



# **Table of Contents**

Table of Contents	2
Introduction to the ngena PL/SQL and SQL Coding Guidelines	5
Why are standards important	5
License	5
Trademarks	5
Disclaimer	5
Revision History	6
Document Conventions	6
Scope	6
SQALE	6
SQALE characteristics and subcharacteristics Severity of the rule	6 7
Keywords used	
General Guidelines	
Naming Conventions for PL/SQL	8
Database Object Naming Conventions	9
Collection Type	9
Column	9
DML / Instead of Trigger Foreign Key Constraint	9 10
Function	10
Index	10
Object Type	10
Package	10
Primary Key Constraint	11
Procedure Sequence	11 11
Synonym	'.' 11
System Trigger	11
Table	12
Surrogate Key Columns	12
Temporary Table (Global Temporary Table) Unique Key Constraint	
View	13
Coding Style	13
General Style	13
Formatting	13
Rules Example	14 14
Package Version Function	14
Comments Style	15
Commenting Goals	15
The JavaDoc Template	15
Commenting Tags	16
Generated Documentation	16
Control Instrumentation	16
Code Instrumentation	
Language Usage	17
General	17
G-1010: Try to label your sub blocks.	17
G-1020: Have a matching loop or block label.	17
G-1030: Avoid defining variables that are not used.	19
G-1040: Always avoid dead code. G-1050: Avoid using literals in your code.	20
G-1060: Avoid storing ROWIDs or UROWIDs in database tables.	22

G-1070: Avoid nesting comment blocks.	23
Variables & Types	23
General	23
G-2110: Try to use anchored declarations for variables, constants and types.	23
G-2120: Try to have a single location to define your types.	24
G-2130: Try to use subtypes for constructs used often in your code.	25
G-2140: Never initialize variables with NULL.	25
G-2150: Never use comparisons with NULL values, use IS [NOT] NULL. G-2160: Avoid initializing variables using functions in the declaration section.	26 26
G-2170: Never overload variables.	27
G-2180: Never use quoted identifiers.	28
G-2185: Avoid using overly short names for explicitly or implicitly declared identifiers.	28
G-2190: Avoid using ROWID or UROWID.	29
Numeric Data Types	30
G-2220: Try to use PLS_INTEGER instead of NUMBER for arithmetic operations with integer values.	30
G-2230: Try to use SIMPLE_INTEGER datatype when appropriate.	30
Character Data Types	31
G-2310: Avoid using CHAR data type.	31
G-2320: Avoid using VARCHAR data type.	32
G-2330: Never use zero-length strings to substitute NULL. G-2340: Always define your VARCHAR2 variables using CHAR SEMANTIC (if not defined anchored).	32
Boolean Data Types	33
G-2410: Try to use boolean data type for values with dual meaning.	33
Large Objects	34
G-2510: Avoid using the LONG and LONG RAW data types.	34
DML & SQL	35
General	35
G-3110: Always specify the target columns when coding an insert statement.	35
G-3120: Always use table aliases when your SQL statement involves more than one source.	35
G-3130: Try to use ANSI SQL-92 join syntax.	36
G-3140: Try to use anchored records as targets for your cursors.	37
G-3150: Try to use identity columns for surrogate keys.	38
G-3160: Avoid visible virtual columns.	38
G-3170: Always use DEFAULT ON NULL declarations to assign default values to table columns if you refuse to store NULL values. G-3180: Always specify column names instead of positional references in ORDER BY clauses.	39
G-3190: Avoid using NATURAL JOIN.	40
G-3200: Avoid using NATONAL 30IN.  G-3200: Avoid using an ON clause when a USING clause will work.	42
Bulk Operations	42
G-3210: Always use BULK OPERATIONS (BULK COLLECT, FORALL) whenever you have to execute a DML statement for more than 4 times.	42
Control Structures	43
CURSOR	43
G-4110: Always use %NOTFOUND instead of NOT %FOUND to check whether a cursor returned data.	43
G-4120: Avoid using %NOTFOUND directly after the FETCH when working with BULK OPERATIONS and LIMIT clause.	44
G-4130: Always close locally opened cursors.	45
G-4140: Avoid executing any statements between a SQL operation and the usage of an implicit cursor attribute.	46
CASE / IF / DECODE / NVL / NVL2 / COALESCE	47
G-4210: Try to use CASE rather than an IF statement with multiple ELSIF paths.	48
G-4220: Try to use CASE rather than DECODE.	48
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.  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.	49
Flow Control	50
G-4310: Never use GOTO statements in your code.	50
G-4320: Always label your loops.	51
G-4330: Always use a CURSOR FOR loop to process the complete cursor results unless you are using bulk operations.	52
G-4340: Always use a NUMERIC FOR loop to process a dense array.	53
G-4350: Always use 1 as lower and COUNT() as upper bound when looping through a dense array.	54
G-4360: Always use a WHILE loop to process a loose array.	55
G-4370: Avoid using EXIT to stop loop processing unless you are in a basic loop.	56
G-4375: Always use EXIT WHEN instead of an IF statement to exit from a loop.	57
G-4380 Try to label your EXIT WHEN statements.	58 50
G-4385: Never use a cursor for loop to check whether a cursor returns data. G-4390: Avoid use of unreferenced FOR loop indexes.	59 60
G-4395: Avoid bard-coded upper or lower bound values with FOR loops.	61
Exception Handling	61
G-5010: Always use an error/logging framework for your application. G-5020: Never handle unnamed exceptions using the error number.	61 62
G-5020. Never handle unitaritied exceptions using the error number. G-5030: Never assign predefined exception names to user defined exceptions.	63
G-5040: Avoid use of WHEN OTHERS clause in an exception section without any other specific handlers.	64

G-5050: Avoid use of the RAISE_APPLICATION_ERROR built-in procedure with a hard-coded 20nnn error number or hard-coded message.	64
G-5060: Avoid unhandled exceptions.	65
G-5070: Avoid using Oracle predefined exceptions.	66
Dynamic SQL	66
G-6010: Always use a character variable to execute dynamic SQL.	66
G-6020: Try to use output bind arguments in the RETURNING INTO clause of dynamic DML statements rather than the USING clause.	67
G-6030: Always verify parameters that will be used in dynamic SQL with DBMS_ASSERT	68
Stored Objects	69
General	69
G-7110: Try to use named notation when calling program units.	69
G-7120 Always add the name of the program unit to its end keyword.	70
G-7130: Always use parameters or pull in definitions rather than referencing external variables in a local program unit.	71
G-7140: Always ensure that locally defined procedures or functions are referenced.	72
G-7150: Try to remove unused parameters.	73
Packages	74
G-7210: Try to keep your packages small. Include only few procedures and functions that are used in the same context.	74
G-7220: Always use forward declaration for private functions and procedures.	74
G-7230: Avoid declaring global variables public. G-7240: Avoid using an IN OUT parameter as IN or OUT only.	75 77
G-7250: Always use NOCOPY when appropriate	78
Procedures	79
G-7310: Avoid standalone procedures – put your procedures in packages.	79
G-7320: Avoid using RETURN statements in a PROCEDURE.	79
Functions	80
G-7410: Avoid standalone functions – put your functions in packages.	80
G-7420: Always make the RETURN statement the last statement of your function.	81
G-7430: Try to use no more than one RETURN statement within a function.	81
G-7440: Never use OUT parameters to return values from a function.	82
G-7450: Never return a NULL value from a BOOLEAN function.	83
G-7460: Try to define your packaged/standalone function deterministic if appropriate.	83
Oracle Supplied Packages	84
G-7510: Always prefix ORACLE supplied packages with owner schema name.	84
Object Types	84
Triggers	84
G-7710: Avoid cascading triggers.	84
G-7720: Avoid triggers for business logic	85
G-7730: If using triggers, use compound triggers	86
Sequences	86
G-7810: Never use SQL inside PL/SQL to read sequence numbers (or SYSDATE).	87
Patterns	87
Checking the Number of Rows	87
G-8110: Never use SELECT COUNT(*) if you are only interested in the existence of a row.	87
G-8120: Never check existence of a row to decide whether to create it or not.	88
Access objects of foreign application schemas	89
G-8210: Always use synonyms when accessing objects of another application schema.	89
Validating input parameter size	90
G-8310: Always validate input parameter size by assigning the parameter to a size limited variable in the declaration section of program uni	
Ensure single execution at a time of a program unit	91
G-8410: Always use application locks to ensure a program unit is only running once at a given time.  Use dbms_application_info package to follow progress of a process	91 92
G-8510: Always use dbms_application_info to track program process transiently.	92
o ooto. Aiways ase abinis_application_inio to track program process transiently.	٦٧.

