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# About

# Foreword



In the I.T. world of today, robust and secure applications are becoming more and more important. Many business processes no longer work without I.T. and the dependence of businesses on their I.T. has grown tremendously, meaning we need robust and maintainable applications. An important requirement is to have standards and guidelines, which make it possible to maintain source code created by a number of people quickly and easily. This forms the basis of well functioning off- or onshoring strategy, as it allows quality assurance to be carried out efficiently at the source.

Good standards and guidelines are based on the wealth of experience and knowledge gained from past (and future?) problems, such as those, which can arise in a cloud environment, for example.



Urban Lankes
President of the bord of directors
Trivadis



The Oracle Database Developer community is made stronger by resources freely shared by experts around the world, such as the Trivadis Coding Guidelines. If you have not yet adopted standards for writing SQL and PL/SQL in your applications, this is a great place to start.

Steven Feuerstein

Steven Feuerstein Team Lead, Oracle Developer Advocates Oracle



Coding Guidelines are a crucial part of software development. It is a matter of fact, that code is more often read than written – therefore we should take efforts to ease the work of the reader, which is not necessarily the author.

I am convinced that this standard may be a good starting point for your own guidelines.

Roger Troller Senior Consultant finnova AG Bankware

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0.1	Troller	17.03.2009	Created.
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0.3	Reiner	12.05.2009	Extended with comments in code.
0.4	Troller	14.05.2009	Extended formatting.
0.5	Kulessa	20.05.2009	Added more CodeXpert rules.
0.6	Troller	22.05.2009	Formatting changes. Added categories to rules.
0.7	Reiner	10.06.2009	Extended with example code commenting.
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1.1	Troller	19.08.2009	Added Inspection results AFI.
1.2	Troller	21.08.2009	Added Inspection results ThM.
1.3	Troller	April 2010	Several Corrections. New Rule Oracle Supplied Packages.
1.3.1	Troller	October 2010	Some formatting.
2.0	Troller	August 2011	Added Error Handling Section. Added rule 23, 30, 31, 43.
3.0	Troller	January 2016	Added Rules for ORACLE 12c. Added SQALE Metrics. New guideline numbering system.
3.1	Troller	April 2016	Corrections
3.2	Salvisberg	January 2017	Various small corrections
3.3	Salvisberg	07.07.2018	Migrated from Microsoft Word document to MkDocs, added missing reasons, prefixed rules with "G-" as in PL/SQL Cop.
3.4	Salvisberg	20.09.2019	See Relase Information

# Introduction

This document describes rules and recommendations for developing applications using the PL/SQL & SQL Language.

# Scope

This document applies to the PL/SQL and SQL language as used within ORACLE databases and tools, which access ORACLE databases.

# **Document Conventions**

SQALE (Software Quality Assessment based on Lifecycle Expectations) is a method to support the evaluation of a software application source code. It is a generic method, independent of the language and source code analysis tools.

# SQALE characteristics and subcharacteristics

Characteristic	Description and Subcharacteristics
Changeability	The capability of the software product to enable a specified modification to be implemented.  • Architecture related changeability  • Logic related changeability  • Data related changeability
Efficiency	The capability of the software product to provide appropriate performance, relative to the amount of resources used, under stated conditions.  • Memory use  • Processor use  • Network use
Maintainability	The capability of the software product to be modified. Modifications may include corrections, improvements or adaptation of the software to changes in environment, and in requirements and functional specifications.  • Understandability  • Readability
Portability	The capability of the software product to be transferred from one environment to another.  Compiler related portability  Hardware related portability  Language related portability  OS related portability  Software related portability  Time zone related portability.
Reliability	The capability of the software product to maintain a specified level of performance when used under specified conditions.  • Architecture related reliability  • Data related reliability

	<ul> <li>Exception handling</li> <li>Fault tolerance</li> <li>Instruction related reliability</li> <li>Logic related reliability</li> <li>Resource related reliability</li> <li>Synchronization related reliability</li> <li>Unit tests coverage.</li> </ul>
Reusability	The capability of the software product to be reused within the development process.  • Modularity  • Transportability.
Security	The capability of the software product to protect information and data so that unauthorized persons or systems cannot read or modify them and authorized persons or systems are not denied access to them.  • API abuse  • Errors (e.g. leaving a system in a vulnerable state)  • Input validatation and representation  • Security features.
Testability	The capability of the software product to enable modified software to be validated.  Integration level testability  Unit level testability.

# Severity of the rule



**Blocker** 

Will or may result in a bug.



Critical

Will have a high/direct impact on the maintenance cost.



Major

Will have a medium/potential impact on the maintenance cost.



Minor

Will have a low impact on the maintenance cost.



1nfo

Very low impact; it is just a remediation cost report.

# Keywords used

Keyword	Meaning
Always	Emphasizes this rule must be enforced.
Never	Emphasizes this action must not happen.
Avoid	Emphasizes that the action should be prevented, but some exceptions may exist.
Try	Emphasizes that the rule should be attempted whenever possible and appropriate.
Example	Precedes text used to illustrate a rule or a recommendation.
Reason	Explains the thoughts and purpose behind a rule or a recommendation.
Restriction	Describes the circumstances to be fulfilled to make use of a rule.

# Why are standards important

For a machine executing a program, code formatting is of no importance. However, for the human eye, well-formatted code is much easier to read. Modern tools can help to implement format and coding rules.

Implementing formatting and coding standards has the following advantages for PL/SQL development:

- Well-formatted code is easier to read, analyze and maintain (not only for the author but also for other developers).
- The developers do not have to define their own guidelines it is already defined.
- The code has a structure that makes it easier to avoid making errors.
- The code is more efficient concerning performance and organization of the whole application.
- The code is more modular and thus easier to use for other applications.

#### We have other standards

This document only defines possible standards. These standards are not written in stone, but are meant as guidelines. If standards already exist, and they are different from those in this document, it makes no sense to change them.

# We do not agree with all your standards

There are basically two types of standards.

#### 1. Non-controversial

These standards make sense. There is no reason not to follow them. An example of this category is G-2150: Avoid comparisons with NULL value, consider using IS [NOT] NULL.

#### 2. Controversial

Almost every rule/guildeline falls into this category. An example of this category is 3 space indention. - Why not 2 or 4 or even 8? Why not use tabs? You can argue in favor of all these options. In most cases it does not really matter which option you choose. Being consistent is more important. In this case it will make the code easier to read.

For very controversial rules, we have started to include the reasoning either as a footnote or directly in the text.

Usually it is not helpful to open an issue on GitHub to request to change a highly controversial rule such as the one mentioned. For example, use 2 spaces instead of 3 spaces for an indentation. This leads to a discussion where the people in favor of 4 spaces start to argument as well. There is no right or wrong here. You just have to agree on a standard.

More effective is to fork this repository and amend the standards fit your needs/expectations.

# Naming Conventions

# General Guidelines

- 1. Never use names with a leading numeric character.
- 2. Always choose meaningful and specific names.
- 3. Avoid using abbreviations unless the full name is excessively long.
- 4. Avoid long abbreviations. Abbreviations should be shorter than 5 characters.
- 5. Any abbreviations must be widely known and accepted.
- 6. Create a glossary with all accepted abbreviations.
- 7. Never use ORACLE keywords as names. A list of ORACLEs keywords may be found in the dictionary view V\$RESERVED\_WORDS.
- 8. Avoid adding redundant or meaningless prefixes and suffixes to identifiers. Example: CREATE TABLE emp\_table.
- 9. Always use one spoken language (e.g. English, German, French) for all objects in your application.
- 10. Always use the same names for elements with the same meaning.

# Naming Conventions for PL/SQL

In general, ORACLE is not case sensitive with names. A variable named personname is equal to one named PersonName, as well as to one named PERSONNAME. Some products (e.g. TMDA by Trivadis, APEX, OWB) put each name within double quotes (") so ORACLE will treat these names to be case sensitive. Using case sensitive variable names force developers to use double quotes for each reference to the variable. Our recommendation is to write all names in lowercase and to avoid double quoted identifiers.

A widely used convention is to follow a {prefix}variablecontent{suffix} pattern.

The following table shows a possible set of naming conventions.

Identifier	Prefix	Suffix	Example
Global Variable	g_		g_version
Local Variable	1_		l_version
Cursor	c_		c_employees
Record	r		r_employee
Array / Table	t_		t_employees
Object	0_		o_employee
Cursor Parameter	p_		p_empno
In Parameter	in_		in_empno
Out Parameter	out_		out_ename
In/Out Parameter	io_		io_employee
Record Type Definitions	r	_type	r_employee_type
Array/Table Type Definitions	t_	_type	t_employees_type
Exception	e_		e_employee_exists
Constants	co_		co_empno
Subtypes		_type	big_string_type

# **Database Object Naming Conventions**

Never enclose object names (table names, column names, etc.) in double quotes to enforce mixed case or lower case object names in the data dictionary.

# Collection Type

A collection type should include the name of the collected objects in their name. Furthermore, they should have the suffix to identify it as a collection.

Optionally prefixed by a project abbreviation.

- employees\_ct
- orders\_ct

#### Column

Singular name of what is stored in the column (unless the column data type is a collection, in this case you use plural names)

Add a comment to the database dictionary for every column.

#### **Check Constraint**

Table name or table abbreviation followed by the column and/or role of the check constraint, a \_ck and an optional number suffix.

#### Examples:

- employees\_salary\_min\_ck
- orders\_mode\_ck

# DML / Instead of Trigger

Choose a naming convention that includes:

#### either

- the name of the object the trigger is added to,
- any of the triggering events:
  - \_br\_iud for Before Row on Insert, Update and Delete
  - \_io\_id for Instead of Insert and Delete

or

- the name of the object the trigger is added to,
- · the activity done by the trigger,
- the suffix \_trg

#### Examples:

- employees\_br\_iud
- orders\_audit\_trg
- orders\_journal\_trg

# Foreign Key Constraint

Table abbreviation followed by referenced table abbreviation followed by a \_fk and an optional number suffix.

- empl\_dept\_fk
- sct\_icmd\_ic\_fk1

#### **Function**

Name is built from a verb followed by a noun in general. Nevertheless, it is not sensible to call a function get\_... as a function always gets something.

The name of the function should answer the question "What is the outcome of the function?"

Optionally prefixed by a project abbreviation.

Example: employee\_by\_id

If more than one function provides the same outcome, you have to be more specific with the name.

### Index

Indexes serving a constraint (primary, unique or foreign key) are named accordingly.

Other indexes should have the name of the table and columns (or their purpose) in their name and should also have \_idx as a suffix.

# Object Type

The name of an object type is built by its content (singular) followed by a \_ot suffix.

Optionally prefixed by a project abbreviation.

Example: employee\_ot

# Package

Name is built from the content that is contained within the package.

Optionally prefixed by a project abbreviation.

#### Examples:

- employees\_api API for the employee table
- logging\_up Utilities including logging support

# **Primary Key Constraint**

Table name or table abbreviation followed by the suffix \_pk .

- employees\_pk
- departments\_pk
- sct\_contracts\_pk

#### Procedure

Name is built from a verb followed by a noun. The name of the procedure should answer the question "What is done?"

Procedures and functions are often named with underscores between words because some editors write all letters in uppercase in the object tree, so it is difficult to read them.

Optionally prefixed by a project abbreviation.

#### Examples:

- calculate\_salary
- set\_hiredate
- check\_order\_state

## Sequence

Name is built from the table name (or its abbreviation) the sequence serves as primary key generator and the suffix <code>\_seq</code> or the purpose of the sequence followed by a <code>\_seq</code>.

Optionally prefixed by a project abbreviation.

### Examples:

- employees\_seq
- order\_number\_seq

# Synonym

Synonyms should be used to address an object in a foreign schema rather than to rename an object. Therefore, synonyms should share the name with the referenced object.

# System Trigger

Name of the event the trigger is based on.

- · Activity done by the trigger
- Suffix \_trg

- ddl\_audit\_trg
- logon\_trg

### Table

Plural<sup>1</sup> name of what is contained in the table (unless the table is designed to always hold one row only – then you should use a singular name).

Suffixed by \_eb when protected by an editioning view.

Add a comment to the database dictionary for every table and every column in the table.

Optionally prefixed by a project abbreviation.

#### Examples:

- employees
- departments
- countries\_eb table interfaced by an editioning view named countries
- sct\_contracts
- sct\_contract\_lines
- sct\_incentive\_modules

# Temporary Table (Global Temporary Table)

Naming as described for tables.

Optionally suffixed by \_tmp

Optionally prefixed by a project abbreviation.

#### Examples:

- employees\_tmp
- contracts\_tmp

# **Unique Key Constraint**

Table name or table abbreviation followed by the role of the unique key constraint, a \_uk and an optional number suffix.

- employees\_name\_uk
- departments\_deptno\_uk
- sct\_contracts\_uk
- sct\_coli\_uk
- sct\_icmd\_uk1

### View

Plural<sup>1</sup> name of what is contained in the view. Optionally suffixed by an indicator identifying the object as a view (mostly used, when a 1:1 view layer lies above the table layer)

Editioning views are named like the original underlying table to avoid changing the existing application code when introducing edition based redefinition (EBR).

Add a comment to the database dictionary for every view and every column.

Optionally prefixed by a project abbreviation.

- active\_orders
- orders\_v a view to the orders table
- countries an editioning view for table countries\_eb

# Coding Style

# Formatting

#### Rules

Rule	Description
1	Keywords are written uppercase, names are written in lowercase.
2	3 space indention <sup>2</sup> .
3	One command per line.
4	Keywords LOOP, ELSE, ELSIF, END IF, WHEN on a new line.
5	Commas in front of separated elements.
6	Call parameters aligned, operators aligned, values aligned.
7	SQL keywords are right aligned within a SQL command.
8	Within a program unit only line comments are used.
9	Brackets are used when needed or when helpful to clarify a construct.

# Example

```
PROCEDURE set_salary(in_employee_id IN employees.employee_id%TYPE) IS
  CURSOR c_employees(p_employee_id IN employees.employee_id%TYPE) IS
     SELECT last_name
           ,first_name
           ,salary
       FROM employees
      WHERE employee_id = p_employee_id
      ORDER BY last_name
             ,first_name;
               c_employees%ROWTYPE;
  r_employee
  1_new_salary employees.salary%TYPE;
BEGIN
  OPEN c_employees(p_employee_id => in_employee_id);
  FETCH c_employees INTO r_employee;
  CLOSE c_employees;
  new_salary (in_employee_id => in_employee_id
              ,out_salary
                          => l_new_salary);
  -- Check whether salary has changed
  IF r_employee.salary <> l_new_salary THEN
     UPDATE employees
        SET salary = l_new_salary
      WHERE employee_id = in_employee_id;
  END IF;
END set_salary;
```

# Code Commenting

#### Conventions

Inside a program unit only use the line commenting technique — unless you temporarly deactivate code sections for testing.

To comment the source code for later document generation, comments like /\*\* ... \*/ are used. Within these documentation comments, tags may be used to define the documentation structure.

Tools like ORACLE SQL Developer or PL/SQL Developer include documentation functionality based on a javadoc-like tagging.

# **Commenting Tags**

Tag	Meaning	Example
param	Description of a parameter.	@param in_string input string
return	Description of the return value of a function.	@return result of the calculation
throws	Describe errors that may be raised by the program unit.	@throws NO_DATA_FOUND

# Example

This is an example using the documentation capabilities of SQL Developer.

```
/**
Check whether we passed a valid sql name

@param in_name string to be checked
@return in_name if the string represents a valid sql name
@throws ORA-44003: invalid SQL name

<br/>
<br/>
<br/>
<br/>
<br/>
<br/>

    SELECT TVDAssert.valid_sql_name('TEST') from dual;
    SELECT TVDAssert.valid_sql_name('123') from dual

*/
```

# Language Usage

# General

G-1010: Try to label your sub blocks.

```
Maintainability
```

#### Reason

It's a good alternative for comments to indicate the start and end of a named processing.

# Example (bad)

```
BEGIN
BEGIN
NULL;
END;

BEGIN
NULL;
END;
END;
```

G-1020: Always have a matching loop or block label.

```
Maintainability
```

#### Reason

Use a label directly in front of loops and nested anonymous blocks:

- To give a name to that portion of code and thereby self-document what it is doing.
- So that you can repeat that name with the END statement of that block or loop.

#### Example (bad)

```
DECLARE
  i INTEGER;
  co_min_value CONSTANT INTEGER := 1;
  co_max_value CONSTANT INTEGER := 10;
  co_increment CONSTANT INTEGER := 1;
BEGIN
   <<pre><<pre>cata>>
   BEGIN
      NULL;
   END;
   <<pre><<pre><<pre>codess_data>>
   BEGIN
      NULL;
   END;
   i := co_min_value;
   <<while_loop>>
   WHILE (i <= co_max_value)</pre>
     i := i + co_increment;
   END LOOP;
   <<basic_loop>>
   L00P
     EXIT basic_loop;
  END LOOP;
   <<for_loop>>
   FOR i IN co_min_value..co_max_value
      sys.dbms_output.put_line(i);
   END LOOP;
END;
```

```
DECLARE
  i INTEGER;
   co_min_value CONSTANT INTEGER := 1;
   co_max_value CONSTANT INTEGER := 10;
   co_increment CONSTANT INTEGER := 1;
BEGIN
   <<pre><<pre>cata>>
   BEGIN
     NULL;
   END prepare_data;
   <<pre><<pre><<pre>codess_data>>
   BEGIN
     NULL;
   END process_data;
   i := co_min_value;
   <<while_loop>>
   WHILE (i <= co_max_value)</pre>
   L00P
     i := i + co_increment;
   END LOOP while_loop;
   <<basic_loop>>
   L00P
     EXIT basic_loop;
   END LOOP basic_loop;
   <<for_loop>>
   FOR i IN co_min_value..co_max_value
     sys.dbms_output.put_line(i);
  END LOOP for_loop;
END;
```

G-1030: Avoid defining variables that are not used.

```
Minor

Efficiency, Maintainability
```

#### Reason

Unused variables decrease the maintainability and readability of your code.

