, such as closing an unopened cursor.
INVALID_NUMBER	01722	-1722	It is raised when the conversion of a character string into a number fails because the string does not represent a valid number.
LOGIN_DENIED	01017	-1017	It is raised when a program attempts to log on to the database with an invalid username or password.
NO_DATA_FOUND	01403	+100	It is raised when a SELECT INTO statement returns no rows.

NOT_LOGGED_ON	01012	-1012	It is raised when a database call is issued without being connected to the database.
PROGRAM_ERROR	06501	-6501	It is raised when PL/SQL has an internal problem.
ROWTYPE_MISMATCH	06504	-6504	It is raised when a cursor fetches value in a variable having incompatible data type.
SELF_IS_NULL	30625	-30625	It is raised when a member method is invoked, but the instance of the object type was not initialized.
STORAGE_ERROR	06500	-6500	It is raised when PL/SQL ran out of memory or memory was corrupted.
TOO_MANY_ROWS	01422	-1422	It is raised when a SELECT INTO statement returns more than one row.
VALUE_ERROR	06502	-6502	It is raised when an arithmetic, conversion, truncation, or sizeconstraint error occurs.
ZERO_DIVIDE	01476	1476	It is raised when an attempt is made to divide a number by zero.

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