Code Reviews

93

# Introduction to the ngena PL/SQL and SQL Coding Guidelines

SQL and PL/SQL code is fundamentally some of the most important code that we write. The difference between SQL and PL/SQL that performs well and that doesn't can be the difference between a successful system and a huge disappointment.

For a PDF version of these guidelines use

In 2021 Neil Fernandez of ngena forked these guidelines from nsum guidelines and changed rules to comply with ngena coding standards.

In 2019, Rich Soule of Insum forked these guidelines from the Trivadis guidelines and changed most of the rules to comply with Insum coding standards and added many new guidelines. New rules were also suggested in the Trivadis Issues, and while many were adopted, some (and some we consider very important) were not.

Originally, Trivadis published their guidelines for PL/SQL & SQL in 2009 in the context of the DOAG conference in Nuremberg. Since then these guidelines have been continuously extended and improved. Now they are managed as a set of markdown files. This makes the the guidelines more adaptable for individual application needs and simplifies the continuous improvement.

We all stand in the shoulders of giants. Many people have participated in the creation and refinement of these guidelines. Without the efforts from Roger Troller, Jörn Kulessa, Daniela Reiner, Richard Bushnell, Andreas Flubacher, Thomas Mauch, and Philipp Salvisberg, and, more recently, many folks from the Insum Team, these guidelines wouldn't be what they are today.

# 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.

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 unless the existing standards have fundamental flaws that would decrease performance and/or significantly decrease the maintainability of code. Almost every system has a mixture of "code that follows the standards" and "code that doesn't follow the standards". Gentle migration over time to follow a good set of reasonable standards will always be much better than giving up because standards were not followed in the past.

Overall, the most important thing when writing good code is that you must be able to defend your work.

# License

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time without notice.

# **Revision History**

Version	Who	Date	Comment
1.0	Soule	2020.02.05	Forked from the Trivadis standards with many updates due to coding style and minor updates to grammar, removal of some sections, changes to titles of other sections, etc.

# **Document Conventions**

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.

# **SQALE**

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
- · Exception handling
- · Fault tolerance
- · Instruction related reliability
- · Logic related reliability
- Resource related reliability
- · Synchronization related reliability
- Unit tests coverage.

#### 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



Will or may result in a bug.



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



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

#### Minor

Will have a low impact on the maintenance cost.

# Info

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

# Keywords used

Keyword Meaning

Always Emphasizes this rule must be enforced.

Aiways	Emphasizes this rule must be emorced.
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.
# Naming Conventions	

# General Guidelines

- 1. Never use names with a leading numeric character.
- 2. Always choose meaningful and specific names.
- 3. Avoid using abbreviations.
- 4. If abbreviations are used, they must be widely known and accepted.
- 5. Create a glossary with all accepted abbreviations.
- 6. Never use ORACLE keywords as names. A list of ORACLEs keywords may be found in the dictionary view\$RESERVED\_WORDS.
- 7. Avoid adding redundant or meaningless prefixes and suffixes to identifiers. Example: CREATE TABLE emp\_table.
- 8. Always use one spoken language (e.g. English, German, French) for all objects in your application.
- 9. 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  $\{prefix\}$  variable content  $\{suffix\}$  pattern.

The following table shows a possible set of naming conventions.

Identifier	Prefix	Suffix	Example
Global Variable	g_		$g_{\_}$ version
Local Variable	1_		1_version
Constants *	k_		k_employee_permanent
Record	r_		r_employee
Array / Table	t_		t_employee
Object	0_		o_employee

Cursor Parameter	p_		p_empno
In Parameter	p_   in_		p_empno
Out Parameter	x_   out_		x_ename
In/Out Parameter	x_   io_		io_employee
Record Type Definitions	r_	_type	r_employee_type
Array/Table Type Definitions	t_	_type	t_employee_type
Exception	e_		e_employee_exists
Subtypes		_type	big_string_type
Cursor		_cur	employee_cur

<sup>\*</sup> Why k\_ instead of c\_ for constants? A k is hard (straight lines, hard sound when pronouced in English) while a c is soft (curved lines and soft sound when pronounced in English). C also has the possibility of being vague (some folks use c\_ for cursors) and sounds changable... Also, very big companies (like Google in their coding standards) use k as a prefix for constants.

# **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.

Edition Based Redefinition (EBR) is one major exception to this guideline. When naming tables that will be covered by editioning views, it is preferable to name the covered table in lower case begining with an underscore (for example: "\_employee"). The base table will be covered by an editioning view that has the name employee. This greatly simplifies migration from non-EBR systems to EBR systems since all existing code already references data stored in employee. "Embracing the abomination of forced lower case names" highlights the fact that these objects shouldn't be directly referenced (execpt, obviously, by forward and reverse cross edition triggers during edition migration, and simple auditing/surrogate key triggers, if they are used). Since developers and users should only be referencing data through editioning views (which to them are effectively the tables of the applications) they won't be tempted to use the base table. In addition, when using tools to look at the list of tables, all editioning view covered tables will be aligned together and thus clearly delinated from non-covered tables.

# Collection Type

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

Optionally prefixed by a project abbreviation.

# Examples:

- employee\_ct
- order\_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 useful comment to the database dictionary for every column.

# DML / Instead of Trigger

Choose a naming convention that includes:

oncood a naming contention that moraco.

#### either

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

or

- 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

#### Examples:

- employee\_br\_iud
- order\_audit\_trg
- order\_journal\_trg

# Foreign Key Constraint

Table name followed by referenced table name followed by a\_fk and an optional number suffix. If working on a pre-12.2 database, then you will probably end up being forced into abbreviations due to short object name lengths in older databases.

#### Examples:

- employee\_department\_fk
- sct\_icmd\_ic\_fk1 --Pre 12.2 database

#### **Function**

Name is built from a verb followed by a noun in general. Nevertheless, it is not sensible to call a functionget\_... 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.

Ontionally profived by a project abbreviation

optionally prefixed by a project appreviation.

## Examples:

- employee\_api API for the employee table
- · logger Utilities including logging support
- · constants Constants for use across a project
- types Types for use across a project

# **Primary Key Constraint**

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

#### Examples:

- employee\_pk
- department\_pk
- contract\_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 the sequence serves as primary key generator and the  $suffix\_seq$  or the purpose of the sequence followed by a  $\_seq$ .