#### Example (bad)

```
CREATE OR REPLACE PACKAGE BODY my_package IS
   PROCEDURE my_proc IS
     1_last_name employees.last_name%TYPE;
      l_first_name employees.first_name%TYPE;
      co_department_id CONSTANT departments.department_id%TYPE := 10;
      e_good EXCEPTION;
   BEGIN
      SELECT e.last_name
       INTO l_last_name
       FROM employees e
      WHERE e.department_id = co_department_id;
   EXCEPTION
      WHEN no_data_found THEN NULL; -- handle_no_data_found;
      WHEN too_many_rows THEN null; -- handle_too_many_rows;
   END my_proc;
END my_package;
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS
   PROCEDURE my_proc IS
     l_last_name employees.last_name%TYPE;
      co_department_id CONSTANT departments.department_id%TYPE := 10;
      e_good EXCEPTION;
   BEGIN
     SELECT e.last_name
       INTO l_last_name
       FROM employees e
      WHERE e.department_id = co_department_id;
      RAISE e_good;
   EXCEPTION
      WHEN no_data_found THEN NULL; -- handle_no_data_found;
      WHEN too_many_rows THEN null; -- handle_too_many_rows;
   END my_proc;
END my_package;
```



Maintainability

#### Reason

Any part of your code, which is no longer used or cannot be reached, should be eliminated from your programs to simplify the code

#### Example (bad)

```
DECLARE
  co_dept_purchasing CONSTANT departments.department_id%TYPE := 30;
BEGIN
  IF 2=3 THEN
     NULL; -- some dead code here
   END IF;
   NULL; -- some enabled code here
   <<my_loop>>
   L00P
     EXIT my_loop;
     NULL; -- some dead code here
   END LOOP my_loop;
   NULL; -- some other enabled code here
   CASE
      WHEN 1 = 1 AND 'x' = 'y' THEN
         NULL; -- some dead code here
         NULL; -- some further enabled code here
   END CASE;
   <<my_loop2>>
   FOR r_emp IN (SELECT last_name
                  FROM employees
                  WHERE department_id = co_dept_purchasing
                     OR commission_pct IS NOT NULL
                    AND 5=6)
                -- "OR commission_pct IS NOT NULL" is dead code
   L00P
      SYS.dbms_output.put_line(r_emp.last_name);
   END LOOP my_loop2;
   RETURN;
   NULL; -- some dead code here
END;
```

G-1050: Avoid using literals in your code.

```
Minor
Changeability
```

#### Reason

Literals are often used more than once in your code. Having them defined as a constant reduces typos in your code and improves the maintainability.

All constants should be collated in just one package used as a library. If these constants should be used in SQL too it is good practice to write a deterministic package function for every constant.

## Example (bad)

```
DECLARE
   1_job employees.job_id%TYPE;
BEGIN
   SELECT e.job_id
    INTO l_job
    FROM employees e
    WHERE e.manager_id IS NULL;
  IF l_{job} = 'AD_{PRES'} THEN
     NULL;
   END IF:
EXCEPTION
   WHEN NO_DATA_FOUND THEN
     NULL; -- handle_no_data_found;
   WHEN TOO_MANY_ROWS THEN
      NULL; -- handle_too_many_rows;
END;
```

```
CREATE OR REPLACE PACKAGE constants_up IS
  co_president CONSTANT employees.job_id%TYPE := 'AD_PRES';
END constants_up;
DECLARE
  l_job employees.job_id%TYPE;
BEGIN
  SELECT e.job_id
    INTO l_job
    FROM employees e
   WHERE e.manager_id IS NULL;
   IF l_job = constants_up.co_president THEN
     NULL;
   END IF;
EXCEPTION
   WHEN NO_DATA_FOUND THEN
     NULL; -- handle_no_data_found;
   WHEN TOO_MANY_ROWS THEN
      NULL; -- handle_too_many_rows;
END:
```

G-1060: Avoid storing ROWIDs or UROWIDs in database tables.

```
Major
Reliability
```

#### Reason

It is an extremely dangerous practice to store ROWIDs in a table, except for some very limited scenarios of runtime duration. Any manually explicit or system generated implicit table reorganization will reassign the row's ROWID and break the data consistency.

Instead of using ROWID for later reference to the original row one should use the primary key column(s).

### Example (bad)

G-1070: Avoid nesting comment blocks.

```
Minor

Maintainability
```

#### Reason

Having an end-of-comment within a block comment will end that block-comment. This does not only influence your code but is also very hard to read.

# Example (bad)

```
BEGIN
  /* comment one -- nested comment two */
  NULL;
  -- comment three /* nested comment four */
  NULL;
END;
/
```

```
BEGIN
  /* comment one, comment two */
  NULL;
  -- comment three, comment four
  NULL;
END;
/
```

# Variables & Types

#### General

G-2110: Try to use anchored declarations for variables, constants and types.

```
Maintainability, Reliability
```

#### **REASON**

Changing the size of the database column last\_name in the employees table from VARCHAR2(20) to VARCHAR2(30) will result in an error within your code whenever a value larger than the hard coded size is read from the table. This can be avoided using anchored declarations.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS

PROCEDURE my_proc IS

l_last_name VARCHAR2(20 CHAR);

co_first_row CONSTANT INTEGER := 1;

BEGIN

SELECT e.last_name
    INTO l_last_name
    FROM employees e

WHERE rownum = co_first_row;

EXCEPTION

WHEN no_data_found THEN NULL; -- handle no_data_found
WHEN too_many_rows THEN NULL; -- handle too_many_rows (impossible)

END my_proc;

END my_package;

/
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS

PROCEDURE my_proc IS

l_last_name employees.last_name%TYPE;

co_first_row CONSTANT INTEGER := 1;

BEGIN

SELECT e.last_name

INTO l_last_name

FROM employees e

WHERE rownum = co_first_row;

EXCEPTION

WHEN no_data_found THEN NULL; -- handle no_data_found

WHEN too_many_rows THEN NULL; -- handle too_many_rows (impossible)

END my_proc;

END my_package;

/
```

#### G-2120: Try to have a single location to define your types.



REASON

Single point of change when changing the data type. No need to argue where to define types or where to look for existing definitions.

A single location could be either a type specification package or the database (database-defined types).

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS
    PROCEDURE my_proc IS
    SUBTYPE big_string_type IS VARCHAR2(1000 CHAR);
    l_note big_string_type;
BEGIN
    l_note := some_function();
END my_proc;
END my_package;
/
```

```
CREATE OR REPLACE PACKAGE types_up IS
    SUBTYPE big_string_type IS VARCHAR2(1000 CHAR);
END types_up;
/

CREATE OR REPLACE PACKAGE BODY my_package IS
    PROCEDURE my_proc IS
        1_note types_up.big_string_type;
BEGIN
        1_note := some_function();
END my_proc;
END my_package;
/
```

### G-2130: Try to use subtypes for constructs used often in your code.



REASON

Single point of change when changing the data type.

Your code will be easier to read as the usage of a variable/constant may be derived from its definition.

**EXAMPLES OF POSSIBLE SUBTYPE DEFINITIONS** 

Туре	Usage
ora_name_type	Object corresponding to the ORACLE naming conventions (table, variable, column, package, etc.).
max_vc2_type	String variable with maximal VARCHAR2 size.
array_index_type	Best fitting data type for array navigation.
id_type	Data type used for all primary key (id) columns.

#### **EXAMPLE (BAD)**

```
CREATE OR REPLACE PACKAGE BODY my_package IS
    PROCEDURE my_proc IS
        1_note VARCHAR2(1000 CHAR);
BEGIN
        1_note := some_function();
END my_proc;
END my_proc;
END my_package;
//
```

```
CREATE OR REPLACE PACKAGE types_up IS
    SUBTYPE big_string_type IS VARCHAR2(1000 CHAR);
END types_up;
/

CREATE OR REPLACE PACKAGE BODY my_package IS
    PROCEDURE my_proc IS
        1_note types_up.big_string_type;
BEGIN
        1_note := some_function();
END my_proc;
END my_package;
/
```

### G-2140: Never initialize variables with NULL.



**Minor** 

Maintainability

REASON

Variables are initialized to NULL by default.

EXAMPLE (BAD)

```
DECLARE
  l_note big_string_type := NULL;
  sys.dbms_output.put_line(l_note);
END;
```

```
DECLARE
  l_note big_string_type;
BEGIN
  sys.dbms_output.put_line(l_note);
END;
```

# G-2150: Avoid comparisons with NULL value, consider using IS [NOT] NULL.

 ## Blocker

 Portability, Reliability

REASON

The NULL value can cause confusion both from the standpoint of code review and code execution. You must always use the IS NULL or IS NOT NULL syntax when you need to check if a value is or is not NULL.

**EXAMPLE (BAD)** 

```
DECLARE
    1_value INTEGER;
BEGIN
    IF 1_value = NULL THEN
        NULL;
    END IF;
END;
/
```

#### G-2160: Avoid initializing variables using functions in the declaration section.

Critical
Reliability

REASON

If your initialization fails, you will not be able to handle the error in your exceptions block.

**EXAMPLE (BAD)** 

```
DECLARE
    co_department_id CONSTANT INTEGER := 100;
    l_department_name departments.department_name%TYPE :=
        department_api.name_by_id(in_id => co_department_id);
BEGIN
    sys.dbms_output.put_line(l_department_name);
END;
//
```

#### G-2170: Never overload variables.

```
Major
Reliability
```

**REASON** 

The readability of your code will be higher when you do not overload variables.

**EXAMPLE (BAD)** 

```
BEGIN
     <<main>>
     DECLARE
          co_main CONSTANT user_objects.object_name%TYPE := 'test_main';
          co_sub CONSTANT user_objects.object_name%TYPE := 'test_sub';
          co_sep CONSTANT user_objects.object_name%TYPE := ' - ';
          l_main_variable user_objects.object_name%TYPE := co_main;

BEGIN
          <<sub>
          DECLARE
                l_sub_variable user_objects.object_name%TYPE := co_sub;

BEGIN
                sys.dbms_output.put_line(l_sub_variable || co_sep || l_main_variable);
                 END sub;
                 END main;

END;
//
```

# G-2180: Never use quoted identifiers.

```
Major

Maintainability
```

REASON

Quoted identifiers make your code hard to read and maintain.

**EXAMPLE (BAD)** 

```
DECLARE
    "sal+comm" INTEGER;
    "my constant" CONSTANT INTEGER := 1;
    "my exception" EXCEPTION;

BEGIN
    "sal+comm" := "my constant";

EXCEPTION
    WHEN "my exception" THEN
        NULL;

END;
/
```

# G-2185: Avoid using overly short names for explicitly or implicitly declared identifiers.

**₩ Minor**Maintainability

REASON

You should ensure that the name you have chosen well defines its purpose and usage. While you can save a few keystrokes typing very short names, the resulting code is obscure and hard for anyone besides the author to understand.

**EXAMPLE (BAD)** 

```
DECLARE
    i INTEGER;
    c CONSTANT INTEGER := 1;
    e EXCEPTION;

BEGIN
    i := c;

EXCEPTION
    WHEN e THEN
    NULL;

END;
/
```

## G-2190: Avoid using ROWID or UROWID.



Major

Portability, Reliability

REASON

Be careful about your use of Oracle-specific data types like ROWID and UROWID. They might offer a slight improvement in performance over other means of identifying a single row (primary key or unique index value), but that is by no means guaranteed.

Use of ROWID or UROWID means that your SQL statement will not be portable to other SQL databases. Many developers are also not familiar with these data types, which can make the code harder to maintain.

**EXAMPLE (BAD)** 

```
DECLARE
  1_department_name departments.department_name%TYPE;
  1_rowid ROWID;
BEGIN
  UPDATE departments
     SET department_name = 1_department_name
   WHERE ROWID = 1_rowid;
END;
```

```
DECLARE
  1_department_name departments.department_name%TYPE;
                      departments.department_id%TYPE;
  l_department_id
BEGIN
  UPDATE departments
     SET department_name = l_department_name
    WHERE department_id = l_department_id;
END;
```

# Numeric Data Types

G-2210: Avoid declaring NUMBER variables, constants or subtypes with no precision.



**REASON** 

If you do not specify precision NUMBER is defaulted to 38 or the maximum supported by your system, whichever is less. You may well need all this precision, but if you know you do not, you should specify whatever matches your needs.

**EXAMPLE (BAD)** 

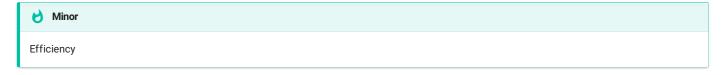
```
CREATE OR REPLACE PACKAGE BODY constants_up IS
   co_small_increase CONSTANT NUMBER := 0.1;

FUNCTION small_increase RETURN NUMBER IS
   BEGIN
        RETURN co_small_increase;
END small_increase;
END constants_up;
//
```

```
CREATE OR REPLACE PACKAGE BODY constants_up IS
  co_small_increase CONSTANT NUMBER(5,1) := 0.1;

FUNCTION small_increase RETURN NUMBER IS
  BEGIN
     RETURN co_small_increase;
END small_increase;
END constants_up;
//
```

## G-2220: Try to use PLS\_INTEGER instead of NUMBER for arithmetic operations with integer values.



REASON

PLS\_INTEGER having a length of -2,147,483,648 to 2,147,483,647, on a 32bit system.

There are many reasons to use PLS\_INTEGER instead of NUMBER:

- PLS\_INTEGER uses less memory
- PLS\_INTEGER uses machine arithmetic, which is up to three times faster than library arithmetic, which is used by NUMBER.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY constants_up IS
   co_big_increase CONSTANT NUMBER(5,0) := 1;

FUNCTION big_increase RETURN NUMBER IS
   BEGIN
        RETURN co_big_increase;
END big_increase;
END constants_up;
//
```

```
CREATE OR REPLACE PACKAGE BODY constants_up IS

co_big_increase CONSTANT PLS_INTEGER := 1;

FUNCTION big_increase RETURN PLS_INTEGER IS

BEGIN

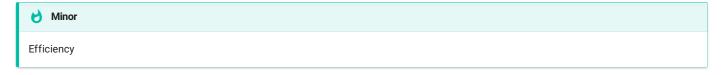
RETURN co_big_increase;

END big_increase;

END constants_up;

/
```

#### G-2230: Try to use SIMPLE\_INTEGER datatype when appropriate.



RESTRICTION

**ORACLE 11g or later** 

**REASON** 

SIMPLE\_INTEGER does no checks on numeric overflow, which results in better performance compared to the other numeric datatypes.

With ORACLE 11g, the new data type SIMPLE\_INTEGER has been introduced. It is a sub-type of PLS\_INTEGER and covers the same range. The basic difference is that SIMPLE\_INTEGER is always NOT NULL. When the value of the declared variable is never going to be null then you can declare it as SIMPLE\_INTEGER. Another major difference is that you will never face a numeric overflow using SIMPLE\_INTEGER as this data type wraps around without giving any error. SIMPLE\_INTEGER data type gives major performance boost over PLS\_INTEGER when code is compiled in NATIVE mode, because arithmetic operations on SIMPLE\_INTEGER type are performed directly at the hardware level.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY constants_up IS
   co_big_increase CONSTANT NUMBER(5,0) := 1;

FUNCTION big_increase RETURN NUMBER IS
   BEGIN
        RETURN co_big_increase;
END big_increase;
END constants_up;
//
```

```
CREATE OR REPLACE PACKAGE BODY constants_up IS
   co_big_increase CONSTANT SIMPLE_INTEGER := 1;

FUNCTION big_increase RETURN SIMPLE_INTEGER IS
   BEGIN
        RETURN co_big_increase;
   END big_increase;
END constants_up;
//
```

# **Character Data Types**

# G-2310: Avoid using CHAR data type.



Reliability

#### **REASON**

CHAR is a fixed length data type, which should only be used when appropriate. CHAR columns/variables are always filled to its specified lengths; this may lead to unwanted side effects and undesired results.

EXAMPLE (BAD)

```
CREATE OR REPLACE PACKAGE types_up
IS
    SUBTYPE description_type IS CHAR(200);
END types_up;
/
```

```
CREATE OR REPLACE PACKAGE types_up
IS
SUBTYPE description_type IS VARCHAR2(200 CHAR);
END types_up;
/
```

# G-2320: Avoid using VARCHAR data type.



REASON

Do not use the VARCHAR data type. Use the VARCHAR2 data type instead. Although the VARCHAR data type is currently synonymous with VARCHAR2, the VARCHAR data type is scheduled to be redefined as a separate data type used for variable-length character strings compared with different comparison semantics.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE types_up IS
   SUBTYPE description_type IS VARCHAR(200);
END types_up;
/
```

```
CREATE OR REPLACE PACKAGE types_up IS
SUBTYPE description_type IS VARCHAR2(200 CHAR);
END types_up;
/
```

# G-2330: Never use zero-length strings to substitute NULL.