Optionally prefixed by a project abbreviation.

#### Examples:

- employee\_seq
- order\_number\_seq

# Synonym

Synonyms should share the name with the object referenced in another schema.

# System Trigger

Name of the event the trigger is based on.

- · Activity done by the trigger
- Suffix \_trg

#### Examples:

- ddl\_audit\_trg
- logon\_trg

#### Table

Singular name of what is contained in the table.

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

Optionally prefixed by a project abbreviation.

## Examples:

- employee
- department
- sct contract
- sct\_contract\_line
- sct\_incentive\_module

Reason: Singular names have the following advantages over plural names: 1. In general, tables represent entities. Entities are singular. This encourages the art of Entity-Relationship modeling. 2. If all table names are singular, then you don't have to know if a table has a single row or multiple rows before you use it. 3. Plural names can be vastly different from singular names. What is the plural of news? lotus? knife? cactus? nucleus? There are so many words that are difficult and nonstandard to pluralize that it can add significant work to a project to 'figure out the plurals'. 4. For non-native speakers of whatever language is being used for table names, point number 3 is magnified significantly. 5. Plurals add extra unnecessary length to table names. 6. By far the biggest reason: There is no value in going through all the work to plural a table name. SQL statements often deal with a single row from a table with multiple rows, so you can't make the argument that employees is better than employee 'because the SQL will read better'.

#### Example (bad):

```
1  well_bores
2  well_bore_completions
3  well_bore_completion_components
4  well_bore_studies
5  well_bore_study_results
6  wells
```

## Example (good):

```
1  well
2  well_bore
3  well_bore_completion
4  well_bore_completion_component
5  well_bore_study
6  well_bore_study_result
```

# Surrogate Key Columns

Surrogate primary key columns should be the table name with an underscore and id appended. For exampleemployee\_id

Reason: Naming the surrogate primary key column the same name that it would have (at least 99% of the time) when used as a foreign key allows the use of the using clause in SQL which greatly increases readability and maintainability of SQL code. When each table has a surrogate primary key column named id, then select clauses that select multiple id columns will need aliases (more code, harder to read and maintain). Additionally, the id surrogate key column means that every join will be forced into theon syntax which is more error-prone and harder to read than the using clause.

#### Example (bad):

```
1 select e.id as employee_id
```

```
d.id as department_id
,e.last_name
,d.name
from employee e
join department d on (e.department_id =
d.id);
```

# Example (good):

# Temporary Table (Global Temporary Table)

Naming as described for tables.

Ideally suffixed by \_gtt

Optionally prefixed by a project abbreviation.

# Examples:

- employee\_gtt
- contract\_gtt

# **Unique Key Constraint**

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

# Examples:

- employee\_name\_uk
- department\_deptno\_uk
- sct\_contract\_uk

# View

Singular name of what is contained in the view.

Ideally, suffixed by an indicator identifying the object as a view like\_v or \_vw (mostly used, when a 1:1 view layer lies above the table layer, but *not* used for editioning views)

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

Optionally prefixed by a project abbreviation.

# Examples:

- active\_order A view that selects only active orders from the order table
- order\_v A view to the order table
- order An editioning view that covers the "\_order" base table

# Coding Style

# General Style

# Formatting

#### Rules

Rule	Description
1	All code is written in lowercase.
2	3 space indention.
3	One command per line.
4	Keywords loop, else, elseif, 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

```
1
    procedure set_salary(in_employee_id IN employee.employee_id%type)
 2
    is
 3
       cursor c_employee(p_employee_id IN employee.employee_id%type) is
          select last_name
 4
              , first_name
 5
               , salary
 6
            from employee
 7
           where employee_id = p_employee_id
 8
        order by last_name
               , first_name;
 9
10
       r_employee
                      c_employee%rowtype;
11
       1_new_salary employee.salary%type;
12
13
       open c_employee(p_employee_id => in_employee_id);
14
       fetch c_employee into r_employee;
       close c_employee;
15
16
       new_salary (in_employee_id => in_employee_id
17
                                => l_new_salary);
                 , out_salary
18
19
       -- Check whether salary has changed
       if r_{employee.salary} <> l_{new_salary} then
20
          update employee
21
             set salary = l_new_salary
22
           where employee_id = in_employee_id;
23
       end if;
24
    end set_salary;
25
26
27
28
```

# **Package Version Function**

When version control is not available, each package could have a package\_version function that returns a varchar2.

Note: If you are using a version control system (like Git for example) to track all code changes and you feel that you'll be able to track everything below using your version control system, and everyone that might need to figure out 'what is happening', from all developers to

purely operational DBAs, knows how to use the version control system to figure out the below, then you might consider the below redundant and 'extra work'. If so, feel free not implement this function.

#### PACKAGE SPEC

```
--This function returns the version number of the package using the following rules:
-- 1. If there is a major change that impacts multiple packages, increment the first digit, e.g. 03.05.09 ->
04.00.00
-- 2. If there is a change to the package spec, increment the first dot, e.g. 03.02.05 -> 03.03.00
-- 3. If there is a minor change, only to the package body, increment the last dot e.g. 03.02.05 -> 03.02.06
-- 4. If the function returns a value ending in WIP, then the package is actively being worked on by a developer. function package_version return varchar2;
```

#### PACKAGE BODY

```
-- Increment the version number based upon the following rules
 2
   -- 1. If there is a major change that impacts multiple packages, increment the first digit, e.g. 03.05.09 ->
 3 04.00.00
    -- 2. If there is a change to the package spec, increment the first dot, e.g. 03.02.05 -> 03.03.00
 4
   -- 3. If there is a minor change, only to the package body, increment the last dot e.g. 03.02.05 -> 03.02.06
 5
    -- 4. If a developer begins work on a package, increment the comment version and include the words 'IN PROGRESS'
 6
    in
 7
          the new version line. Increment the return value and add WIP to the return value. Example: return
 8
   '01.00.01 WIP
         And then IMMEDIATELY push/commit & compile the package.
 9
         As you are working on the package and make updates to lines, use the version number at the end of the line
10
    to indicate when
11
    -- the line was changed. Example: l_person := 'Bob'; -- 01.00.01 Bob is the new person, was Joe.
12
    -- 5. Once work is complete, remove 'IN PROGRESS' from the comment and remove WIP from the return value.
13
    -- 6. If your work crosses the boundary of a sprint, having WIP in the return value will indicate that the
14 package should not be promoted.
   function package_version return varchar2
15
16
    begin
17
      -- 01.00.00 YYYY-MM-DD First & Last Name Initial Version
18
      -- 01.00.01 YYYY-MM-DD First & Last Name Fixed issue number 72 documented in Jira ticket 87:
    https://ourjiraurl.com/f?p=87
       return '01.00.01'
    end package_version;
```

Some notes on the above: We are computer scientists, we write dates as YYYY-MM-DD, not DD-MON-RR or MON-DD-YYYY or any other way.

If you are in the middle of an update, then the function would look like this:

```
[snip]
-- 01.00.00 YYYY-MM-DD First & Last Name
-- 01.00.01 YYYY-MM-DD First & Last Name
-- 01.00.02 2019-10-25 Rich Soule
```

# Comments Style

# **Commenting Goals**

Code comments are there to help future readers of the code (there is a good chance that future reader is you... Any code that you wrote six months to a year ago might as well have been written by someone else) understand how to use the code (especially in PL/SQL package specs) and how to maintain the code (especially in PL/SQL package bodies).

# The JavaDoc Template

Use the JavaDoc style comments, as seen in the example below and read more hereJavaDoc Template and JavaDoc for the Oracle Database a la DBDOC.

```
1
 2
     * Description
 3
 4
     * @example
 5
 6
     * @issue
 7
 8
     * @author
     * @created
 9
     * @param
10
      * @return
11
12
13
```

# **Commenting Tags**

Tag	Meaning	Example
example	Code snippet that shows how the procedure or function can be called.	
issue	Ticketing system issue or ticket that explains the code functionality	@issue IE-234
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

## **Generated Documentation**

If you used the JavaDoc syntax then you can useplsql-md-doc to generate an easy to read document.

Alternatively, Oracle SQL Developer or PL/SQL Developer include documentation functionality based on a javadoc-like tagging.

# **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.

# Code Instrumentation

Code Instrumentation refers, among other things, to an ability to monitor, measure, and diagnose errors. In short, we'll call them debug messages or log messages.

By far, the best logging framework available is Logger from OraOpenSource.

Consider using logger calls **instead** of comments when the information will, explain the logic, help diagnose errors, and monitor execution flow.

For example:

```
procedure verify_valid_auth
is

l_scope logger_logs.scope%type := k_scope_prefix || 'verify_valid_auth';
begin
logger.log('BEGIN', l_scope);

if is_token_expired then
```

```
logger.log('Time to renew the expired token, and set headers.',
 8
    l_scope);
 9
        hubspot_auth;
      else
10
        logger.log('We have a good token, set headers.', l_scope);
11
        set_rest_headers;
12
      end if;
13
14
      logger.log('END', l_scope);
15
16
      when OTHERS then
17
        logger.log_error('Unhandled Exception', l_scope);
18
        raise;
19
   end verify_valid_auth;
20
21
```

# Language Usage

# General

G-1010: Try to label your sub blocks.



#### Reason

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

## Example (bad)

```
1
    begin
 2
       begin
 3
          null;
       end;
 4
 5
       begin
 6
          null;
 7
       end;
 8
    end;
 9
10
```

# Example (good)

```
1
     <<good>>
 2
    begin
 3
        <<pre><<pre><<pre>data>>
        begin
 4
           null;
 5
        end prepare_data;
 6
 7
        <<pre><<pre><<pre>codess_data>>
 8
        begin
 9
           null;
        end process_data;
10
     end good;
11
12
13
```

G-1020: Have a matching loop or block label.

Minor

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)

```
1
     declare
 2
       i integer;
 3
        k_min_value constant integer := 1;
       k_max_value constant integer := 10;
 4
       k_increment constant integer := 1;
 5
    begin
 6
        <<pre><<pre><<pre>cata>>
 7
       begin
 8
          null;
 9
        end;
10
        <<pre><<pre><<pre>c<ah</pre>
11
       begin
12
          null;
13
        end;
14
        i := k_min_value;
15
        <<while_loop>>
16
        while (i <= k_max_value)</pre>
17
        loop
18
          i := i + k_increment;
19
        end loop;
20
        <<basic_loop>>
21
22
          exit basic_loop;
23
        end loop;
24
25
        <<for_loop>>
        for i in k_min_value..k_max_value
26
27
          sys.dbms_output.put_line(i);
28
        end loop;
29
30
31
32
33
34
35
```

# Example (good)

```
1
    declare
 2
        i integer;
 3
       k_min_value constant integer := 1;
 4
       k_max_value constant integer := 10;
       k_increment constant integer := 1;
 5
    begin
 6
        <<pre><<pre>cata>>
 7
       begin
 8
          null;
 9
       end prepare_data;
10
        <<pre><<pre><<pre>codess_data>>
11
       begin
12
           null;
```

```
13
       end process_data;
14
       i := k_min_value;
15
       <<while_loop>>
16
       while (i <= k_max_value)
17
18
          i := i + k_increment;
19
       end loop while_loop;
20
       <<basic_loop>>
21
22
          exit basic_loop;
23
       end loop basic_loop;
24
25
       <<for_loop>>
       for i in k_min_value..k_max_value
26
27
         sys.dbms_output.put_line(i);
28
       end loop for_loop;
29
    end;
30
31
32
33
34
35
```

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



#### Reason

Unused variables decrease the maintainability and readability of your code.

# Example (bad)

```
create or replace package body my_package is
 2
       procedure my_proc is
 3
          1_last_name employee.last_name%type;
          1_first_name employee.first_name%type;
 4
          k_department_id constant department.department_id%type := 10;
 5
          e_good exception;
 6
       begin
 7
          select e.last_name
 8
            into l_last_name
 9
            from employee e
           where e.department_id = k_department_id;
10
11
          when no_data_found then null; -- handle_no_data_found;
12
          when too_many_rows then null; -- handle_too_many_rows;
13
       end my_proc;
    end my_package;
14
15
16
17
```

# Example (good)

```
create or replace package body my_package is
procedure my_proc is

l_last_name employee.last_name%type;
k_department_id constant department_id%type := 10;
e_good exception;
begin
select e.last_name
```

```
into I_last_name
 8
            from employee e
           where e.department_id = k_department_id;
 9
10
          raise e_good;
11
       exception
12
          when no_data_found then null; -- handle_no_data_found;
13
          when too_many_rows then null; -- handle_too_many_rows;
14
       end my_proc;
    end my_package;
15
16
17
18
```

G-1040: Always avoid dead code.



#### 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)

```
1
    declare
 2
       k_dept_purchasing constant departments.department_id%type := 30;
 3
    begin
       if 2=3 then
 4
          null; -- some dead code here
 5
       end if:
 6
 7
       null; -- some enabled code here
 8
 9
       <<my_loop>>
10
       loop
          exit my_loop;
11
          null; -- some dead code here
12
       end loop my_loop;
13
14
       null; -- some other enabled code here
15
16
          when 1 = 1 and 'x' = 'y' then
17
             null; -- some dead code here
18
19
             null; -- some further enabled code here
       end case;
20
21
       <<my_loop2>>
22
       for r_emp in (select last_name
23
                       from employee
24
                       where department_id = k_dept_purchasing
                         or commission_pct is not null
25
                        and 5=6)
26
                     -- "or commission_pct is not null" is dead code
27
28
          sys.dbms_output.put_line(r_emp.last_name);
29
       end loop my_loop2;
30
31
       null; -- some dead code here
32
    end;
33
34
35
36
37
38
39
```

# Example (good)

```
1
    declare
 2
       k_dept_admin constant dept.deptno%type := 10;
 3
    begin
       null; -- some enabled code here
 4
       null; -- some other enabled code here
 5
       null; -- some further enabled code here
 6
 7
       <<my_loop2>>
 8
       for r_emp in (select last_name
 9
                       from employee
                      where department_id = k_dept_admin
10
                         or commission_pct is not null)
11
12
          sys.dbms_output.put_line(r_emp.last_name);
13
       end loop my_loop2;
14
    end:
15
16
17
```

G-1050: Avoid using literals in your code.