```
<u>A</u> Major

Portability
```

REASON

Today zero-length strings and NULL are currently handled identical by ORACLE. There is no guarantee that this will still be the case in future releases, therefore if you mean NULL use NULL.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY constants_up IS
  co_null_string CONSTANT VARCHAR2(1) := '';

FUNCTION null_string RETURN VARCHAR2 IS
  BEGIN
        RETURN co_null_string;
  END null_string;
END constants_up;
//
```

```
CREATE OR REPLACE PACKAGE BODY constants_up IS

FUNCTION empty_string RETURN VARCHAR2 IS
BEGIN
RETURN NULL;
END empty_string;
END constants_up;
/
```

## G-2340: Always define your VARCHAR2 variables using CHAR SEMANTIC (if not defined anchored).



REASON

Changes to the NLS\_LENGTH\_SEMANTIC will only be picked up by your code after a recompilation.

In a multibyte environment a VARCHAR2(10) definition may not necessarily hold 10 characters, when multibyte characters a part of the value that should be stored unless the definition was done using the char semantic.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE types_up IS
   SUBTYPE description_type IS VARCHAR2(200);
END types_up;
/
```

```
CREATE OR REPLACE PACKAGE types_up IS
   SUBTYPE description_type IS VARCHAR2(200 CHAR);
END types_up;
/
```

# **Boolean Data Types**

## G-2410: Try to use boolean data type for values with dual meaning.



**REASON** 

The use of TRUE and FALSE clarifies that this is a boolean value and makes the code easier to read.

**EXAMPLE (BAD)** 

```
DECLARE
    co_newFile CONSTANT PLS_INTEGER := 1000;
    co_oldFile CONSTANT PLS_INTEGER := 500;
    l_bigger    PLS_INTEGER;

BEGIN
    If co_newFile < co_oldFile THEN
        l_bigger := constants_up.co_numeric_true;

ELSE
        l_bigger := constants_up.co_numeric_false;
    END IF;

END;
//</pre>
```

**EXAMPLE (BETTER)** 

```
DECLARE
    co_newFile CONSTANT PLS_INTEGER := 1000;
    co_oldFile CONSTANT PLS_INTEGER := 500;
    l_bigger BOOLEAN;
BEGIN
    If co_newFile < co_oldFile THEN
        l_bigger := TRUE;
    ELSE
        l_bigger := FALSE;
    END IF;
END;
/</pre>
```

```
DECLARE
    co_newFile CONSTANT PLS_INTEGER := 1000;
    co_oldFile CONSTANT PLS_INTEGER := 500;
    l_bigger BOOLEAN;
BEGIN
    l_bigger := NVL(co_newFile < co_oldFile,FALSE);
END;
/</pre>
```

# Large Objects

## G-2510: Avoid using the LONG and LONG RAW data types.

```
Major
Portability
```

#### **REASON**

LONG and LONG RAW data types have been deprecated by ORACLE since version 8i - support might be discontinued in future ORACLE releases.

There are many constraints to LONG datatypes in comparison to the LOB types.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE example_package IS
    g_long LONG;
    g_raw LONG RAW;

PROCEDURE do_something;
END example_package;
/

CREATE OR REPLACE PACKAGE BODY example_package IS
    PROCEDURE do_something IS
    BEGIN
        NULL;
    END do_something;
END example_package;
/
```

```
CREATE OR REPLACE PACKAGE example_package IS
    PROCEDURE do_something;
END example_package;
/

CREATE OR REPLACE PACKAGE BODY example_package IS
    g_long CLOB;
    g_raw BLOB;

PROCEDURE do_something IS
    BEGIN
    NULL;
    END do_something;
END example_package;
/
```

# DML & SQL

# General

G-3110: Always specify the target columns when coding an insert statement.

```
Major

Maintainability, Reliability
```

REASON

Data structures often change. Having the target columns in your insert statements will lead to change-resistant code.

EXAMPLE (BAD)

```
INSERT INTO departments
   VALUES (departments_seq.nextval
    ,'Support'
    ,100
    ,10);
```

#### G-3120: Always use table aliases when your SQL statement involves more than one source.

<u>A</u> Major

Maintainability

REASON

It is more human readable to use aliases instead of writing columns with no table information.

Especially when using subqueries the omission of table aliases may end in unexpected behavior and result.

**EXAMPLE (BAD)** 

```
SELECT last_name
   ,first_name
   ,department_name
FROM employees
    JOIN departments USING (department_id)
WHERE EXTRACT(MONTH FROM hire_date) = EXTRACT(MONTH FROM SYSDATE);
```

**EXAMPLE (BETTER)** 

```
SELECT e.last_name
    ,e.first_name
    ,d.department_name
FROM employees e
    JOIN departments d ON (e.department_id = d.department_id)
WHERE EXTRACT(MONTH FROM e.hire_date) = EXTRACT(MONTH FROM SYSDATE);
```

**EXAMPLE (GOOD)** 

Using meaningful aliases improves the readability of your code.

```
SELECT emp.last_name
   ,emp.first_name
   ,dept.department_name
FROM employees emp
   JOIN departments dept ON (emp.department_id = dept.department_id)
WHERE EXTRACT(MONTH FROM emp.hire_date) = EXTRACT(MONTH FROM SYSDATE);
```

**EXAMPLE SUBQUERY (BAD)** 

If the jobs table has no employee\_id column and employees has one this query will not raise an error but return all rows of the employees table as a subquery is allowed to access columns of all its parent tables - this construct is known as correlated subquery.

**EXAMPLE SUBQUERY (GOOD)** 

If the jobs table has no employee\_id column this query will return an error due to the directive (given by adding the table alias to the column) to read the employee\_id column from the jobs table.

# G-3130: Try to use ANSI SQL-92 join syntax.



Minor

Maintainability, Portability

REASON

ANSI SQL-92 join syntax supports the full outer join. A further advantage of the ANSI SQL-92 join syntax is the separation of the join condition from the query filters.

**EXAMPLE (BAD)** 

```
SELECT e.employee_id
      ,e.last_name
     ,e.first_name
     ,d.department_name
 FROM employees e
     ,departments d
WHERE e.department_id = d.department_id
  AND EXTRACT(MONTH FROM e.hire_date) = EXTRACT(MONTH FROM SYSDATE);
```

```
SELECT emp.employee_id
      ,emp.last_name
      ,emp.first_name
     ,dept.department_name
           employees emp
      JOIN departments dept ON dept.department_id = emp.department_id
 WHERE EXTRACT(MONTH FROM emp.hire_date) = EXTRACT(MONTH FROM SYSDATE);
```

#### G-3140: Try to use anchored records as targets for your cursors.

Major

Maintainability, Reliability

**REASON** 

Using cursor-anchored records as targets for your cursors results enables the possibility of changing the structure of the cursor without regard to the target structure.

**EXAMPLE (BAD)** 

```
DECLARE
   CURSOR c_employees IS
      SELECT employee_id, first_name, last_name
        FROM employees;
   1_employee_id employees.employee_id%TYPE;
   l_first_name employees.first_name%TYPE;
                 employees.last_name%TYPE;
   l_last_name
BEGIN
   OPEN c_employees;
   FETCH c_employees INTO l_employee_id, l_first_name, l_last_name;
   <<pre><<pre><<pre>cess_employees>>
   WHILE c_employees%FOUND
   L00P
      -- do something with the data
      FETCH c_employees INTO l_employee_id, l_first_name, l_last_name;
   END LOOP process_employees;
   CLOSE c_employees;
END;
```

```
DECLARE
   CURSOR c_employees IS
      SELECT employee_id, first_name, last_name
        FROM employees;
   r_employee c_employees%ROWTYPE;
BEGIN
   OPEN c_employees;
   FETCH c_employees INTO r_employee;
   <<pre><<pre>cess_employees>>
   WHILE c_employees%FOUND
   L00P
      -- do something with the data
      FETCH c_employees INTO r_employee;
   END LOOP process_employees;
   CLOSE c_employees;
END;
```

#### G-3150: Try to use identity columns for surrogate keys.



Minor

Maintainability, Reliability

RESTRICTION

**ORACLE 12c** 

**REASON** 

An identity column is a surrogate key by design - there is no reason why we should not take advantage of this natural implementation when the keys are generated on database level. Using identity column (and therefore assigning sequences as default values on columns) has a huge performance advantage over a trigger solution.

**EXAMPLE (BAD)** 

```
CREATE TABLE locations (
  location_id NUMBER(10)
                                      NOT NULL
 ,location_name VARCHAR2(60 CHAR) NOT NULL
 ,city
                   VARCHAR2(30 CHAR) NOT NULL
  ,CONSTRAINT locations_pk PRIMARY KEY (location_id)
  )
CREATE SEQUENCE location_seq START WITH 1 CACHE 20
CREATE OR REPLACE TRIGGER location_br_i
   BEFORE INSERT ON LOCATIONS
  FOR EACH ROW
BEGIN
   :new.location_id := location_seq.nextval;
END;
```

**EXAMPLE (GOOD)** 

```
CREATE TABLE locations (
 location_id NUMBER(10) GENERATED ALWAYS AS IDENTITY
 ,CONSTRAINT locations_pk PRIMARY KEY (location_id))
```

GENERATED ALWAYS AS IDENTITY ensures that the location\_id is populated by a sequence. It is not possible to override the behavior in the application.

However, if you use a framework that produces an INSERT statement including the surrogate key column, and you cannot change this behavior, then you have to use the GENERATED BY DEFAULT ON NULL AS IDENTITY option. This has the downside that the application may pass a value, which might lead to an immediate or delayed ORA-00001: unique constraint violated error.

#### G-3160: Avoid visible virtual columns.

Major

Maintainability, Reliability

RESTRICTION

**ORACLE 12c** 

**REASON** 

In contrast to visible columns, invisible columns are not part of a record defined using %ROWTYPE construct. This is helpful as a virtual column may not be programmatically populated. If your virtual column is visible you have to manually define the record types used in API packages to be able to exclude them from being part of the record definition.

Invisible columns may be accessed by explicitly adding them to the column list in a SELECT statement.

**EXAMPLE (BAD)** 

```
ALTER TABLE employees
   ADD total_salary GENERATED ALWAYS AS (salary + NVL(commission_pct,0) * salary)
DECLARE
   r_employee employees%ROWTYPE;
   l_id employees.employee_id%TYPE := 107;
BEGIN
   r_employee := employee_api.employee_by_id(l_id);
   r_employee.salary := r_employee.salary * constants_up.small_increase();
   UPDATE employees
     SET ROW = r_{employee}
   WHERE employee_id = l_id;
END;
Error report -
ORA-54017: UPDATE operation disallowed ON virtual COLUMNS
ORA-06512: at line 9
```

```
ALTER TABLE employees
   ADD total_salary INVISIBLE GENERATED ALWAYS AS
      (salary + NVL(commission_pct,0) * salary)
DECLARE
   r_employee employees%ROWTYPE;
   co_id CONSTANT employees.employee_id%TYPE := 107;
   r_employee := employee_api.employee_by_id(co_id);
   r_employee.salary := r_employee.salary * constants_up.small_increase();
   UPDATE employees
      SET ROW = r_{employee}
    WHERE employee_id = co_id;
END:
```

G-3170: Always use DEFAULT ON NULL declarations to assign default values to table columns if you refuse to store NULL values.



RESTRICTION

**ORACLE 12c** 

**REASON** 

Default values have been nullifiable until ORACLE 12c. Meaning any tool sending null as a value for a column having a default value bypassed the default value. Starting with ORACLE 12c default definitions may have an ON NULL definition in addition, which will assign the default value in case of a null value too.

**EXAMPLE (BAD)** 

# G-3180: Always specify column names instead of positional references in ORDER BY clauses.

Major

Changeability, Reliability

## REASON

If you change your select list afterwards the ORDER BY will still work but order your rows differently, when not changing the positional number. Furthermore, it is not comfortable to the readers of the code, if they have to count the columns in the SELECT list to know the way the result is ordered.

**EXAMPLE (BAD)** 

```
SELECT UPPER(first_name)
   ,last_name
   ,salary
   ,hire_date
FROM employees
ORDER BY 4,1,3;
```

```
SELECT upper(first_name) AS first_name
   ,last_name
   ,salary
   ,hire_date
FROM employees
ORDER BY hire_date
   ,first_name
   ,salary;
```

#### G-3190: Avoid using NATURAL JOIN.



Major

Changeability, Reliability

#### **REASON**

A natural join joins tables on equally named columns. This may comfortably fit on first sight, but adding logging columns to a table (changed\_by, changed\_date) will result in inappropriate join conditions.

**EXAMPLE (BAD)** 

```
SELECT department_name
     ,last_name
     ,first_name
 FROM employees NATURAL JOIN departments
ORDER BY department_name
   ,last_name;
                        LAST_NAME
                                        FIRST_NAME
DEPARTMENT_NAME
                          Gietz William
Accounting
Executive
                           De Haan
                                                   Lex
ALTER TABLE departments ADD modified_at DATE DEFAULT ON NULL SYSDATE;
ALTER TABLE employees ADD modified_at DATE DEFAULT ON NULL SYSDATE;
SELECT department_name
     ,last_name
     ,first_name
 FROM employees NATURAL JOIN departments
ORDER BY department_name
        ,last_name;
No data found
```

```
SELECT d.department_name
   ,e.last_name
    ,e.first_name
 FROM employees e
 JOIN departments d ON (e.department_id = d.department_id)
ORDER BY d.department_name
     ,e.last_name;
DEPARTMENT_NAME
                     LAST_NAME
                                        FIRST_NAME
William
Accounting
                      Gietz
Executive
                      De Haan
                                         Lex
```

# **Bulk Operations**

G-3210: Always use BULK OPERATIONS (BULK COLLECT, FORALL) whenever you have to execute a DML statement for more than 4 times.

```
Major

Efficiency
```

REASON

Context switches between PL/SQL and SQL are extremely costly. BULK Operations reduce the number of switches by passing an array to the SQL engine, which is used to execute the given statements repeatedly.

(Depending on the PLSQL\_OPTIMIZE\_LEVEL parameter a conversion to BULK COLLECT will be done by the PL/SQL compiler automatically.)

**EXAMPLE (BAD)** 

```
DECLARE
   t_employee_ids employee_api.t_employee_ids_type;
   co_increase CONSTANT employees.salary%type := 0.1;
   co_department_id CONSTANT departments.department_id%TYPE := 10;
BEGIN
   t_employee_ids := employee_api.employee_ids_by_department(
                         id_in => co_department_id
                      );
   <<pre><<pre><<pre>cess_employees>>
   FOR i IN 1..t_employee_ids.COUNT()
   L00P
      UPDATE employees
        SET salary = salary + (salary * co_increase)
       WHERE employee_id = t_employee_ids(i);
   END LOOP process_employees;
END;
```

# Control Structures

# **CURSOR**

G-4110: Always use %NOTFOUND instead of NOT %FOUND to check whether a cursor returned data.



**REASON** 

The readability of your code will be higher when you avoid negative sentences.

**EXAMPLE (BAD)** 

#### G-4120: Avoid using %NOTFOUND directly after the FETCH when working with BULK OPERATIONS and LIMIT clause.

Critical
Reliability

REASON

%NOTFOUND is set to TRUE as soon as less than the number of rows defined by the LIMIT clause has been read.

**EXAMPLE (BAD)** 

The employees table holds 107 rows. The example below will only show 100 rows as the cursor attribute NOTFOUND is set to true as soon as the number of rows to be fetched defined by the limit clause is not fulfilled anymore.

```
DECLARE
   CURSOR c_employees IS
      SELECT *
        FROM employees
       ORDER BY employee_id;
   TYPE t_employees_type IS TABLE OF c_employees%ROWTYPE;
   t_employees t_employees_type;
   co_bulk_size CONSTANT SIMPLE_INTEGER := 10;
BEGIN
   OPEN c_employees;
   <<pre><<pre><<pre>cess_employees>>
   L<sub>00</sub>P
      FETCH c_employees BULK COLLECT INTO t_employees LIMIT co_bulk_size;
      EXIT process_employees WHEN c_employees%NOTFOUND;
      <<display_employees>>
      FOR i IN 1..t_employees.COUNT()
         sys.dbms_output.put_line(t_employees(i).last_name);
      END LOOP display_employees;
   END LOOP process_employees;
   CLOSE c_employees;
END;
```

**EXAMPLE (BETTER)** 

This example will show all 107 rows but execute one fetch too much (12 instead of 11).

```
DECLARE
   CURSOR c_employees IS
      SELECT *
        FROM employees
       ORDER BY employee_id;
   TYPE t_employees_type IS TABLE OF c_employees%ROWTYPE;
   t_employees t_employees_type;
   co_bulk_size CONSTANT SIMPLE_INTEGER := 10;
BEGIN
   OPEN c_employees;
   <<pre><<pre>cess_employees>>
   L00P
      FETCH c_employees BULK COLLECT INTO t_employees LIMIT co_bulk_size;
      EXIT process_employees WHEN t_employees.COUNT() = 0;
      <<display_employees>>
      FOR i IN 1..t_employees.COUNT()
      L00P
         sys.dbms_output.put_line(t_employees(i).last_name);
      END LOOP display_employees;
   END LOOP process_employees;
   CLOSE c_employees;
END;
```

**EXAMPLE (GOOD)** 

This example does the trick (11 fetches only to process all rows)

```
DECLARE
   CURSOR c_employees IS
      SELECT *
       FROM employees
       ORDER BY employee_id;
  TYPE t_employees_type IS TABLE OF c_employees%ROWTYPE;
   t_employees t_employees_type;
   co_bulk_size CONSTANT SIMPLE_INTEGER := 10;
BEGIN
  OPEN c_employees;
   <<pre><<pre><<pre>cess_employees>>
      FETCH c_employees BULK COLLECT INTO t_employees LIMIT co_bulk_size;
      <<display_employees>>
      FOR i IN 1..t_employees.COUNT()
         sys.dbms_output.put_line(t_employees(i).last_name);
      END LOOP display_employees;
      EXIT process_employees WHEN t_employees.COUNT() <> co_bulk_size;
   END LOOP process_employees;
   CLOSE c_employees;
END;
```

#### G-4130: Always close locally opened cursors.

Major

Efficiency, Reliability

#### REASON

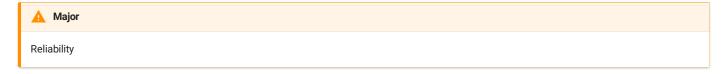
Any cursors left open can consume additional memory space (i.e. SGA) within the database instance, potentially in both the shared and private SQL pools. Furthermore, failure to explicitly close cursors may also cause the owning session to exceed its maximum limit of open cursors (as specified by the OPEN\_CURSORS database initialization parameter), potentially resulting in the Oracle error of "ORA-01000: maximum open cursors exceeded".