#### 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)

```
1
    declare
 2
       l_job employee.job_id%type;
 3
    begin
 4
       select e.job_id
        into l_job
 5
         from employee e
 6
        where e.manager_id is null;
 7
 8
       if l_{job} = 'ad_{pres'} then
 9
          null;
       end if;
10
    exception
11
       when no_data_found then
12
          null; -- handle_no_data_found;
13
       when too_many_rows then
14
          null; -- handle_too_many_rows;
    end;
15
16
17
18
```

# Example (good)

```
1 create or replace package constants is
2 k_president constant employee.job_id%type := 'ad_pres';
3 end constants;
```

```
4
 5
    declare
 6
       1_job employee.job_id%type;
 7
    begin
 8
       select e.job_id
 9
         into l_job
         from employee e
10
        where e.manager_id is null;
11
12
       if l_{job} = constants.k_{president} then
13
          null;
14
       end if;
    exception
15
       when no_data_found then
16
          null; -- handle_no_data_found;
17
       when too_many_rows then
18
          null; -- handle_too_many_rows;
19
    end;
20
21
22
23
```

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)

```
1
 2
       insert into employee_log (employee_id
 3
                                  ,last_name
                                  ,first_name
 4
                                  ,rid)
 5
        select employee_id
 6
              ,last_name
 7
              ,first_name
 8
              ,rowid
 9
          from employee;
    end;
10
11
12
```

# Example (good)

```
1
 2
       insert into employee_log (employee_id
 3
                                  ,last_name
                                  ,first_name)
 4
       select employee_id
 5
              ,last_name
 6
              ,first_name
 7
         from employee;
 8
    end:
 9
10
```

G-1070: Avoid nesting comment blocks.



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;
// end;
```

# Example (good)

```
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 employee table from varchar2(20 char) to varchar2(30 char) 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)

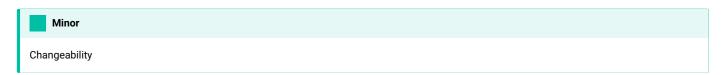
```
1
   create or replace package body my_package is
2
      procedure my_proc is
3
         1_last_name varchar2(20 char);
         k_first_row constant integer := 1;
4
      begin
5
         select e.last_name
6
           into l_last_name
7
           from employee e
8
          where rownum = k_first_row;
```

```
9    exception
10    when no_data_found then null; -- handle no_data_found
11    when too_many_rows then null; -- handle too_many_rows (impossible)
end my_proc;
end my_package;
13  /
14
15
```

## **EXAMPLE (GOOD)**

```
create or replace package body my_package is
 2
       procedure my_proc is
 3
          1_last_name employee.last_name%type;
          k_first_row constant integer := 1;
 4
 5
          select e.last_name
 6
            into l_last_name
 7
            from employee e
 8
           where rownum = k_first_row;
 9
          when no_data_found then null; -- handle no_data_found
10
          when too_many_rows then null; -- handle too_many_rows (impossible)
11
       end my_proc;
12
    end my_package;
13
14
15
```

## 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)**

```
1
   create or replace package body my_package is
2
      procedure my_proc is
3
         subtype big_string_type is varchar2(1000 char);
         l_note big_string_type;
4
      begin
5
        1_note := some_function();
6
      end my_proc;
7
   end my_package;
8
9
```

# EXAMPLE (GOOD)

```
1
    create or replace package types is
 2
       subtype big_string_type is varchar2(1000 char);
 3
    end types;
 4
 5
    create or replace package body my_package is
 6
       procedure my_proc is
 7
          l_note types.big_string_type;
 8
       begin
 9
          1_note := some_function();
       end my_proc;
10
    end my_package;
11
12
```

## 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**

```
Type 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 (table_name_id) columns.
```

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

```
1  create or replace package body my_package is
2  procedure my_proc is
3  l_note varchar2(1000 char);
4  begin
5  l_note := some_function();
6  end my_proc;
end my_package;
7  /
8
```

#### **EXAMPLE (GOOD)**

```
1
    create or replace package types is
2
       subtype big_string_type is varchar2(1000 char);
 3
    end types;
 4
 5
    create or replace package body my_package is
 6
       procedure my_proc is
 7
          l_note types.big_string_type;
 8
       begin
 9
          1_note := some_function();
       end my_proc;
10
    end my_package;
11
12
13
```

# G-2140: Never initialize variables with NULL.

```
Minor

Maintainability
```

#### REASON

Variables are initialized to NULL by default.

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

```
declare
2
      l_note big_string_type := null;
3
   begin
4
      sys.dbms_output.put_line(l_note);
   end;
5
6
EXAMPLE (GOOD)
1
   declare
2
     l_note big_string_type;
3
   begin
      sys.dbms_output.put_line(l_note);
4
```

# G-2150: Never use comparisons with NULL values, use IS [NOT] NULL.

```
Blocker
Portability, Reliability
```

#### REASON

end;

5 6

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)

```
1
   declare
2
     l_value integer;
3
   begin
4
      if l_value = null then
        null; -- Nothing ever equals null, so this code will never be
5
   run
6
      end if;
7
   end;
8
```

# EXAMPLE (GOOD)

```
1 declare
2 l_value integer;
3 begin
4 if l_value is null then
5 null;
6 end if;
end;
7 /
8
```

# 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)**

```
1
   declare
2
      k_department_id constant integer := 100;
3
      1_department_name department.department_name%type :=
         \label{lem:department_api.name_by_id(in_id => k_department_id);} \\
4
5
      sys.dbms_output.put_line(l_department_name);
6
   end;
7
8
EXAMPLE (GOOD)
 1
     declare
 2
       k_department_id constant integer := 100;
 3
       k_unkown_name constant department.department_name%type := 'unknown';
       1_department_name department.department_name%type;
 4
    begin
 5
        <<init>>
 6
       begin
 7
           1_department_name := department_api.name_by_id(in_id => k_department_id);
 8
       exception
 9
          when value_error then
             1_department_name := k_unkown_name;
10
       end init;
```

# G-2170: Never overload variables.



#### REASON

11 12

13

14 15 16 end;

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

sys.dbms\_output.put\_line(l\_department\_name);

# **EXAMPLE (BAD)**

```
1
    begin
 2
        <<main>>
 3
       declare
          k_main constant user_objects.object_name%type := 'test_main';
 4
           k\_sub\ constant\ user\_objects.object\_name\%type\ \text{:= 'test\_sub'};
 5
           k\_sep~constant~user\_objects.object\_name\%type~:=~'~-~';
 6
           1_variable user_objects.object_name%type := k_main;
 7
       begin
 8
           <<sub>>
 9
           declare
              l_variable user_objects.object_name%type := k_sub;
10
11
              sys.dbms_output.put_line(l_variable || k_sep || main.l_variable);
12
           end sub;
13
        end main;
    end;
14
15
16
17
```

#### **EXAMPLE (GOOD)**

```
1
    begin
 2
       <<main>>
 3
       declare
          k_main constant user_objects.object_name%type := 'test_main';
 4
          k_sub constant user_objects.object_name%type := 'test_sub';
 5
          k_sep constant user_objects.object_name%type := ' - ';
 6
          l_main_variable user_objects.object_name%type := k_main;
 7
       begin
 8
          <<sub>>
 9
          declare
             l_sub_variable user_objects.object_name%type := k_sub;
10
11
             sys.dbms_output.put_line(l_sub_variable || k_sep || l_main_variable);
12
          end sub;
13
       end main;
14
   end;
15
16
17
```

## G-2180: Never use quoted identifiers.



## REASON

Quoted identifiers make your code hard to read and maintain.

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

```
1
    declare
 2
       "sal+comm" integer;
 3
       "my constant" constant integer := 1;
 4
       "my exception" exception;
    begin
 5
       "sal+comm" := "my constant";
 6
    exception
 7
       when "my exception" then
 8
          null;
 9
    end;
10
11
```

# EXAMPLE (GOOD)

```
1
    declare
 2
       {\tt l\_sal\_comm}
                       integer;
 3
       k_my_constant constant integer := 1;
 4
       e_my_exception exception;
    begin
 5
       1_sal_comm := k_my_constant;
 6
     exception
 7
       when e_my_exception then
 8
          null;
 9
    end;
10
11
```

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

```
Minor
```

#### 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)**

```
1
    declare
 2
       i integer;
 3
       c constant integer := 1;
 4
       e exception;
    begin
 5
       i := c;
 6
    exception
 7
       when e then
 8
          null;
 9
    end;
10
11
EXAMPLE (GOOD)
 1
    declare
 2
       l_sal_comm
                      integer;
 3
       k_my_constant constant integer := 1;
 4
       e_my_exception exception;
    begin
 5
       l_sal_comm := k_my_constant;
 6
```

# G-2190: Avoid using ROWID or UROWID.

when e\_my\_exception then

exception

end; / 10 11

null;

7

8

9



#### 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
2
      {\tt l\_department\_name} \ {\tt department\_name\%type};
3
      1_rowid rowid;
4
   begin
      update department
5
        set department_name = l_department_name
6
       where rowid = l_rowid;
7
   end;
8
9
```

# **EXAMPLE (GOOD)**

```
declare
2
      1_department_name department.department_name%type;
3
      1_department_id department.department_id%type;
4
  begin
      update department
5
         set department_name = l_department_name
6
       where department_id = l_department_id;
7
   end:
8
9
```

# **Numeric Data Types**

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

```
Minor

Efficiency
```

#### 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)**

```
1  create or replace package body constants is
2   k_big_increase constant number(1,0) := 1;
3
4   function big_increase return number is
5   begin
6   return k_big_increase;
end big_increase;
end constants;
7  end constants;
8  /
```

#### **EXAMPLE (GOOD)**

```
1  create or replace package body constants is
2  k_big_increase constant pls_integer := 1;
3
4  function big_increase return pls_integer is
5  begin
    return k_big_increase;
end big_increase;
end constants;
7  end constants;
8  /
9
```

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

```
Minor

Efficiency
```

# 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.

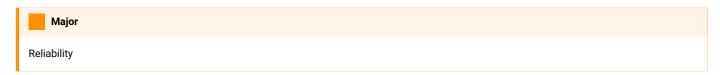
With ORACLE 11g, the new data type SIMPLE\_INTEGER has been introduced. It is a sub-type of PLS\_INTEGER and covers the same range. The basic difference is that SIMPLE\_INTEGER is always NOT NULL. When the value of the declared variable is never going to be null then you can declare it as SIMPLE\_INTEGER. 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 is
2
      k_big_increase constant number(1,0) := 1;
3
      function big_increase return number is
4
      begin
5
         return co_big_increase;
6
      end big_increase;
7
   end constants;
8
9
EXAMPLE (GOOD)
1
   create or replace package body constants is
2
      k_big_increase constant simple_integer := 1;
3
      function big_increase return simple_integer is
4
5
         return co_big_increase;
6
      end big_increase;
7
   end constants;
8
9
```

## Character Data Types

# G-2310: Avoid using CHAR data type.



# 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
2
3
      subtype description_type is char(200);
   end types;
4
5
EXAMPLE (GOOD)
1
   create or replace package types
2
3
      subtype description_type is varchar2(200 char);
   end types;
4
5
```

## 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)**

```
1  create or replace package types is
2   subtype description_type is varchar(200 char);
3  end types;
4  /

EXAMPLE (GOOD)

1  create or replace package types is
2   subtype description_type is varchar2(200 char);
3  end types;
4  /
```

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

```
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)**

```
1
   create or replace package body constants is
2
      k_null_string constant varchar2(1) := '';
3
4
      function null_string return varchar2 is
      begin
5
          return k_null_string;
6
      end null_string;
7
   end constants;
8
9
```

# EXAMPLE (GOOD)

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

Minor
Reliability

#### REASON

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

In a multibyte environment a VARCHAR2 (50) definition may not necessarily hold 50 characters, when multibyte characters a part of the value that should be stored unless the definition was done using the char semantic.

Additionally, business users never say last names should be 50 bytes in length.

# **EXAMPLE (BAD)**

```
1  create or replace package types is
2    subtype description_type is varchar2(200);
3  end types;
4  /

EXAMPLE (GOOD)

1  create or replace package types is
2    subtype description_type is varchar2(200 char);
3  end types;
4  /
```

# **Boolean Data Types**

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

```
Minor

Maintainability
```

#### REASON

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

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

```
1
 2
       k_newfile constant pls_integer := 1000;
 3
       k_oldfile constant pls_integer := 500;
       l_bigger pls_integer;
 4
    begin
 5
       if k_newfile < k_oldfile then
 6
          l_bigger := constants.k_numeric_true;
 7
 8
          l_bigger := constants.k_numeric_false;
 9
       end if;
    end:
10
11
12
```

# EXAMPLE (BETTER)

```
1 declare
2 k_newfile constant pls_integer := 1000;
3 k_oldfile constant pls_integer := 500;
```

```
4
        1_bigger boolean;
     begin
 5
        if k_newfile < k_oldfile then
 6
           l_bigger := true;
 7
 8
           l_bigger := false;
 9
        end if;
10
     end;
11
12
EXAMPLE (GOOD)
   declare
2
       k_newfile constant pls_integer := 1000;
      k_oldfile constant pls_integer := 500;
l_bigger boolean;
3
4
   begin
5
      l_bigger := nvl(k_newfile < k_oldfile,false);</pre>
6
   end;
7
8
```

# Large Objects

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



#### 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
 2
       g_long long;
 3
       g_raw long raw;
 4
       procedure do_something;
 5
    end example_package;
 6
 7
 8
    create or replace package body example_package is
 9
       procedure do_something is
       begin
10
          null;
11
       end do_something;
12
    end example_package;
13
14
15
```

#### **EXAMPLE (GOOD)**

```
1 create or replace package example_package is
2    procedure do_something;
3 end example_package;
4 /
5    create or replace package body example_package is
6    g_long clob;
```

```
g_raw blob;

g 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.



#### REASON

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

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

```
insert into department
values (department_seq.nextval
,'Support'
,100
,10);
```

# **EXAMPLE (GOOD)**

Note: The above good example assumes the use of an identity column for department\_id.