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY employee_api AS
   FUNCTION department_salary (in_dept_id IN departments.department_id%TYPE)
      RETURN NUMBER IS
      CURSOR c_department_salary(p_dept_id IN departments.department_id%TYPE) IS
         SELECT sum(salary) AS sum_salary
           FROM employees
          WHERE department_id = p_dept_id;
      r_department_salary c_department_salary%rowtype;
   BEGIN
      OPEN c_department_salary(p_dept_id => in_dept_id);
      FETCH c_department_salary INTO r_department_salary;
      RETURN r_department_salary.sum_salary;
   END department_salary;
END employee_api;
```

```
CREATE OR REPLACE PACKAGE BODY employee_api AS
   FUNCTION department_salary (in_dept_id IN departments.department_id%TYPE)
      RETURN NUMBER IS
      {\tt CURSOR}\ c\_department\_salary(p\_dept\_id\ IN\ departments.department\_id\%TYPE)\ IS
         SELECT SUM(salary) AS sum_salary
           FROM employees
          WHERE department_id = p_dept_id;
      r_department_salary c_department_salary%rowtype;
   BEGIN
      OPEN c_department_salary(p_dept_id => in_dept_id);
      FETCH c_department_salary INTO r_department_salary;
      CLOSE c_department_salary;
      RETURN r_department_salary.sum_salary;
   END department_salary;
END employee_api;
```

#### G-4140: Avoid executing any statements between a SQL operation and the usage of an implicit cursor attribute.



REASON

Oracle provides a variety of cursor attributes (like %FOUND and %ROWCOUNT) that can be used to obtain information about the status of a cursor, either implicit or explicit.

You should avoid inserting any statements between the cursor operation and the use of an attribute against that cursor. Interposing such a statement can affect the value returned by the attribute, thereby potentially corrupting the logic of your program.

In the following example, a procedure call is inserted between the DELETE statement and a check for the value of SQL%ROWCOUNT, which returns the number of rows modified by that last SQL statement executed in the session. If this procedure includes a COMMIT / ROLLBACK or another implicit cursor the value of SQL%ROWCOUNT is affected.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY employee_api AS
  co_one CONSTANT SIMPLE_INTEGER := 1;
  PROCEDURE process_dept(in_dept_id IN departments.department_id%TYPE) IS
   BEGIN
     NULL;
  END process_dept;
   PROCEDURE remove_employee (in_employee_id IN employees.employee_id%TYPE) IS
                    employees.department_id%TYPE;
     l_dept_id
   BEGIN
     DELETE FROM employees
      WHERE employee_id = in_employee_id
      RETURNING department_id INTO l_dept_id;
      process_dept(in_dept_id => l_dept_id);
      IF SQL%ROWCOUNT > co_one THEN
         -- too many rows deleted.
        ROLLBACK;
     END IF:
   END remove_employee;
END employee_api;
```

```
CREATE OR REPLACE PACKAGE BODY employee_api AS
  co_one CONSTANT SIMPLE_INTEGER := 1;
  PROCEDURE process_dept(in_dept_id IN departments.department_id%TYPE) IS
  BEGIN
     NULL;
  END process_dept;
   PROCEDURE remove_employee (in_employee_id IN employees.employee_id%TYPE) IS
     l_dept_id employees.department_id%TYPE;
     1_deleted_emps SIMPLE_INTEGER;
   BEGIN
     DELETE FROM employees
      WHERE employee_id = in_employee_id
      RETURNING department_id INTO l_dept_id;
     1_deleted_emps := SQL%ROWCOUNT;
     process_dept(in_dept_id => l_dept_id);
     IF l_deleted_emps > co_one THEN
         -- too many rows deleted.
        ROLLBACK;
     END IF;
  END remove_employee;
END employee_api;
```

# CASE / IF / DECODE / NVL / NVL2 / COALESCE

G-4210: Try to use CASE rather than an IF statement with multiple ELSIF paths.

Major

Maintainability, Testability

**REASON** 

IF statements containing multiple ELSIF tend to become complex quickly.

**EXAMPLE (BAD)** 

```
DECLARE
   1_color VARCHAR2(7 CHAR);
BEGIN
   IF l_color = constants_up.co_red THEN
      my_package.do_red();
   ELSIF 1_color = constants_up.co_blue THEN
      my_package.do_blue();
   ELSIF l_color = constants_up.co_black THEN
      my_package.do_black();
   END IF;
END;
```

```
DECLARE
   1_color types_up.color_code_type;
BEGIN
   CASE 1_color
      WHEN constants_up.co_red
                                THEN
        my_package.do_red();
     WHEN constants_up.co_blue THEN
        my_package.do_blue();
     WHEN constants_up.co_black THEN
        my_package.do_black();
     ELSE NULL;
   END CASE;
END;
```

# G-4220: Try to use CASE rather than DECODE.

```
Maintainability, Portability
```

REASON

DECODE is an ORACLE specific function hard to understand and restricted to SQL only. The "newer" CASE function is much more common has a better readability and may be used within PL/SQL too.

**EXAMPLE (BAD)** 

```
SELECT DECODE(dummy, 'X', 1
, 'Y', 2
, 'Z', 3
, 0)
FROM dual;
```

```
SELECT CASE dummy

WHEN 'X' THEN 1

WHEN 'Y' THEN 2

WHEN 'Z' THEN 3

ELSE 0

END

FROM dual;
```

G-4230: Always use a COALESCE instead of a NVL command, if parameter 2 of the NVL function is a function call or a SELECT statement.



**REASON** 

The NVL function always evaluates both parameters before deciding which one to use. This can be harmful if parameter 2 is either a function call or a select statement, as it will be executed regardless of whether parameter 1 contains a NULL value or not.

The COALESCE function does not have this drawback.

**EXAMPLE (BAD)** 

```
SELECT NVL(dummy, my_package.expensive_null(value_in => dummy))
FROM dual;
```

```
SELECT COALESCE(dummy, my_package.expensive_null(value_in => dummy))
FROM dual;
```

G-4240: Always use a CASE instead of a NVL2 command if parameter 2 or 3 of NVL2 is either a function call or a SELECT statement.

**REASON** 

The NVL2 function always evaluates all parameters before deciding which one to use. This can be harmful, if parameter 2 or 3 is either a function call or a select statement, as they will be executed regardless of whether parameter 1 contains a NULL value or not.

**EXAMPLE (BAD)** 

```
SELECT CASE
     WHEN dummy IS NULL THEN
          my_package.expensive_null(value_in => dummy)
     ELSE
          my_package.expensive_nn(value_in => dummy)
     END
FROM dual;
```

#### Flow Control

#### G-4310: Never use GOTO statements in your code.

```
A
```

Major

Maintainability, Testability

#### **REASON**

Code containing gotos is hard to format. Indentation should be used to show logical structure, and gotos have an effect on logical structure. Using indentation to show the logical structure of a goto and its target, however, is difficult or impossible. (...)

Use of gotos is a matter of religion. My dogma is that in modern languages, you can easily replace nine out of ten gotos with equivalent sequential constructs. In these simple cases, you should replace gotos out of habit. In the hard cases, you can still exorcise the goto in nine out of ten cases: You can break the code into smaller routines, use try-finally, use nested ifs, test and retest a status variable, or restructure a conditional. Eliminating the goto is harder in these cases, but it's good mental exercise (...).

- McConnell, Steve C. (2004). Code Complete. Second Edition. Microsoft Press.

#### **EXAMPLE (BAD)**

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  PROCEDURE password_check (in_password IN VARCHAR2) IS
     co_digitarray CONSTANT STRING(10 CHAR) := '0123456789';
     co_lower_bound CONSTANT SIMPLE_INTEGER := 1;
     CONSTANT STRING(100 CHAR) := 'Password must contain a digit.';
     co_errmsg
     CO_ETIMOS

1_isdigit BOOLEAN

1 len_pw PLS_INTEGER;
                            := FALSE;
     1_len_array PLS_INTEGER;
  BEGIN
     1_len_pw := LENGTH(in_password);
     l_len_array := LENGTH(co_digitarray);
     <<check_digit>>
     FOR i IN co_lower_bound .. l_len_array
     L00P
        <<check_pw_char>>
        FOR j IN co_lower_bound .. l_len_pw
           IF SUBSTR(in_password, j, 1) = SUBSTR(co_digitarray, i, 1) THEN
              l_isdigit := TRUE;
              GOTO check_other_things;
           END IF;
        END LOOP check_pw_char;
     END LOOP check_digit;
     <<check_other_things>>
     NULL;
     IF NOT l_isdigit THEN
        raise_application_error(co_errno, co_errmsg);
     END IF:
  END password_check;
END my_package;
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  PROCEDURE password_check (in_password IN VARCHAR2) IS
     co_digitarray CONSTANT STRING(10 CHAR) := '0123456789';
     co_lower_bound CONSTANT SIMPLE_INTEGER := 1;
     1_isdigit BOOLEAN
1_len_pw PLS_INTEGER;
                           := FALSE;
     1_len_array PLS_INTEGER;
  BEGIN
     l_len_pw
             := LENGTH(in_password);
     1_len_array := LENGTH(co_digitarray);
     <<check_digit>>
     FOR i IN co_lower_bound .. l_len_array
       <<check_pw_char>>
       FOR j IN co_lower_bound .. l_len_pw
          IF SUBSTR(in\_password, j, 1) = SUBSTR(co\_digitarray, i, 1) THEN
             l_isdigit := TRUE;
             EXIT check_digit; -- early exit condition
          END IF;
       END LOOP check_pw_char;
     END LOOP check_digit;
     <<check_other_things>>
     NULL;
     IF NOT l_isdigit THEN
       raise_application_error(co_errno, co_errmsg);
     END IF;
  END password_check;
END my_package;
```

# G-4320: Always label your loops.



REASON

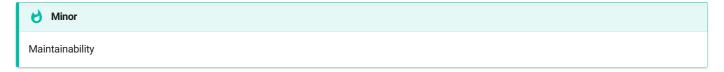
It's a good alternative for comments to indicate the start and end of a named loop processing.

**EXAMPLE (BAD)** 

```
DECLARE
  i INTEGER;
   co_min_value CONSTANT SIMPLE_INTEGER := 1;
   co_max_value CONSTANT SIMPLE_INTEGER := 10;
   co_increment CONSTANT SIMPLE_INTEGER := 1;
BEGIN
   i := co_min_value;
   WHILE (i <= co_max_value)</pre>
   L00P
     i := i + co_increment;
   END LOOP;
   L00P
      EXIT;
   END LOOP;
   FOR i IN co_min_value..co_max_value
      sys.dbms_output.put_line(i);
   END LOOP;
   FOR r_employee IN (SELECT last_name FROM employees)
      sys.dbms_output.put_line(r_employee.last_name);
   END LOOP;
END;
```

```
DECLARE
  i INTEGER;
  co_min_value CONSTANT SIMPLE_INTEGER := 1;
  co_max_value CONSTANT SIMPLE_INTEGER := 10;
   co_increment CONSTANT SIMPLE_INTEGER := 1;
BEGIN
  i := co_min_value;
   <<while_loop>>
   WHILE (i <= co_max_value)</pre>
     i := i + co_increment;
   END LOOP while_loop;
   <<basic_loop>>
  L00P
     EXIT basic_loop;
   END LOOP basic_loop;
   <<for_loop>>
   FOR i IN co_min_value..co_max_value
  L00P
     sys.dbms_output.put_line(i);
  END LOOP for_loop;
   <<pre><<pre>cess_employees>>
  FOR r_employee IN (SELECT last_name
                        FROM employees)
  L00P
     sys.dbms_output.put_line(r_employee.last_name);
  END LOOP process_employees;
END;
```

G-4330: Always use a CURSOR FOR loop to process the complete cursor results unless you are using bulk operations.



REASON

It is easier for the reader to see, that the complete data set is processed. Using SQL to define the data to be processed is easier to maintain and typically faster than using conditional processing within the loop.

Since an EXIT statement is similar to a GOTO statement, it should be avoided, whenever possible.

**EXAMPLE (BAD)** 

```
DECLARE
    CURSOR c_employees IS
        SELECT employee_id, last_name
            FROM employees;
    r_employee c_employees%ROWTYPE;
BEGIN
    OPEN c_employees;

    <<read_employees>>
    LOOP
        FETCH c_employees INTO r_employee;
        EXIT read_employees WHEN c_employees%NOTFOUND;
        sys.dbms_output.put_line(r_employee.last_name);
    END LOOP read_employees;

    CLOSE c_employees;
END;
//
```

```
DECLARE
    CURSOR c_employees IS
        SELECT employee_id, last_name
            FROM employees;

BEGIN
    <<read_employees>>
    FOR r_employee IN c_employees
    LOOP
        sys.dbms_output.put_line(r_employee.last_name);
    END LOOP read_employees;

END;
//
```

## G-4340: Always use a NUMERIC FOR loop to process a dense array.



REASON

It is easier for the reader to see, that the complete array is processed.

Since an EXIT statement is similar to a GOTO statement, it should be avoided, whenever possible.

**EXAMPLE (BAD)** 

```
DECLARE
  TYPE t_employee_type IS VARRAY(10) OF employees.employee_id%TYPE;
  t_employees t_employee_type;
  co_livingston CONSTANT INTEGER := 177;
  co_min_value CONSTANT SIMPLE_INTEGER := 1;
  co_increment CONSTANT SIMPLE_INTEGER := 1;
  i PLS_INTEGER;
BEGIN
   t_employees := t_employee_type(co_himuro, co_livingston);
             := co_min_value;
  <<pre><<pre><<pre>process_employees>>
  L00P
     EXIT process_employees WHEN i > t_employees.COUNT();
     sys.dbms_output.put_line(t_employees(i));
     i := i + co_increment;
   END LOOP process_employees;
END;
```

G-4350: Always use 1 as lower and COUNT() as upper bound when looping through a dense array.

```
▲ Major
Reliability
```

REASON

Doing so will not raise a VALUE\_ERROR if the array you are looping through is empty. If you want to use FIRST()..LAST() you need to check the array for emptiness beforehand to avoid the raise of VALUE\_ERROR.

**EXAMPLE (BAD)** 

**EXAMPLE (BETTER)** 

Raise an unitialized collection error if t\_employees is not initialized.

**EXAMPLE (GOOD)** 

Raises neither an error nor checking whether the array is empty. t\_employees.COUNT() always returns a NUMBER (unless the array is not initialized). If the array is empty COUNT() returns 0 and therefore the loop will not be entered.

## G-4360: Always use a WHILE loop to process a loose array.