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

```
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 behaviors and results.

Also, note that even if you have a single table statement, it will almost always at some point in the future end up getting joined to another table, so you get bonus points if you use table aliases all the time.

# EXAMPLE (BAD)

```
select last_name
first_name
department_name
from employee
join department using (department_id)
where extract(month from hire_date) = extract(month from sysdate);
```

#### **EXAMPLE (BETTER)**

#### **EXAMPLE (GOOD)**

Using meaningful aliases improves the readability of your code.

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

If the job table has no employee\_id column and employee has one this query will not raise an error but return all rows of theemployee 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 job 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 job table.

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



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
2
         ,e.last_name
3
         ,e.first_name
4
         ,d.department_name
    from employees e
5
         ,departments d
6
    where e.department_id = d.department_id
7
      and extract(month from e.hire_date) = extract(month from sysdate);
8
EXAMPLE (GOOD)
   select emp.employee_id
2
         ,emp.last_name
3
         ,emp.first_name
         ,dept.department_name
4
               employees
                          emp
5
          join departments dept using (department_id)
6
    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)

```
1
     declare
 2
        cursor c_employee is
 3
           select employee_id, first_name, last_name
             from employee;
 4
        1_employee_id employee.employee_id%type;
 5
        l_first_name employee.first_name%type;
 6
        1_last_name employee.last_name%type;
 7
     begin
 8
        open c_employee;
 9
        fetch c_employee into l_employee_id, l_first_name, l_last_name;
        <<pre><<pre><<pre>cess_employee>>
10
        while c_employee%found
11
12
            -- do something with the data
13
           \label{lem:c_employee} fetch \ c\_employee \ into \ l\_employee\_id, \ l\_first\_name, \ l\_last\_name;
14
        end loop process_employee;
        close c_employee;
15
     end;
16
17
18
19
```

# EXAMPLE (GOOD)

```
1  declare
2    cursor c_employee is
3     select employee_id, first_name, last_name
4     from employee;
5    r_employee c_employee%rowtype;
6    begin
6     open c_employee;
7    fotch c_employee into r_employee;
```

```
TETCH C-embrosee THEO I -embrosee'
 8
       <<pre><<pre><<pre><<pre><>
 9
       while c_employee%found
       loop
10
           -- do something with the data
11
          fetch c_employee into r_employee;
12
       end loop process_employee;
13
       close c_employee;
14 end;
15
16
17
```

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

```
Minor

Maintainability, Reliability
```

#### RESTRICTION

ORACLE 12c or higher

#### 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)**

```
1
    create table location (
 2
                          number(10)
       location_id
                                            not null
 3
                          varchar2(60 char) not null
      ,location_name
      ,city
                          varchar2(30 char) not null
 4
      ,constraint location_pk primary key (location_id)
 5
 6
 7
 8
    create sequence location_seq start with 1 cache 20
 9
10
    create or replace trigger location_bri
11
       before insert on location
12
       for each row
13
       :new.location_id := location_seq.nextval;
14
15
16
17
18
```

# EXAMPLE (GOOD)

# G-3160: Avoid visible virtual columns.



#### 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)**

```
1
    alter table employee
 2
       add total_salary generated always as
 3
           (salary + nvl(commission_pct,0) * salary)
 4
 5
    declare
 6
       r_employee employee%rowtype;
 7
       l_id employee.employee_id%type := 107;
 8
    begin
 9
       r_employee := employee_api.employee_by_id(l_id);
       r_employee.salary := r_employee.salary * constants.small_increase();
10
11
       update employee
12
         set row = r_employee
13
        where employee_id = l_id;
14
    end;
15
16
    Error report -
17
    ORA-54017: UPDATE operation disallowed ON virtual COLUMNS
18
    ORA-06512: at line 9
19
20
21
```

# **EXAMPLE (GOOD)**

```
1
    alter table employee
 2
       add total_salary invisible generated always as
 3
          (salary + nvl(commission_pct,0) * salary)
 4
 5
    declare
 6
       r_employee employee%rowtype;
 7
       k_id constant employee.employee_id%type := 107;
 8
    begin
       r_employee := employee_api.employee_by_id(k_id);
 9
       {\tt r\_employee.salary := r\_employee.salary * constants.small\_increase();}
10
11
       update employee
12
          set row = r_employee
13
        where employee_id = k_id;
14
    end;
15
16
17
```

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

```
Major
Reliability
```

# RESTRICTION

#### 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)**

```
create table null_test (
 2
                        number(2) not null
       test_case
 3
      ,column_defaulted varchar2(10) default 'Default')
 4
    insert into null_test(test_case, column_defaulted) values (1,'value');
 5
    insert into null_test(test_case, column_defaulted) values (2,default);
 6
    insert into null_test(test_case, column_defaulted) values (3,null);
 7
 8
    select * from null_test;
 q
    TEST_CASE COLUMN_DEF
10
11
            1 Value
12
            2 Default
13
14
15
```

# **EXAMPLE (GOOD)**

```
create table null_test (
 2
                        number(2) not null
       test_case
 3
      ,column_defaulted varchar2(10 char) default on null 'Default')
 4
    insert into null_test(test_case, column_defaulted) values (1,'value');
 5
    insert into null_test(test_case, column_defaulted) values (2,default);
 6
    insert into null_test(test_case, column_defaulted) values (3,null);
 7
 8
    SELECT * FROM null_test;
 9
     TEST_CASE COLUMN_DEF
10
11
             1 Value
12
             2 Default
13
             3 Default
14
15
```

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



# 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.

```
1 select upper(first_name)
2    ,last_name
3    ,salary
4    ,hire_date
5    from employee
6    order by 4,1,3;
```

J

# **EXAMPLE (GOOD)**

# G-3190: Avoid using NATURAL JOIN.



#### REASON

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

# **EXAMPLE (BAD)**

```
select department_name
 2
         ,last_name
 3
          ,first_name
      from employee natural join department
 4
     order by department_name
 5
             ,last_name;
 6
    DEPARTMENT_NAME
                                   LAST_NAME
                                                             FIRST_NAME
 7
 8
    Accounting
                                                             William
                                   Gietz
 9
    Executive
                                   De Haan
                                                             Lex
10
11
    alter table department add updated date default on null sysdate;
12
    alter table employee add updated date default on null sysdate;
13
14
    select department_name
          ,last_name
15
          ,first_name
16
      from employee natural join department
17
     order by department_name
18
             ,last_name;
19
    No data found
20
21
22
23
```

# **EXAMPLE (GOOD)**

```
1
    select dept.department_name
 2
        ,emp.last_name
 3
          ,emp.first_name
      from employee
                    emp
 4
      join department dept using (department_id)
 5
     order by dept.department_name
 6
          ,emp.last_name;
 7
 8
   DEPARTMENT_NAME
                                                           FIRST_NAME
 9
    Accounting
                                  Gietz
                                                           William
10
                                  De Haan
    Executive
                                                           Lex
11
12
```

# G-3200: Avoid using an ON clause when a USING clause will work.

```
Minor

Maintainability
```

# REASON

An on clause requires more code than a using clause and presents a greater possibility for making errors. Theusing clause is easier to read and maintain.

Note that the using clause prevents the use of a table alias for the join column in any of the other clauses of the sql statement.

# **EXAMPLE (BAD)**

```
select e.deparment_id
d.department_name
,e.last_name
from employee e join department d on (e.department_id = d.department_id);
EXAMPLE (GOOD)
```

```
1 select department_id
2     dept.department_name
3     ,emp.last_name
4     ,emp.first_name
5     from employee emp join department dept using (department_id);
```

# **Bulk Operations**

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



# 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.)