```
∀ Minor

Efficiency
```

REASON

When a loose array is processed using a NUMERIC FOR LOOP we have to check with all iterations whether the element exist to avoid a NO\_DATA\_FOUND exception. In addition, the number of iterations is not driven by the number of elements in the array but by the number of the lowest/highest element. The more gaps we have, the more superfluous iterations will be done.

**EXAMPLE (BAD)** 

```
DECLARE
  TYPE t_employee_type IS TABLE OF employees.employee_id%TYPE;
  t_employees t_employee_type;
  co_index_matos CONSTANT INTEGER := 2;
               PLS_INTEGER;
BEGIN
  t_employees := t_employee_type(co_rogers, co_matos, co_mcewen);
  t_employees.DELETE(co_index_matos);
  l_index := t_employees.FIRST();
  <<pre><<pre><<pre>cess_employees>>
  WHILE 1_index IS NOT NULL
  L00P
     sys.dbms_output.put_line(t_employees(l_index));
     l_index := t_employees.NEXT(l_index);
  END LOOP process_employees;
END;
```

### G-4370: Avoid using EXIT to stop loop processing unless you are in a basic loop.

Major

Maintainability

REASON

A numeric for loop as well as a while loop and a cursor for loop have defined loop boundaries. If you are not able to exit your loop using those loop boundaries, then a basic loop is the right loop to choose.

**EXAMPLE (BAD)** 

```
DECLARE
  i INTEGER:
  co_min_value CONSTANT SIMPLE_INTEGER := 1;
  co_max_value CONSTANT SIMPLE_INTEGER := 10;
   co_increment CONSTANT SIMPLE_INTEGER := 1;
BEGIN
   i := co_min_value;
   <<while_loop>>
   WHILE (i <= co_max_value)</pre>
   L00P
      i := i + co_increment;
      EXIT while_loop WHEN i > co_max_value;
   END LOOP while_loop;
   <<basic_loop>>
   L00P
      EXIT basic_loop;
   END LOOP basic_loop;
   <<for_loop>>
   FOR i IN co_min_value..co_max_value
   L00P
      NULL;
      EXIT for_loop WHEN i = co_max_value;
   END LOOP for_loop;
   <<pre><<pre>cess_employees>>
   FOR r_employee IN (SELECT last_name
                        FROM employees)
   L00P
      sys.dbms_output.put_line(r_employee.last_name);
      NULL; -- some processing
      EXIT process_employees;
   END LOOP process_employees;
END;
```

```
DECLARE
  i INTEGER;
  co_min_value CONSTANT SIMPLE_INTEGER := 1;
  co_max_value CONSTANT SIMPLE_INTEGER := 10;
   co_increment CONSTANT SIMPLE_INTEGER := 1;
BEGIN
  i := co_min_value;
   <<while_loop>>
   WHILE (i <= co_max_value)</pre>
     i := i + co_increment;
   END LOOP while_loop;
   <<basic_loop>>
  L00P
     EXIT basic_loop;
   END LOOP basic_loop;
   <<for_loop>>
   FOR i IN co_min_value..co_max_value
  L00P
     sys.dbms_output.put_line(i);
  END LOOP for_loop;
   <<pre><<pre>cess_employees>>
  FOR r_employee IN (SELECT last_name
                        FROM employees)
  L00P
     sys.dbms_output.put_line(r_employee.last_name); -- some processing
  END LOOP process_employees;
END;
```

## G-4375: Always use EXIT WHEN instead of an IF statement to exit from a loop.



REASON

If you need to use an EXIT statement use its full semantic to make the code easier to understand and maintain. There is simply no need for an additional IF statement.

**EXAMPLE (BAD)** 

## G-4380 Try to label your EXIT WHEN statements.



REASON

It's a good alternative for comments, especially for nested loops to name the loop to exit.

**EXAMPLE (BAD)** 

```
DECLARE
  co_init_loop CONSTANT SIMPLE_INTEGER
                                                   := 0;
  co_increment CONSTANT SIMPLE_INTEGER
                                                   := 1;
  co_exit_value CONSTANT SIMPLE_INTEGER
                                                   := 3;
  co_outer_text CONSTANT types_up.short_text_type := 'Outer Loop counter is ';
  co_inner_text CONSTANT types_up.short_text_type := ' Inner Loop counter is ';
  l_outerlp PLS_INTEGER;
  1_innerlp PLS_INTEGER;
BEGIN
  l_outerlp := co_init_loop;
   <<outerloop>>
  L00P
     l_innerlp := co_init_loop;
     l_outerlp := NVL(l_outerlp,co_init_loop) + co_increment;
     <<innerloop>>
     L00P
        l_innerlp := NVL(l_innerlp, co_init_loop) + co_increment;
        sys.dbms_output.put_line(co_outer_text || l_outerlp ||
                                  co_inner_text || l_innerlp);
        EXIT WHEN l_innerlp = co_exit_value;
     END LOOP innerloop;
     EXIT WHEN l_innerlp = co_exit_value;
  END LOOP outerloop;
END;
```

```
DECLARE
  co_init_loop CONSTANT SIMPLE_INTEGER
                                                   := 0;
  co_increment CONSTANT SIMPLE_INTEGER := 1;
co_exit_value CONSTANT SIMPLE_INTEGER := 3;
  co_outer_text CONSTANT types_up.short_text_type := 'Outer Loop counter is ';
  co_inner_text CONSTANT types_up.short_text_type := ' Inner Loop counter is ';
   l_outerlp PLS_INTEGER;
   l_innerlp PLS_INTEGER;
   l_outerlp := co_init_loop;
   <<outerloop>>
   L00P
      l_innerlp := co_init_loop;
      1\_outerlp := NVL(1\_outerlp, co\_init\_loop) + co\_increment;
      <<innerloop>>
      L00P
         l_innerlp := NVL(l_innerlp, co_init_loop) + co_increment;
         sys.dbms_output.put_line(co_outer_text || l_outerlp ||
                                   co_inner_text || l_innerlp);
         EXIT outerloop WHEN l_innerlp = co_exit_value;
      END LOOP innerloop;
  END LOOP outerloop;
END;
```

### G-4385: Never use a cursor for loop to check whether a cursor returns data.

Major

Efficiency

REASON

You might process more data than required, which leads to bad performance.

**EXAMPLE (BAD)** 

## G-4390: Avoid use of unreferenced FOR loop indexes.

```
<u>Major</u>
Efficiency
```

REASON

If the loop index is used for anything but traffic control inside the loop, this is one of the indicators that a numeric FOR loop is being used incorrectly. The actual body of executable statements completely ignores the loop index. When that is the case, there is a good chance that you do not need the loop at all.

**EXAMPLE (BAD)** 

```
DECLARE
  1_row PLS_INTEGER;
  1_value PLS_INTEGER;
  co_lower_bound CONSTANT SIMPLE_INTEGER
                                              := 1;
  co_upper_bound CONSTANT SIMPLE_INTEGER
                                               := 5;
  := 1;
  co_value_incr CONSTANT SIMPLE_INTEGER
                                              := 10;
  co_delimiter    CONSTANT types_up.short_text_type := ' ';
  co_first_value CONSTANT SIMPLE_INTEGER
                                              := 100;
BEGIN
  1_row := co_lower_bound;
  l_value := co_first_value;
  <<for_loop>>
  FOR i IN co_lower_bound .. co_upper_bound
     sys.dbms_output.put_line(l_row || co_delimiter || l_value);
     1_{row} := 1_{row} + co_{row_incr};
     l_value := l_value + co_value_incr;
  END LOOP for_loop;
END;
```

```
DECLARE
  co_lower_bound CONSTANT SIMPLE_INTEGER
                                              := 1;
  co_upper_bound CONSTANT SIMPLE_INTEGER
                                               := 5:
  := 10;
  co_delimiter    CONSTANT types_up.short_text_type := ' ';
  co_first_value CONSTANT SIMPLE_INTEGER
                                               := 100;
BEGIN
  <<for_loop>>
  FOR i IN co_lower_bound .. co_upper_bound
     sys.dbms_output.put_line(i || co_delimiter ||
                            to_char(co_first_value + i * co_value_incr));
  END LOOP for_loop;
END;
```

## G-4395: Avoid hard-coded upper or lower bound values with FOR loops.

Minor
Changeability, Maintainability

REASON

Your LOOP statement uses a hard-coded value for either its upper or lower bounds. This creates a "weak link" in your program because it assumes that this value will never change. A better practice is to create a named constant (or function) and reference this named element instead of the hard-coded value.

**EXAMPLE (BAD)** 

```
BEGIN
    <<for_loop>>
    FOR i IN 1..5
    LOOP
        sys.dbms_output.put_line(i);
    END LOOP for_loop;
END;
/
```

```
DECLARE
    co_lower_bound CONSTANT SIMPLE_INTEGER := 1;
    co_upper_bound CONSTANT SIMPLE_INTEGER := 5;
BEGIN
    <<for_loop>>
    FOR i IN co_lower_bound..co_upper_bound
    LOOP
        sys.dbms_output.put_line(i);
    END LOOP for_loop;
END;
/
```

# **Exception Handling**

G-5010: Try to use a error/logging framework for your application.

```
Critical

Reliability, Reusability, Testability
```

#### Reason

Having a framework to raise/handle/log your errors allows you to easily avoid duplicate application error numbers and having different error messages for the same type of error.

This kind of framework should include

- Logging (different channels like table, mail, file, etc. if needed)
- Error Raising
- Multilanguage support if needed
- Translate ORACLE error messages to a user friendly error text
- Error repository

# Example (bad)

```
BEGIN
    sys.dbms_output.put_line('START');
    -- some processing
    sys.dbms_output.put_line('END');
END;
/
```

```
DECLARE
   -- see https://github.com/OraOpenSource/Logger
   l_scope logger_logs.scope%type := 'DEMO';
BEGIN
   logger.log('START', l_scope);
   -- some processing
   logger.log('END', l_scope);
END;
/
```

G-5020: Never handle unnamed exceptions using the error number.

Critical
Maintainability

#### Reason

When literals are used for error numbers the reader needs the error message manual to unterstand what is going on. Commenting the code or using constants is an option, but it is better to use named exceptions instead, because it ensures a certain level of consistency which makes maintenance easier.

# Example (bad)

```
DECLARE
    co_no_data_found CONSTANT INTEGER := -1;
BEGIN
    my_package.some_processing(); -- some code which raises an exception
EXCEPTION
    WHEN TOO_MANY_ROWS THEN
        my_package.some_further_processing();
WHEN OTHERS THEN
    IF SQLCODE = co_no_data_found THEN
        NULL;
    END IF;
END;
//
```

```
BEGIN
    my_package.some_processing(); -- some code which raises an exception
EXCEPTION
    WHEN TOO_MANY_ROWS THEN
        my_package.some_further_processing();
WHEN NO_DATA_FOUND THEN
        NULL; -- handle no_data_found
END;
/
```

G-5030: Never assign predefined exception names to user defined exceptions.

```
Blocker

Reliability, Testability
```

#### Reason

This is error-prone because your local declaration overrides the global declaration. While it is technically possible to use the same names, it causes confusion for others needing to read and maintain this code. Additionally, you will need to be very careful to use the prefix STANDARD in front of any reference that needs to use Oracle's default exception behavior.

## Example (bad)

Using the code below, we are not able to handle the no\_data\_found exception raised by the SELECT statement as we have overwritten that exception handler. In addition, our exception handler doesn't have an exception number assigned, which should be raised when the SELECT statement does not find any rows.

```
DECLARE
  1_dummy dual.dummy%TYPE;
  no_data_found EXCEPTION;
  := 0:
  co_no_data_found CONSTANT types_up.short_text_type := 'no_data_found';
BEGIN
  SELECT dummy
    INTO l_dummy
    FROM dual
   WHERE ROWNUM = co_rownum;
  IF 1_dummy IS NULL THEN
     RAISE no_data_found;
  END IF;
EXCEPTION
  WHEN no_data_found THEN
     sys.dbms_output.put_line(co_no_data_found);
END:
/
Error report -
ORA-01403: no data found
ORA-06512: at line 5
01403. 00000 - "no data found"
*Cause: No data was found from the objects.
*Action: There was no data from the objects which may be due to end of fetch.
```

```
DECLARE
  1_dummy dual.dummy%TYPE;
  empty_value EXCEPTION;
co_rownum CONSTANT simple_integer := 0;
  co_empty_value CONSTANT types_up.short_text_type := 'empty_value';
  co_no_data_found CONSTANT types_up.short_text_type := 'no_data_found';
   SELECT dummy
    INTO 1_dummy
    FROM dual
   WHERE rownum = co_rownum;
  IF 1_dummy IS NULL THEN
     RAISE empty_value;
  END IF;
EXCEPTION
  WHEN empty_value THEN
     sys.dbms_output.put_line(co_empty_value);
  WHEN no_data_found THEN
     sys.dbms_output.put_line(co_no_data_found);
END;
```

G-5040: Avoid use of WHEN OTHERS clause in an exception section without any other specific handlers.

```
Major
Reliability
```

#### Reason

There is not necessarily anything wrong with using WHEN OTHERS, but it can cause you to "lose" error information unless your handler code is relatively sophisticated. Generally, you should use WHEN OTHERS to grab any and every error only after you have thought about your executable section and decided that you are not able to trap any specific exceptions. If you know, on the other hand, that a certain exception might be raised, include a handler for that error. By declaring two different exception handlers, the code more clearly states what we expect to have happen and how we want to handle the errors. That makes it easier to maintain and enhance. We also avoid hard-coding error numbers in checks against SQLCODE.

## Example (bad)

```
BEGIN
   my_package.some_processing();
EXCEPTION
   WHEN OTHERS THEN
       my_package.some_further_processing();
END;
/
```

```
BEGIN
   my_package.some_processing();
EXCEPTION
   WHEN DUP_VAL_ON_INDEX THEN
       my_package.some_further_processing();
END;
/
```

G-5050: Avoid use of the RAISE\_APPLICATION\_ERROR built-in procedure with a hard-coded 20nnn error number or hard-coded message.



#### Reason

If you are not very organized in the way you allocate, define and use the error numbers between 20999 and 20000 (those reserved by Oracle for its user community), it is very easy to end up with conflicting usages. You should assign these error numbers to named constants and consolidate all definitions within a single package. When you call RAISE\_APPLICATION\_ERROR, you should reference these named elements and error message text stored in a table. Use your own raise procedure in place of explicit calls to RAISE\_APPLICATION\_ERROR. If you are raising a "system" exception like NO\_DATA\_FOUND, you must use RAISE. However, when you want to raise an application-specific error, you use RAISE\_APPLICATION\_ERROR. If you use the latter, you then have to provide an error number and message. This leads to unnecessary and damaging hard-coded values. A more fail-safe approach is to provide a predefined raise procedure that automatically checks the error number and determines the correct way to raise the error.

### Example (bad)

```
BEGIN
    raise_application_error(-20501,'Invalid employee_id');
END;
/
```

```
BEGIN
    err_up.raise(in_error => err.co_invalid_employee_id);
END;
/
```

G-5060: Avoid unhandled exceptions.

```
Major
Reliability
```

#### Reason

This may be your intention, but you should review the code to confirm this behavior.

If you are raising an error in a program, then you are clearly predicting a situation in which that error will occur. You should consider including a handler in your code for predictable errors, allowing for a graceful and informative failure. After all, it is much more difficult for an enclosing block to be aware of the various errors you might raise and more importantly, what should be done in response to the error.

The form that this failure takes does not necessarily need to be an exception. When writing functions, you may well decide that in the case of certain exceptions, you will want to return a value such as NULL, rather than allow an exception to propagate out of the function.

## Example (bad)

```
CREATE OR REPLACE PACKAGE BODY department_api IS
   FUNCTION name_by_id (in_id IN departments.department_id%TYPE)
    RETURN departments.department_name%TYPE IS
        1_department_name departments.department_name%TYPE;
BEGIN
    SELECT department_name
        INTO 1_department_name
        FROM departments
        WHERE department_id = in_id;

        RETURN 1_department_name;
        END name_by_id;
END department_api;
//
```

```
CREATE OR REPLACE PACKAGE BODY department_api IS

FUNCTION name_by_id (in_id IN departments.department_id%TYPE)

RETURN departments.department_name%TYPE IS

l_department_name departments.department_name%TYPE;

BEGIN

SELECT department_name

INTO l_department_name

FROM departments

WHERE department_id = in_id;

RETURN l_department_name;

EXCEPTION

WHEN NO_DATA_FOUND THEN RETURN NULL;

WHEN TOO_MANY_ROWS THEN RAISE;

END name_by_id;

END department_api;

/
```

G-5070: Avoid using Oracle predefined exceptions.

```
        ✓ Critical

    Reliability
```

#### Reason

You have raised an exception whose name was defined by Oracle. While it is possible that you have a good reason for "using" one of Oracle's predefined exceptions, you should make sure that you would not be better off declaring your own exception and raising that instead.

If you decide to change the exception you are using, you should apply the same consideration to your own exceptions. Specifically, do not "re-use" exceptions. You should define a separate exception for each error condition, rather than use the same exception for different circumstances.

Being as specific as possible with the errors raised will allow developers to check for, and handle, the different kinds of errors the code might produce.

# Example (bad)

```
BEGIN
    RAISE NO_DATA_FOUND;
END;
/
```

```
DECLARE
  my_exception EXCEPTION;
BEGIN
  RAISE my_exception;
END;
/
```

# Dynamic SQL

G-6010: Always use a character variable to execute dynamic SQL.

```
Major

Maintainability, Testability
```

## Reason

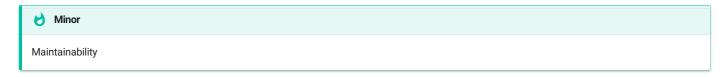
Having the executed statement in a variable makes it easier to debug your code (e.g. by logging the statement that failed).

# Example (bad)

```
DECLARE
    l_next_val employees.employee_id%TYPE;
BEGIN
    EXECUTE IMMEDIATE 'select employees_seq.nextval from dual' INTO l_next_val;
END;
/
```

```
DECLARE
    l_next_val employees.employee_id%TYPE;
    co_sql CONSTANT types_up.big_string_type :=
        'select employees_seq.nextval from dual';
BEGIN
    EXECUTE IMMEDIATE co_sql INTO l_next_val;
END;
//
```

G-6020: Try to use output bind arguments in the RETURNING INTO clause of dynamic DML statements rather than the USING clause.



#### Reason

When a dynamic INSERT, UPDATE, or DELETE statement has a RETURNING clause, output bind arguments can go in the RETURNING INTO clause or in the USING clause.

You should use the RETURNING INTO clause for values returned from a DML operation. Reserve OUT and IN OUT bind variables for dynamic PL/SQL blocks that return values in PL/SQL variables.

## Example (bad)

```
CREATE OR REPLACE PACKAGE BODY employee_api IS
  PROCEDURE upd_salary (in_employee_id IN
                                               employees.employee_id%TYPE
                       ,in_increase_pct IN
                                              types_up.percentage
                       ,out_new_salary OUT employees.salary%TYPE)
  TS
     co_sql_stmt CONSTANT types_up.big_string_type :=
         'UPDATE employees SET salary = salary + (salary / 100 * :1)
           WHERE employee_id = :2
       RETURNING salary INTO :3';
  BEGIN
    EXECUTE IMMEDIATE co_sql_stmt
          USING in_increase_pct, in_employee_id
          RETURNING INTO out_new_salary;
  END upd_salary;
END employee_api;
```

# Stored Objects

### General

G-7110: Try to use named notation when calling program units.



Major

Changeability, Maintainability

**REASON** 

Named notation makes sure that changes to the signature of the called program unit do not affect your call.

This is not needed for standard functions like ( TO\_CHAR , TO\_DATE , NVL , ROUND , etc.) but should be followed for any other stored object having more than one parameter.

**EXAMPLE (BAD)** 

```
DECLARE
   r_employee employees%rowtype;
   co_id CONSTANT employees.employee_id%type := 107;
   employee_api.employee_by_id(r_employee, co_id);
END;
```

```
DECLARE
   r_employee employees%rowtype;
   co_id CONSTANT employees.employee_id%type := 107;
BEGIN
   {\tt employee\_api.employee\_by\_id(out\_row => r\_employee, in\_employee\_id => co\_id);}
END;
```

## G-7120 Always add the name of the program unit to its end keyword.



REASON

It's a good alternative for comments to indicate the end of program units, especially if they are lengthy or nested.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY employee_api IS
   FUNCTION employee_by_id (in_employee_id IN employees.employee_id%TYPE)
      RETURN employees%rowtype IS
      r_employee employees%rowtype;
   BEGIN
      SELECT *
       INTO r_employee
       FROM employees
      WHERE employee_id = in_employee_id;
      RETURN r_employee;
  EXCEPTION
      WHEN NO_DATA_FOUND THEN
        NULL;
      WHEN TOO_MANY_ROWS THEN
        RAISE;
   END;
END;
```

```
CREATE OR REPLACE PACKAGE BODY employee_api IS
  FUNCTION employee_by_id (in_employee_id IN employees.employee_id%TYPE)
     RETURN employees%rowtype IS
      r_employee employees%rowtype;
   BEGIN
     SELECT *
       INTO r_employee
       FROM employees
      WHERE employee_id = in_employee_id;
      RETURN r_employee;
   EXCEPTION
      WHEN NO_DATA_FOUND THEN
         NULL:
      WHEN TOO_MANY_ROWS THEN
         RAISE;
   END employee_by_id;
END employee_api;
```

### G-7130: Always use parameters or pull in definitions rather than referencing external variables in a local program unit.

Major

Maintainability, Reliability, Testability

#### REASON

Local procedures and functions offer an excellent way to avoid code redundancy and make your code more readable (and thus more maintainable). Your local program refers, however, an external data structure, i.e., a variable that is declared outside of the local program. Thus, it is acting as a global variable inside the program.

This external dependency is hidden, and may cause problems in the future. You should instead add a parameter to the parameter list of this program and pass the value through the list. This technique makes your program more reusable and avoids scoping problems, i.e. the program unit is less tied to particular variables in the program. In addition, unit encapsulation makes maintenance a lot easier and cheaper.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY EMPLOYEE_API IS
   PROCEDURE calc_salary (in_employee_id IN employees.employee_id%TYPE) IS
      r_emp employees%rowtype;
      FUNCTION commission RETURN NUMBER IS
         l_commission employees.salary%TYPE := 0;
      BFGTN
         IF r_emp.commission_pct IS NOT NULL
         THFN
            l_commission := r_emp.salary * r_emp.commission_pct;
         END IF;
         RETURN l_commission;
      END commission;
   BEGIN
      SELECT *
       INTO r_emp
       FROM employees
      WHERE employee_id = in_employee_id;
      SYS.DBMS_OUTPUT.PUT_LINE(r_emp.salary + commission());
   EXCEPTION
      WHEN NO_DATA_FOUND THEN
        NULL;
      WHEN TOO_MANY_ROWS THEN
        NULL;
   END calc_salary;
END employee_api;
```

```
CREATE OR REPLACE PACKAGE BODY EMPLOYEE API IS
  PROCEDURE calc_salary (in_employee_id IN employees.employee_id%TYPE) IS
     r_emp employees%rowtype;
     FUNCTION commission (in_salary IN employees.salary%TYPE
                         ,in_comm_pct IN employees.commission_pct%TYPE)
        RETURN NUMBER IS
        l_commission employees.salary%TYPE := 0;
     BEGIN
        IF in_comm_pct IS NOT NULL THEN
           l_commission := in_salary * in_comm_pct;
        END IF;
        RETURN 1_commission;
     END commission;
   BEGIN
     SELECT *
       INTO r_emp
       FROM employees
      WHERE employee_id = in_employee_id;
     SYS.DBMS_OUTPUT.PUT_LINE(
        r_emp.salary + commission(in_salary => r_emp.salary
                                 ,in_comm_pct => r_emp.commission_pct)
     );
  EXCEPTION
     WHEN NO_DATA_FOUND THEN
        NULL;
     WHEN TOO_MANY_ROWS THEN
        NULL;
  END calc_salary;
END employee_api;
```

### G-7140: Always ensure that locally defined procedures or functions are referenced.

A Major

Maintainability, Reliability

REASON

This can occur as the result of changes to code over time, but you should make sure that this situation does not reflect a problem. And you should remove the declaration to avoid maintenance errors in the future.

You should go through your programs and remove any part of your code that is no longer used. This is a relatively straightforward process for variables and named constants. Simply execute searches for a variable's name in that variable's scope. If you find that the only place it appears is in its declaration, delete the declaration.

There is never a better time to review all the steps you took, and to understand the reasons you took them, then immediately upon completion of your program. If you wait, you will find it particularly difficult to remember those parts of the program that were needed at one point, but were rendered unnecessary in the end.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS

PROCEDURE my_procedure IS

FUNCTION my_func RETURN NUMBER IS

co_true CONSTANT INTEGER := 1;

BEGIN

RETURN co_true;

END my_func;

BEGIN

NULL;

END my_procedure;

END my_package;

/
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS
    PROCEDURE my_procedure IS
        FUNCTION my_func RETURN NUMBER IS
            co_true CONSTANT INTEGER := 1;
        BEGIN
            RETURN co_true;
        END my_func;
    BEGIN
            sys.dbms_output.put_line(my_func());
    END my_procedure;
END my_package;
//
```

## G-7150: Try to remove unused parameters.



**Minor** 

Efficiency, Maintainability

REASON

You should go through your programs and remove any partameter that is no longer used.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY department_api IS
  FUNCTION name_by_id (in_department_id IN departments.department_id%TYPE
                       ,in_manager_id
                                      IN departments.manager_id%TYPE)
     RETURN departments.department_name%TYPE IS
     1_department_name departments.department_name%TYPE;
  BEGIN
     <<find_department>>
     BEGIN
        SELECT department_name
          INTO l_department_name
          FROM departments
         WHERE department_id = in_department_id;
     EXCEPTION
        WHEN NO_DATA_FOUND OR TOO_MANY_ROWS THEN
           1_department_name := NULL;
     END find_department;
     RETURN 1_department_name;
  END name_by_id;
END department_api;
```

```
CREATE OR REPLACE PACKAGE BODY department_api IS
   FUNCTION name_by_id (in_department_id IN departments.department_id%TYPE)
     RETURN departments.department_name%TYPE IS
      1_department_name departments.department_name%TYPE;
   BEGIN
      <<find_department>>
     BEGIN
        SELECT department_name
          INTO l_department_name
          FROM departments
          WHERE department_id = in_department_id;
      EXCEPTION
         WHEN NO_DATA_FOUND OR TOO_MANY_ROWS THEN
            1_department_name := NULL;
      END find_department;
      RETURN 1_department_name;
   END name_by_id;
END department_api;
```

# **Packages**

G-7210: Try to keep your packages small. Include only few procedures and functions that are used in the same context.



### REASON

The entire package is loaded into memory when the package is called the first time. To optimize memory consumption and keep load time small packages should be kept small but include components that are used together.

## G-7220: Always use forward declaration for private functions and procedures.



REASON

Having forward declarations allows you to order the functions and procedures of the package in a reasonable way.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE department_api IS
  PROCEDURE del (in_department_id IN departments.department_id%TYPE);
END department_api;
CREATE OR REPLACE PACKAGE BODY department_api IS
   FUNCTION does_exist (in_department_id IN departments.department_id%TYPE)
     RETURN BOOLEAN IS
     1_return PLS_INTEGER;
   BEGIN
      <<check_row_exists>>
     BEGIN
        SELECT 1
          INTO l_return
           FROM departments
          WHERE department_id = in_department_id;
      EXCEPTION
         WHEN no_data_found OR too_many_rows THEN
           1_return := 0;
      END check_row_exists;
      RETURN l_return = 1;
   END does_exist;
   PROCEDURE del (in_department_id IN departments.department_id%TYPE) IS
      IF does_exist(in_department_id) THEN
        NULL;
      END IF;
   END del;
END department_api;
```

```
CREATE OR REPLACE PACKAGE department_api IS
  PROCEDURE del (in_department_id IN departments.department_id%TYPE);
END department_api;
CREATE OR REPLACE PACKAGE BODY department_api IS
   FUNCTION does_exist (in_department_id IN departments.department_id%TYPE)
      RETURN BOOLEAN;
   PROCEDURE del (in_department_id IN departments.department_id%TYPE) IS
      IF does_exist(in_department_id) THEN
       NULL;
      END IF;
   END del;
   FUNCTION does_exist (in_department_id IN departments.department_id%TYPE)
      RETURN BOOLEAN IS
      1_return PLS_INTEGER;
   BEGIN
      <<check_row_exists>>
      BEGIN
         SELECT 1
          INTO l_return
          FROM departments
          WHERE department_id = in_department_id;
      EXCEPTION
         WHEN no_data_found OR too_many_rows THEN
           1_return := 0;
      END check_row_exists;
      RETURN 1_return = 1;
  END does_exist;
END department_api;
```

### G-7230: Avoid declaring global variables public.

```
<u>A</u> Major

Reliability
```

REASON

You should always declare package-level data inside the package body. You can then define "get and set" methods (functions and procedures, respectively) in the package specification to provide controlled access to that data. By doing so you can guarantee data integrity, you can change your data structure implementation, and also track access to those data structures.

Data structures (scalar variables, collections, cursors) declared in the package specification (not within any specific program) can be referenced directly by any program running in a session with EXECUTE rights to the package.

Instead, declare all package-level data in the package body and provide "get and set" methods - a function to get the value and a procedure to set the value - in the package specification. Developers then can access the data using these methods - and will automatically follow all rules you set upon data modification.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE employee_api AS
   co_min_increase CONSTANT types_up.sal_increase_type := 0.01;
   co_max_increase CONSTANT types_up.sal_increase_type := 0.5;
   g_salary_increase types_up.sal_increase_type := co_min_increase;
   PROCEDURE set_salary_increase (in_increase IN types_up.sal_increase_type);
   FUNCTION salary_increase RETURN types_up.sal_increase_type;
END employee_api;
CREATE OR REPLACE PACKAGE BODY employee_api AS
   PROCEDURE set_salary_increase (in_increase IN types_up.sal_increase_type) IS
   BEGIN
      g_salary_increase := GREATEST(LEAST(in_increase, co_max_increase)
                                   ,co_min_increase);
   END set_salary_increase;
   FUNCTION salary_increase RETURN types_up.sal_increase_type IS
   BEGIN
      RETURN g_salary_increase;
   END salary_increase;
END employee_api;
```

```
CREATE OR REPLACE PACKAGE employee_api AS
  PROCEDURE set_salary_increase (in_increase IN types_up.sal_increase_type);
   FUNCTION salary_increase RETURN types_up.sal_increase_type;
END employee_api;
CREATE OR REPLACE PACKAGE BODY employee_api AS
   g_salary_increase types_up.sal_increase_type(4,2);
   PROCEDURE init;
   PROCEDURE set_salary_increase (in_increase IN types_up.sal_increase_type) IS
      g_salary_increase := GREATEST(LEAST(in_increase
                                         , constants_up.max_salary_increase())
                                   , constants_up.min_salary_increase());
   END set_salary_increase;
   FUNCTION salary_increase RETURN types_up.sal_increase_type IS
   BEGIN
      RETURN g_salary_increase;
   END salary_increase;
   PROCEDURE init
   BEGIN
      g_salary_increase := constants_up.min_salary_increase();
   END init;
BEGIN
   init();
END employee_api;
```

## G-7240: Avoid using an IN OUT parameter as IN or OUT only.

```
Major

Efficiency, Maintainability
```

REASON

By showing the mode of parameters, you help the reader. If you do not specify a parameter mode, the default mode is IN. Explicitly showing the mode indication of all parameters is a more assertive action than simply taking the default mode. Anyone reviewing the code later will be more confident that you intended the parameter mode to be IN / OUT.

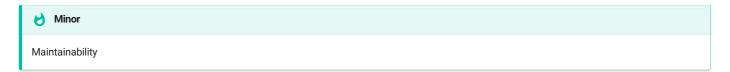
**EXAMPLE (BAD)** 

```
-- Bad
CREATE OR REPLACE PACKAGE BODY employee_up IS
  ,io_phone_number IN OUT employees.phone_number%TYPE
                  ,io_commission_pct IN OUT employees.commission_pct%TYPE
                   ,io_manager_id IN OUT employees.manager_id%TYPE
                   ,io_department_id IN OUT employees.department_id%TYPE
                   ,in_wait
                                          INTEGER) IS
     1_status PLS_INTEGER;
     co_dflt_pipe_name CONSTANT STRING(30 CHAR) := 'MyPipe';
     co_ok CONSTANT PLS_INTEGER := 1;
  BFGTN
      -- Receive next message and unpack for each column.
     1_status := SYS.dbms_pipe.receive_message(pipename => co_dflt_pipe_name
                                          ,timeout => in_wait);
     IF l_status = co_ok THEN
        SYS.dbms_pipe.unpack_message (io_first_name);
        SYS.dbms_pipe.unpack_message (io_last_name);
        SYS.dbms_pipe.unpack_message (io_email);
        SYS.dbms_pipe.unpack_message (io_phone_number);
        SYS.dbms_pipe.unpack_message (io_hire_date);
        SYS.dbms_pipe.unpack_message (io_job_id);
        SYS.dbms_pipe.unpack_message (io_salary);
        SYS.dbms_pipe.unpack_message (io_commission_pct);
        SYS.dbms_pipe.unpack_message (io_manager_id);
        SYS.dbms_pipe.unpack_message (io_department_id);
     END IF;
  END rcv_emp;
END employee_up;
```

```
CREATE OR REPLACE PACKAGE BODY employee_up IS
  , \verb"OUT_phone_number" \verb"OUT employees.phone_number%TYPE"
                     ,OUT_hire_date OUT employees.hire_date%TYPE OUT_job_id OUT employees.job_id%TYPE OUT_salary OUT employees.salary%TYPE
                     ,OUT_commission_pct OUT employees.commission_pct%TYPE
                     ,OUT_manager_id OUT employees.manager_id%TYPE
                     ,OUT_department_id OUT employees.department_id%TYPE
                     ,in_wait
                                       IN
                                               INTEGER) IS
      1_status PLS_INTEGER;
      co_dflt_pipe_name CONSTANT STRING(30 CHAR) := 'MyPipe';
      co_ok CONSTANT PLS_INTEGER := 1;
   BEGIN
      -- Receive next message and unpack for each column.
      1_status := SYS.dbms_pipe.receive_message(pipename => co_dflt_pipe_name
                                               ,timeout => in_wait);
      IF l_status = co_ok THEN
         SYS.dbms_pipe.unpack_message (out_first_name);
         SYS.dbms_pipe.unpack_message (out_last_name);
         SYS.dbms_pipe.unpack_message (out_email);
         SYS.dbms_pipe.unpack_message (out_phone_number);
         SYS.dbms_pipe.unpack_message (out_hire_date);
         SYS.dbms_pipe.unpack_message (out_job_id);
         SYS.dbms_pipe.unpack_message (out_salary);
         SYS.dbms_pipe.unpack_message (out_commission_pct);
         SYS.dbms_pipe.unpack_message (out_manager_id);
        SYS.dbms_pipe.unpack_message (out_department_id);
     END IF;
   END rcv_emp;
END employee_up;
```

#### **Procedures**

G-7310: Avoid standalone procedures - put your procedures in packages.



**REASON** 

Use packages to structure your code, combine procedures and functions which belong together.

Package bodies may be changed and compiled without invalidating other packages. This is major advantage compared to standalone procedures and functions.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PROCEDURE my_procedure IS

BEGIN

NULL;

END my_procedure;
/
```

```
CREATE OR REPLACE PACKAGE my_package IS
    PROCEDURE my_procedure;
END my_package;
/

CREATE OR REPLACE PACKAGE BODY my_package IS
    PROCEDURE my_procedure IS
    BEGIN
         NULL;
    END my_procedure;
END my_package;
/
```

#### G-7320: Avoid using RETURN statements in a PROCEDURE.

Major

Maintainability, Testability

REASON

Use of the RETURN statement is legal within a procedure in PL/SQL, but it is very similar to a GOTO, which means you end up with poorly structured code that is hard to debug and maintain.

A good general rule to follow as you write your PL/SQL programs is "one way in and one way out". In other words, there should be just one way to enter or call a program, and there should be one way out, one exit path from a program (or loop) on successful termination. By following this rule, you end up with code that is much easier to trace, debug, and maintain.

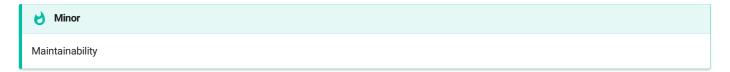
**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS
   PROCEDURE my_procedure IS
     l_idx SIMPLE_INTEGER := 1;
     co_modulo CONSTANT SIMPLE_INTEGER := 7;
   BEGIN
      <<mod7_loop>>
      L00P
       IF MOD(l_idx, co_modulo) = 0 THEN
           RETURN;
        END IF;
       l_{idx} := l_{idx} + 1;
      END LOOP mod7_loop;
   END my_procedure;
END my_package;
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS
   PROCEDURE my_procedure IS
     l_idx SIMPLE_INTEGER := 1;
     co_modulo CONSTANT SIMPLE_INTEGER := 7;
   BEGIN
      <<mod7_loop>>
      L00P
        EXIT mod7_loop WHEN MOD(l_idx,co_modulo) = 0;
       l_{idx} := l_{idx} + 1;
      END LOOP mod7_loop;
   END my_procedure;
END my_package;
```

#### **Functions**

G-7410: Avoid standalone functions - put your functions in packages.



**REASON** 

Use packages to structure your code, combine procedures and functions which belong together.

Package bodies may be changed and compiled without invalidating other packages. This is major advantage compared to standalone procedures and functions.

EXAMPLE (BAD)

```
CREATE OR REPLACE FUNCTION my_function RETURN VARCHAR2 IS
BEGIN
RETURN NULL;
END my_function;
/
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS
FUNCTION my_function RETURN VARCHAR2 IS
BEGIN
RETURN NULL;
END my_function;
END my_package;
/
```

#### G-7420: Always make the RETURN statement the last statement of your function.

Major

Maintainability

REASON

The reader expects the RETURN statement to be the last statement of a function.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  FUNCTION my_function (in_from IN PLS_INTEGER
                      , in_to IN PLS_INTEGER) RETURN PLS_INTEGER IS
     1_ret PLS_INTEGER;
   BEGIN
     l_ret := in_from;
     <<for_loop>>
     FOR i IN in_from .. in_to
     L00P
        l_ret := l_ret + i;
        IF i = in_to THEN
           RETURN 1_ret;
        END IF;
     END LOOP for_loop;
  END my_function;
END my_package;
```

#### G-7430: Try to use no more than one RETURN statement within a function.

Major

Will have a medium/potential impact on the maintenance cost. Maintainability, Testability

REASON

A function should have a single point of entry as well as a single exit-point.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  FUNCTION my_function (in_value IN PLS_INTEGER) RETURN BOOLEAN IS
     co_yes CONSTANT PLS_INTEGER := 1;
   BEGIN
     IF in_value = co_yes THEN
        RETURN TRUE;
     ELSE
        RETURN FALSE;
     END IF;
  END my_function;
END my_package;
```

**EXAMPLE (BETTER)** 

CREATE OR REPLACE PACKAGE BODY my\_package IS FUNCTION my\_function (in\_value IN PLS\_INTEGER) RETURN BOOLEAN IS co\_yes CONSTANT PLS\_INTEGER := 1; I\_ret BOOLEAN; BEGIN IF in\_value = co\_yes THEN I\_ret := TRUE; ELSE I\_ret := FALSE; END IF;

```
RETURN l_ret;
```

END my\_function; END my\_package; /

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  FUNCTION my_function (in_value IN PLS_INTEGER) RETURN BOOLEAN IS
     co_yes CONSTANT PLS_INTEGER := 1;
   BEGIN
     RETURN in_value = co_yes;
  END my_function;
END my_package;
```

#### G-7440: Never use OUT parameters to return values from a function.

```
<u>A</u> Major

Reusability
```

REASON

A function should return all its data through the RETURN clause. Having an OUT parameter prohibits usage of a function within SQL statements.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  FUNCTION my_function (out_date OUT DATE) RETURN BOOLEAN IS
  BEGIN
    out_date := SYSDATE;
    RETURN TRUE;
  END my_function;
END my_package;
/
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS

FUNCTION my_function RETURN DATE IS

BEGIN

RETURN SYSDATE;

END my_function;

END my_package;
/
```

#### G-7450: Never return a NULL value from a BOOLEAN function.



Major

Reliability, Testability

REASON

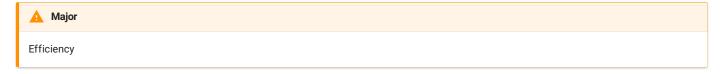
If a boolean function returns null, the caller has do deal with it. This makes the usage cumbersome and more error-prone.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY my_package IS
  FUNCTION my_function RETURN BOOLEAN IS
  BEGIN
     RETURN NULL;
  END my_function;
END my_package;
```

```
CREATE OR REPLACE PACKAGE BODY my_package IS
   FUNCTION my_function RETURN BOOLEAN IS
   BEGIN
      RETURN TRUE;
  END my_function;
END my_package;
```

#### G-7460: Try to define your packaged/standalone function deterministic if appropriate.



REASON

A deterministic function (always return same result for identical parameters) which is defined to be deterministic will be executed once per different parameter within a SQL statement whereas if the function is not defined to be deterministic it is executed once per result row.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE department_api IS
  FUNCTION name_by_id (in_department_id IN departments.department_id%TYPE)
    RETURN departments.department_name%TYPE;
END department_api;
/
```

```
CREATE OR REPLACE PACKAGE department_api IS
  FUNCTION name_by_id (in_department_id IN departments.department_id%TYPE)
    RETURN departments.department_name%TYPE DETERMINISTIC;
END department_api;
//
```

## **Oracle Supplied Packages**

G-7510: Always prefix ORACLE supplied packages with owner schema name.

```
    ▲ Major

    Security
```

**REASON** 

The signature of oracle-supplied packages is well known and therefore it is quite easy to provide packages with the same name as those from oracle doing something completely different without you noticing it.

**EXAMPLE (BAD)** 

```
DECLARE
   co_hello_world CONSTANT STRING(30 CHAR) := 'Hello World';
BEGIN
   dbms_output.put_line(co_hello_world);
END;
/
```

```
DECLARE
   co_hello_world CONSTANT STRING(30 CHAR) := 'Hello World';
BEGIN
   sys.dbms_output.put_line(co_hello_world);
END;
/
```

# Object Types

There are no object type-specific recommendations to be defined at the time of writing.

#### **Triggers**

#### G-7710: Avoid cascading triggers.



Major

Maintainability, Testability

**REASON** 

Having triggers that act on other tables in a way that causes triggers on that table to fire lead to obscure behavior.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE TRIGGER dept_br_u
BEFORE UPDATE ON departments FOR EACH ROW
BEGIN
   INSERT INTO departments_hist (department_id
                                 ,department_name
                                 ,manager_id
                                 ,location_id
                                , modification_date)
        VALUES (:OLD.department_id
               ,:OLD.department_name
               ,:OLD.manager_id
               ,:OLD.location_id
               , SYSDATE);
END;
CREATE OR REPLACE TRIGGER dept_hist_br_i
BEFORE INSERT ON departments_hist FOR EACH ROW
BEGIN
   INSERT INTO departments_log (department_id
                                ,department_name
                                , modification_date)
                        VALUES (:NEW.department_id
                               ,:NEW.department_name
                                , SYSDATE);
END;
```

```
CREATE OR REPLACE TRIGGER dept_br_u
BEFORE UPDATE ON departments FOR EACH ROW
BEGIN
   INSERT INTO departments_hist (department_id
                                ,department_name
                                ,manager_id
                                ,location_id
                                , modification_date)
        VALUES (:OLD.department_id
               ,:OLD.department_name
               ,:OLD.manager_id
               ,:OLD.location_id
               ,SYSDATE);
  INSERT INTO departments_log (department_id
                               ,department_name
                               , modification_date)
                        VALUES (:OLD.department_id
                               ,:OLD.department_name
                               ,SYSDATE);
END;
```

#### Sequences

G-7810: Never use SQL inside PL/SQL to read sequence numbers (or SYSDATE).



Major

Efficiency, Maintainability

**REASON** 

Since ORACLE 11g it is no longer needed to use a SELECT statement to read a sequence (which would imply a context switch).

**EXAMPLE (BAD)** 

```
DECLARE
  1_sequence_number employees.emloyee_id%type;
  SELECT employees_seq.NEXTVAL
    INTO l_sequence_number
    FROM DUAL;
END;
```

```
DECLARE
   1_sequence_number employees.emloyee_id%type;
   1_sequence_number := employees_seq.NEXTVAL;
END;
```

#### **Patterns**

#### Checking the Number of Rows

G-8110: Never use SELECT COUNT(\*) if you are only interested in the existence of a row.

```
Major
Efficiency
```

#### REASON

If you do a SELECT count() all rows will be read according to the WHERE clause, even if only the availability of data is of interest. For this we have a big performance overhead. If we do a SELECT count() ... WHERE ROWNUM = 1 there is also a overhead as there will be two communications between the PL/SQL and the SQL engine. See the following example for a better solution.

**EXAMPLE (BAD)** 

```
DECLARE
  1_count PLS_INTEGER;
   co_zero CONSTANT SIMPLE_INTEGER := 0;
  co_salary CONSTANT employees.salary%TYPE := 5000;
BEGIN
  SELECT count(*)
    INTO 1_count
    FROM employees
    WHERE salary < co_salary;</pre>
    IF 1_count > co_zero THEN
       <<emp_loop>>
       FOR r_emp IN (SELECT employee_id
                       FROM employees)
       L00P
          IF r_emp.salary < co_salary THEN</pre>
             my_package.my_proc(in_employee_id => r_emp.employee_id);
          END IF;
       END LOOP emp_loop;
    END IF;
END;
```

#### G-8120: Never check existence of a row to decide whether to create it or not.

```
Major

Efficiency, Reliability
```

REASON

The result of an existence check is a snapshot of the current situation. You never know whether in the time between the check and the (insert) action someone else has decided to create a row with the values you checked. Therefore, you should only rely on constraints when it comes to prevention of duplicate records.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY department_api IS

PROCEDURE ins (in_r_department IN departments%ROWTYPE) IS

l_count PLS_INTEGER;

BEGIN

SELECT count(*)

INTO l_count

FROM departments

WHERE department_id = in_r_department.department_id;

IF l_count = 0 THEN

INSERT INTO departments

VALUES in_r_department;

END IF;

END ins;

END department_api;

/
```

```
CREATE OR REPLACE PACKAGE BODY department_api IS

PROCEDURE ins (in_r_department IN departments%ROWTYPE) IS

BEGIN

INSERT INTO departments

VALUES in_r_department;

EXCEPTION

WHEN dup_val_on_index THEN NULL; -- handle exception

END ins;

END department_api;

/
```

#### Access objects of foreign application schemas

G-8210: Always use synonyms when accessing objects of another application schema.



Major

Changeability, Maintainability

**REASON** 

If a connection is needed to a table that is placed in a foreign schema, using synonyms is a good choice. If there are structural changes to that table (e.g. the table name changes or the table changes into another schema) only the synonym has to be changed no changes to the package are needed (single point of change). If you only have read access for a table inside another schema, or there is another reason that does not allow you to change data in this table, you can switch the synonym to a table in your own schema. This is also good practice for testers working on test systems.

**EXAMPLE (BAD)** 

```
DECLARE
    l_product_name oe.products.product_name%TYPE;
    co_price CONSTANT oe.products@list_price%TYPE := 1000;
BEGIN
    SELECT p.product_name
    INTO l_product_name
    FROM oe.products p
    WHERE list_price > co_price;
EXCEPTION
    WHEN NO_DATA_FOUND THEN
        NULL; -- handle_no_data_found;
WHEN TOO_MANY_ROWS THEN
        NULL; -- handle_too_many_rows;
END;
//
```

```
CREATE SYNONYM oe_products FOR oe.products;

DECLARE
    1_product_name oe_products.product_name%TYPE;
    co_price CONSTANT oe_products.list_price%TYPE := 1000;

BEGIN
    SELECT p.product_name
    INTO 1_product_name
    FROM oe_products p
    WHERE list_price > co_price;

EXCEPTION
    WHEN NO_DATA_FOUND THEN
        NULL; -- handle_no_data_found;
    WHEN TOO_MANY_ROWS THEN
        NULL; -- handle_too_many_rows;

END;
//
```

#### Validating input parameter size

G-8310: Always validate input parameter size by assigning the parameter to a size limited variable in the declaration section of program unit.

```
Minor

Maintainability, Reliability, Reusability, Testability
```

REASON

This technique raises an error (value\_error) which may not be handled in the called program unit. This is the right way to do it, as the error is not within this unit but when calling it, so the caller should handle the error.

**EXAMPLE (BAD)** 

```
CREATE OR REPLACE PACKAGE BODY department_api IS
  FUNCTION dept_by_name (in_dept_name IN departments.department_name%TYPE)
     RETURN departments%ROWTYPE IS
     1_return departments%rowtype;
   BEGIN
           in_dept_name IS NULL
      IF
         OR LENGTH(in_dept_name) > 20
      THEN
         RAISE err.e_param_to_large;
      END IF;
       -- get the department by name
       SELECT *
        FROM departments
        WHERE department_name = in_dept_name;
       RETURN 1_return;
   END dept_by_name;
END department_api;
```

**EXAMPLE (GOOD)** 

```
CREATE OR REPLACE PACKAGE BODY department_api IS
   FUNCTION dept_by_name (in_dept_name IN departments.department_name%TYPE)
    RETURN departments%ROWTYPE IS
        l_dept_name departments.department_name%TYPE NOT NULL := in_dept_name;
        l_return departments%rowtype;

BEGIN
        -- get the department by name
        SELECT *
        FROM departments
        WHERE department_name = l_dept_name;

        RETURN l_return;
        END dept_by_name;

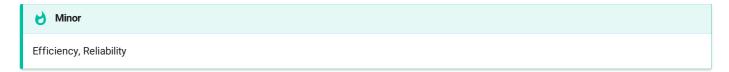
END department_api;
//
```

**FUNCTION CALL** 

```
r_department := department_api.dept_by_name('Far to long name of a department');
...
EXCEPTION
WHEN VALUE_ERROR THEN ...
```

Ensure single execution at a time of a program unit

G-8410: Always use application locks to ensure a program unit is only running once at a given time.



**REASON** 

This technique allows us to have locks across transactions as well as a proven way to clean up at the end of the session.

The alternative using a table where a "Lock-Row" is stored has the disadvantage that in case of an error a proper cleanup has to be done to "unlock" the program unit.

**EXAMPLE (BAD)** 

```
-- Bad
/* Example */
CREATE OR REPLACE PACKAGE BODY lock_up IS
   -- manage locks in a dedicated table created as follows:
   -- CREATE TABLE app_locks (
         lock_name VARCHAR2(128 CHAR) NOT NULL primary key
      );
  PROCEDURE request_lock (in_lock_name IN VARCHAR2) IS
  BEGIN
     -- raises dup_val_on_index
     INSERT INTO app_locks (lock_name) VALUES (in_lock_name);
  END request_lock;
  PROCEDURE release_lock(in_lock_name IN VARCHAR2) IS
     DELETE FROM app_locks WHERE lock_name = in_lock_name;
   END release_lock;
END lock_up;
/* Call bad example */
  co_lock_name CONSTANT VARCHAR2(30 CHAR) := 'APPLICATION_LOCK';
BEGIN
  lock_up.request_lock(in_lock_name => co_lock_name);
   -- processing
  lock_up.release_lock(in_lock_name => co_lock_name);
EXCEPTION
   WHEN OTHERS THEN
     -- log error
     lock_up.release_lock(in_lock_name => co_lock_name);
     RAISE;
END;
/
```

```
/* Example */
CREATE OR REPLACE PACKAGE BODY lock_up IS
   FUNCTION request_lock(
                           IN VARCHAR2,
      in_lock_name
      in_release_on_commit IN BOOLEAN := FALSE)
   RETURN VARCHAR2 IS
      1_lock_handle VARCHAR2(128 CHAR);
   BEGIN
      sys.dbms_lock.allocate_unique(
         lockname => in_lock_name,
         lockhandle
                       => l_lock_handle,
         expiration_secs => constants_up.co_one_week
      ):
      IF sys.dbms_lock.request(
            lockhandle => l_lock_handle,
           lockmode => sys.uums_rec...

+imeout => sys.dbms_lock.maxwait,
            release_on_commit => COALESCE(in_release_on_commit, FALSE)
        ) > 0
      THEN
         RAISE err.e_lock_request_failed;
      END IF;
      RETURN l_lock_handle;
   END request_lock;
   PROCEDURE release_lock(in_lock_handle IN VARCHAR2) IS
   BEGIN
     IF sys.dbms_lock.release(lockhandle => in_lock_handle) > 0 THEN
        RAISE err.e_lock_request_failed;
      END IF;
   END release_lock;
END lock_up;
/* Call good example */
DECLARE
  1_handle VARCHAR2(128 CHAR);
   co_lock_name CONSTANT VARCHAR2(30 CHAR) := 'APPLICATION_LOCK';
BEGIN
   1_handle := lock_up.request_lock(in_lock_name => co_lock_name);
   -- processing
   lock_up.release_lock(in_lock_handle => l_handle);
EXCEPTION
   WHEN OTHERS THEN
      -- log error
      lock_up.release_lock(in_lock_handle => 1_handle);
      RAISE:
END:
```

Use dbms\_application\_info package to follow progress of a process

G-8510: Always use dbms\_application\_info to track program process transiently.



**REASON** 

This technique allows us to view progress of a process without having to persistently write log data in either a table or a file. The information is accessible through the V\$SESSION view.

**EXAMPLE (BAD)** 

# Complexity Analysis

Using software metrics like complexity analysis will guide you towards maintainable and testable pieces of code by reducing the complexity and splitting the code into smaller chunks.

#### Halstead Metrics

#### Calculation

First, we need to compute the following numbers, given the program:

- $n_1$  = the number of distinct operators
- $n_2$  = the number of distinct operands
- $N_1$  = the total number of operators
- $N_2$  = the total number of operands

From these numbers, five measures can be calculated:

• Program length:

$$N = N_1 + N_2$$

• Program vocabulary:

$$n=n_1+n_2$$

• Volume:

$$V = N \cdot log_2 n$$

• Difficulty:

$$D = \frac{n_1}{2} \cdot \frac{N_2}{n_2}$$

• Effort:

$$E = D \cdot V$$

The difficulty measure

D is related to the difficulty of the program to write or understand, e.g. when doing code review.

The volume measure

V describes the size of the implementation of an algorithm.

## McCabe's Cyclomatic Complexity

#### Description

Cyclomatic complexity (or conditional complexity) is a software metric used to measure the complexity of a program. It directly measures the number of linearly independent paths through a program's source code.

Cyclomatic complexity is computed using the control flow graph of the program: the nodes of the graph correspond to indivisible groups of commands of a program, and a directed edge connects two nodes if the second command might be executed immediately after the first command. Cyclomatic complexity may also be applied to individual functions, modules, methods or classes within a program.

The cyclomatic complexity of a section of source code is the count of the number of linearly independent paths through

the source code. For instance, if the source code contains no decision points, such as IF statements or FOR loops, the complexity would be 1, since there is only a single path through the code. If the code has a single IF statement containing a single condition there would be two paths through the code, one path where the IF statement is evaluated as TRUE and one path where the IF statement is evaluated as FALSE.

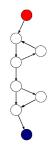
#### Calculation

Mathematically, the cyclomatic complexity of a structured program is defined with reference to a directed graph containing the basic blocks of the program, with an edge between two basic blocks if control may pass from the first to the second (the control flow graph of the program). The complexity is then defined as:

$$M = E - N + 2P$$

where

- M = cyclomatic complexity
- E = the number of edges of the graph
- N = the number of nodes of the graph
- P = the number of connected components.



Take, for example, a control flow graph of a simple program. The program begins executing at the red node, then enters a loop (group of three nodes immediately below the red node). On exiting the loop, there is a conditional statement (group below the loop), and finally the program exits at the blue node. For this graph,

$$E=9$$
.

N=8 and

P=1, so the cyclomatic complexity of the program is

3.

```
BEGIN
    FOR i IN 1..3
    LOOP
        dbms_output.put_line('in loop');
END LOOP;
--
    IF 1 = 1
    THEN
        dbms_output.put_line('yes');
END IF;
--
    dbms_output.put_line('end');
END;
//
```

For a single program (or subroutine or method), P is always equal to 1. Cyclomatic complexity may, however, be applied to several such programs or subprograms at the same time (e.g., to all of the methods in a class), and in these cases P will be equal to the number of programs in question, as each subprogram will appear as a disconnected subset of the graph.

It can be shown that the cyclomatic complexity of any structured program with only one entrance point and one exit point is equal to the number of decision points (i.e., 'if' statements or conditional loops) contained in that program plus one.

Cyclomatic complexity may be extended to a program with multiple exit points; in this case it is equal to:

$$\pi = s + 2$$

#### Where

- $\bullet \ \, \pi$  is the number of decision points in the program, and
- ullet s is the number of exit points.

## Code Reviews

Code reviews check the results of software engineering. According to IEEE-Norm 729, a review is a more or less planned and structured analysis and evaluation process. Here we distinguish between code review and architect review.

To perform a code review means that after or during the development one or more reviewer proof-reads the code to find potential errors, potential areas for simplification, or test cases. A code review is a very good opportunity to save costs by fixing issues before the testing phase.

What can a code-review be good for?

- · Code quality
- · Code clarity and maintainability
- Quality of the overall architecture
- Quality of the documentation
- · Quality of the interface specification

For an effective review, the following factors must be considered:

- Definition of clear goals.
- Choice of a suitable person with constructive critical faculties.
- Psychological aspects.
- · Selection of the right review techniques.
- Support of the review process from the management.
- Existence of a culture of learning and process optimization.

#### Requirements for the reviewer:

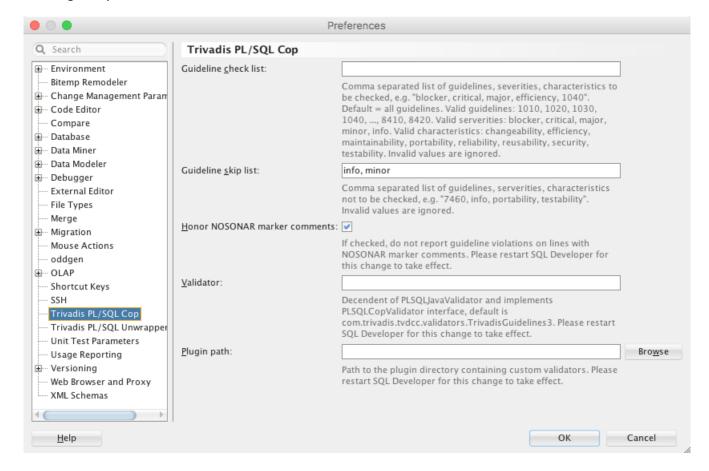
- He must not be the owner of the code.
- Code reviews may be unpleasant for the developer, as he could fear that his code will be criticized. If the critic is not
  considerate, the code writer will build up rejection and resistance against code reviews.

# **Tool Support**

## Development

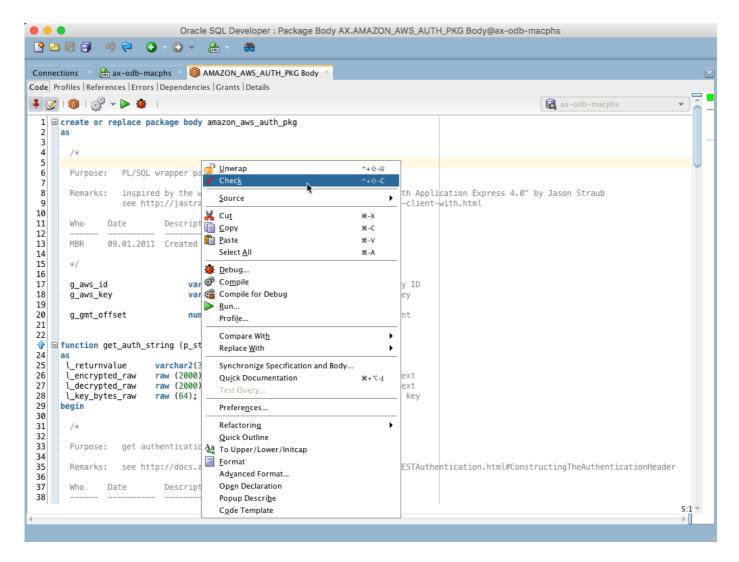
Trivadis offers a cost-free extension to ORACLE SQL Developer to test compliance with this coding guideline. The extension may be parameterized to your preferred set of rules and allows checking this set against a program unit.

### Setting the preferences



There is an include list as well as an exclude list to define which rules to be checked or ignored.

#### Activate PLSQL Cop using context menu

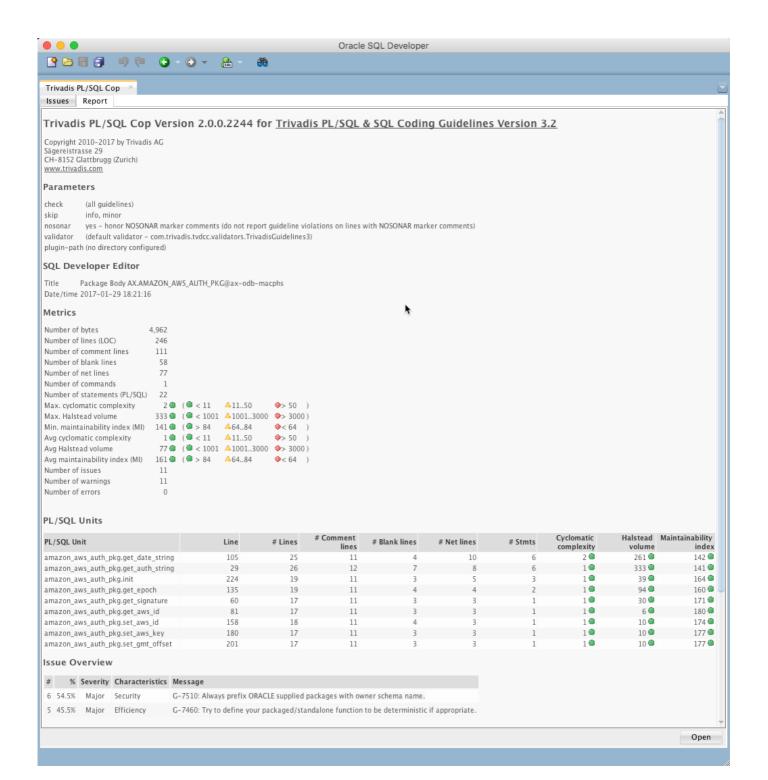


The result of the ckecking process is a list of violations with direct links to the place in the code as well as software metrics like:

- · Cyclomatic complexity
- · Halstead volume
- · Maintainability Index
- · Number of lines of code
- · Number of comment lines
- Issue Overview

This statistics are gathered for each program unit in the reviewed code.

#### Software metrics



# Appendix

# A - Mapping new guidelines to prior versions

Old Id	New Id	Text	Severity	Change- ability	Efficiency	Maintain- ability	Portability
1	1010	Try to label your sub blocks.	Minor			X	
2	1020	Always have a matching loop or block label.	Minor			Х	
3	1030	Avoid defining variables that are not used.	Minor		Х	Х	
4	1040	Avoid dead code.	Minor			X	
5	1050	Avoid using literals in your code.	Minor	Х			
6	1060	Avoid storing ROWIDs or UROWIDs in database tables.	Major				
7	1070	Avoid nesting comment blocks.	Minor			Х	
8	2110	Try to use anchored declarations for variables, constants and types.	Major			Х	
9	2120	Try to have a single location to define your types.	Minor	Х			
10	2130	Try to use subtypes for constructs used often in your code.	Minor	Х			
11	2140	Never initialize variables with NULL.	Minor			Х	
12	2150	Avoid comparisons with NULL value, consider using IS [NOT] NULL.	Blocker				Х
13	2160	Avoid initializing variables using functions in the declaration section.	Critical				
14	2170	Never overload variables.	Major				
15	2180	Never use quoted identifiers.	Major			X	
16	2185	Avoid using overly short names for explicitly or implicitly declared identifiers.	Minor			Х	

17	2190	Avoid the use of ROWID or UROWID.	Major			X
18	2210	Avoid declaring NUMBER variables or subtypes with no precision.	Minor	Х		
19	2220	Try to use PLS_INTEGER instead of NUMBER for arithmetic operations with integer values.	Minor	X		
n/a	2230	Try to use SIMPLE_INTEGER datatype when appropriate.	Minor	Х		
20	2310	Avoid using CHAR data type.	Major			
21	2320	Avoid using VARCHAR data type.	Major			X
22	2330	Never use zero-length strings to substitute NULL.	Major			Х
23	2340	Always define your VARCHAR2 variables using CHAR SEMANTIC (if not defined anchored).	Minor			
24	2410	Try to use boolean data type for values with dual meaning.	Minor		Х	
25	2510	Avoid using the LONG and LONG RAW data types.	Major			Х
26	3110	Always specify the target columns when coding an insert statement.	Major		X	
27	3120	Always use table aliases when your SQL statement involves more than one source.	Major		X	
28	3130	Try to use ANSI SQL-92 join syntax.	Minor		Х	X
29	3140	Try to use anchored records as targets for your cursors.	Major		Х	
n/a	3150	Try to use identity columns for surrogate keys.	Minor		Х	
n/a	3160	Avoid virtual columns to be visible.	Major		х	
n/a	3170	Always use DEFAULT ON NULL declarations to assign default values to table	Major			

		columns it you refuse to store NULL values.				
n/a	3180	Always specify column names instead of positional references in ORDER BY clauses.	Major X			
n/a	3190	Avoid using NATURAL JOIN.	Major X			
30	3210	Always use BULK OPERATIONS (BULK COLLECT, FORALL) whenever you have to execute a DML statement more than 4 times.	Major	X		
31	4110	Always use %NOTFOUND instead of NOT %FOUND to check whether a cursor returned data.	Minor		X	
32	4120	Avoid using %NOTFOUND directly after the FETCH when working with BULK OPERATIONS and LIMIT clause.	Critical			
33	4130	Always close locally opened cursors.	Major	Х		
34	4140	Avoid executing any statements between a SQL operation and the usage of an implicit cursor attribute.	Major			
35	4210	Try to use CASE rather than an IF statement with multiple ELSIF paths.	Major		Х	
36	4220	Try to use CASE rather than DECODE.	Minor		Х	Х
37	4230	Always use COALESCE instead of NVL, if parameter 2 of the NVL function is a function call or a SELECT statement.	Critical	X		
38	4240	Always use CASE instead of NVL2 if parameter 2 or 3 of NVL2 is either a function call or a SELECT statement.	Critical	Х		
39	4310	Never use GOTO statements in your code.	Major		Х	
40	4320	Always label your loops.	Minor		X	
41	4330	Always use a CURSOR FOR	Minor		х	

		loop to process the complete cursor results unless you are using bulk operations.				
42	4340	Always use a NUMERIC FOR loop to process a dense array.	Minor		Х	
43	4350	Always use 1 as lower and COUNT() as upper bound when looping through a dense array.	Major			
44	4360	Always use a WHILE loop to process a loose array.	Minor	Х		
45	4370	Avoid using EXIT to stop loop processing unless you are in a basic loop.	Major		Х	
46	4375	Always use EXIT WHEN instead of an IF statement to exit from a loop.	Minor		Х	
47	4380	Try to label your EXIT WHEN statements.	Minor		Х	
48	4385	Never use a cursor for loop to check whether a cursor returns data.	Major	Х		
49	4390	Avoid use of unreferenced FOR loop indexes.	Major	Х		
50	4395	Avoid hard-coded upper or lower bound values with FOR loops.	Minor X		X	
n/a	5010	Try to use a error/logging framework for your application.	Critical			
51	5020	Never handle unnamed exceptions using the error number.	Critical		Х	
52	5030	Never assign predefined exception names to user defined exceptions.	Blocker			
53	5040	Avoid use of WHEN OTHERS clause in an exception section without any other specific handlers.	Major			
54	n/a	Avoid use of EXCEPTION_INIT pragma for a 20nnn error.	Major			

55	5050	Avoid use of the RAISE_APPLICATION_ERROR built-in procedure with a hard-coded 20nnn error number or hard-coded message.	Major	Х		X	
56	5060	Avoid unhandled exceptions	Major				
57	5070	Avoid using Oracle predefined exceptions	Critical				
58	6010	Always use a character variable to execute dynamic SQL.	Major			X	
59	6020	Try to use output bind arguments in the RETURNING INTO clause of dynamic DML statements rather than the USING clause.	Minor			X	
60	7110	Try to use named notation when calling program units.	Major	Х		Х	
61	7120	Always add the name of the program unit to its end keyword.	Minor			X	
62	7130	Always use parameters or pull in definitions rather than referencing external variables in a local program unit.	Major			X	
63	7140	Always ensure that locally defined procedures or functions are referenced.	Major			X	
64	7150	Try to remove unused parameters.	Minor		Х	Х	
65	7210	Try to keep your packages small. Include only few procedures and functions that are used in the same context.	Minor		X	X	
66	7220	Always use forward declaration for private functions and procedures.	Minor	Х			
67	7230	Avoid declaring global variables public.	Major				
68	7240	Avoid using an IN OUT parameter as IN or OUT only.	Major		X	Х	
69	7310	Avoid standalone procedures  – put your procedures in packages.	Minor			X	

70	7320	Avoid using RETURN statements in a PROCEDURE.	Major		Х	
71	7410	Avoid standalone functions – put your functions in packages.	Minor		Х	
73	7420	Always make the RETURN statement the last statement of your function.	Major		Х	
72	7430	Try to use no more than one RETURN statement within a function.	Major		Х	
74	7440	Never use OUT parameters to return values from a function.	Major			
75	7450	Never return a NULL value from a BOOLEAN function.	Major			
n/a	7460	Try to define your packaged/standalone function to be deterministic if appropriate.	Major	Х		
76	7510	Always prefix ORACLE supplied packages with owner schema name.	Major			
77	7710	Avoid cascading triggers.	Major		x	
n/a	7810	Do not use SQL inside PL/SQL to read sequence numbers (or SYSDATE)	Major	Х	Х	
78	8110	Never use SELECT COUNT(*) if you are only interested in the existence of a row.	Major	Х		
n/a	8120	Never check existence of a row to decide whether to create it or not.	Major	Х		
79	8210	Always use synonyms when accessing objects of another application schema.	Major X		Х	
n/a	8310	Always validate input parameter size by assigning the parameter to a size limited variable in the declaration section of program unit.	Minor		X	
n/a	8410	Always use application locks to ensure a program unit only running once at a given time.	Minor	Х		

n/a	8510	Always use	Minor	X	
		dbms_application_info to track program process			
		transiently			

- 1. We see a table and a view as a collection. A jar containing beans is labeled "beans". In Java we call such a collection also "beans" (List<Bean>beans) and name an entry "bean" (for (Bean bean: beans) {...}). An entry of a table is a row (singular) and a table can contain an unbounded number of rows (plural). This and the fact that the Oracle database uses the same concept for their tables and views lead to the decision to use the plural to name a table or a view.
- 2. Tabs are not used because the indentation depends on the editor configuration. We want to ensure that the code looks the same, indepenent of the editor used. Hence, no tabs. But why not use 8 spaces? That's the traditional value for a tab. When writing a package function the code in the body has an indentation of 3. That's 24 characters as a starting point for the code. We think it's too much. Especially if we try to keep a line below 100 or 80 characters. Other good options would be 2 or 4 spaces. We settled for 3 spaces as a compromise. The indentation is still good visible, but does not use to much space.