```
1
2
       t_employee_ids employee_api.t_employee_ids_type;
 3
       k_increase constant employee.salary%type := 0.1;
       k_department_id constant departments.department_id%type := 10;
 4
    beain
 5
       t_employee_ids := employee_api.employee_ids_by_department(
 6
                              id_in => k_department_id
 7
                           );
 8
       <<pre><<pre><<pre>cess_employees>>
       for i in 1..t_employee_ids.count()
 9
10
          update employee
11
              cot calary - calary + (calary * k increace)
```

```
set satary - satary + (satary - k_tricrease)
12
           where employee_id = t_employee_ids(i);
13
       end loop process_employees;
14 end;
15
16
17
EXAMPLE (GOOD)
 1
    declare
 2
       t_employee_ids employee_api.t_employee_ids_type;
 3
                       constant employee.salary%type := 0.1;
       k_increase
 4
       k_{department_id} constant departments.department_id%type := 10;
    begin
 5
       t_employee_ids := employee_api.employee_ids_by_department(
 6
                             id_in => k_department_id
 7
                          ):
 8
       <<pre><<pre><<pre>cess_employees>>
 9
       forall i in 1..t_employee_ids.count()
10
          update employee
             set salary = salary + (salary * k_increase)
11
           where employee_id = t_employee_ids(i);
12
    end;
13
14
15
```

# 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.

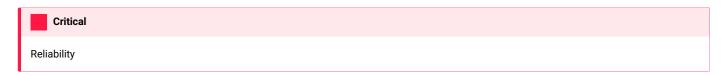
# **EXAMPLE (BAD)**

```
declare
 2
       cursor employee_cur is
 3
          select last_name
 4
                ,first_name
            from employee
 5
           where commission_pct is not null;
 6
 7
       r_employee employee_cur%rowtype;
 8
    begin
 9
       open employee_cur;
10
       <<read_employees>>
11
       loop
12
          fetch employee_cur into r_employee;
13
          exit read_employees when not employee_cur%found;
14
       end loop read_employees;
15
       close employee_cur;
16
    end;
17
18
19
20
```

PL/SQL & SQL Coding Guidelines Version 1.4

```
1
    declare
 2
       cursor employee_cur is
 3
          select last_name
 4
                ,first_name
             from employee
 5
           where commission_pct is not null;
 6
 7
       r_employee employee_cur%rowtype;
 8
    begin
 9
       open employee_cur;
10
        <<read_employees>>
11
       loop
12
          fetch employee_cur into r_employee;
13
          exit read_employees when employee_cur%notfound;
14
       end loop read_employees;
15
       close employee_cur;
16
    end;
17
18
19
20
```

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



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

```
1
    declare
 2
       cursor employee_cur is
 3
           select *
            from employee
 4
            order by employee_id;
 5
 6
       type t_employee_type is table of employee_cur%rowtype;
 7
        t_employee t_employee_type;
 8
       k_bulk_size constant simple_integer := 10;
 9
    begin
       open employee_cur;
10
11
        <<pre><<pre><<pre>cess_employees>>
12
        loop
13
           fetch employee_cur bulk collect into t_employee limit k_bulk_size;
14
           exit process_employees when employee_cur%notfound;
15
           <<display_employees>>
16
           for i in 1..t_employee.count()
17
18
              sys.dbms\_output.put\_line(t\_employee(i).last\_name);\\
19
           end loop display_employees;
       end loop process_employees;
20
21
        close employee_cur;
22
    end;
23
24
25
26
27
```

-

# **EXAMPLE (BETTER)**

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

```
1
    declare
 2
       cursor employee_cur is
 3
          select *
            from employee
 4
           order by employee_id;
 5
 6
       type t_employee_type is table of employee_cur%rowtype;
 7
       t_employee t_employee_type;
 8
       k_bulk_size constant simple_integer := 10;
 9
    begin
       open employee_cur;
10
11
       <<pre><<pre><<pre>cess_employees>>
12
       loop
13
          fetch employee_cur bulk collect into t_employee limit k_bulk_size;
14
          exit process_employees when t_employee.count() = 0;
           <<display_employees>>
15
          for i in 1..t_employee.count()
16
          loop
17
             sys.dbms_output.put_line(t_employee(i).last_name);
18
          end loop display_employees;
19
       end loop process_employees;
20
       close employee_cur;
21
22
23
24
25
26
```

# **EXAMPLE (GOOD)**

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

```
1
    declare
 2
       cursor employee_cur is
 3
          select *
            from employee
 4
            order by employee_id;
 5
 6
       type t_employee_type is table of employee_cur%rowtype;
 7
        t_employee t_employee_type;
 8
       k_bulk_size constant simple_integer := 10;
 9
       open employee_cur;
10
11
        <<pre><<pre><<pre>cess_employees>>
12
       loop
13
          fetch employee_cur bulk collect into t_employee limit k_bulk_size;
14
           <<display employees>>
          for i in 1..t_employee.count()
15
          loop
16
              sys.dbms\_output.put\_line(t\_employee(i).last\_name);\\
17
          end loop display_employees;
18
          exit process_employees when t_employee.count() <> k_bulk_size;
19
        end loop process_employees;
20
        close employee_cur;
21
    end;
22
23
24
25
26
```

# 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)**

```
1
    create or replace package body employee_api as
 2
       function department_salary (in_dept_id in department.department_id%type)
 3
          return number is
          cursor department_salary_cur(p_dept_id in department.department_id%type) is
 4
             select sum(salary) as sum_salary
 5
               from employee
 6
              where department_id = p_dept_id;
 7
          r_department_salary department_salary_cur%rowtype;
 8
       begin
 9
          open department_salary_cur(p_dept_id => in_dept_id);
          fetch department_salary_cur into r_department_salary;
10
11
          return r_department_salary.sum_salary;
12
       end department_salary;
13
    end employee_api;
14
15
16
```

# **EXAMPLE (GOOD)**

```
1
    create or replace package body employee_api as
 2
       function department_salary (in_dept_id in department.department_id%type)
 3
          return number is
          cursor department_salary_cur(p_dept_id in department.department_id%type) is
 4
             select sum(salary) as sum_salary
 5
               from employee
 6
              where department_id = p_dept_id;
 7
          r_department_salary department_salary_cur%rowtype;
 8
       beain
 9
          open department_salary_cur(p_dept_id => in_dept_id);
          fetch department_salary_cur into r_department_salary;
10
          close department_salary_cur;
11
          return r_department_salary.sum_salary;
12
       end department_salary;
13
    end employee_api;
14
15
16
```

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.

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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
 2
       k_one constant simple_integer := 1;
 3
       procedure process_dept(in_dept_id in departments.department_id%type) is
 4
       begin
 5
          null;
 6
       end process_dept;
 7
 8
       procedure remove_employee (in_employee_id in employee.employee_id%type) is
 9
                         employee.department_id%type;
          l_dept_id
10
          delete from employee
11
           where employee_id = in_employee_id
12
           returning department_id into l_dept_id;
13
14
          process_dept(in_dept_id => l_dept_id);
15
          if sql\rowcount > k\_one then
16
              -- too many rows deleted.
17
             rollback;
18
          end if;
19
       end remove_employee;
20
    end employee_api;
21
22
23
24
```

# **EXAMPLE (GOOD)**

```
create or replace package body employee_api as
 2
       k_one constant simple_integer := 1;
 3
       procedure process_dept(in_dept_id in departments.department_id%type) is
 4
       begin
 5
          null;
 6
       end process_dept;
 7
 8
       procedure remove_employee (in_employee_id in employee.employee_id%type) is
 9
          l_dept_id
                         employee.department_id%type;
          l_deleted_emps simple_integer;
10
       begin
11
          delete from employee
12
           where employee_id = in_employee_id
13
           returning department_id into l_dept_id;
14
          1_deleted_emps := sql%rowcount;
15
16
          process_dept(in_dept_id => l_dept_id);
17
18
          if l_deleted_emps > k_one then
19
              -- too many rows deleted.
             rollback;
20
          end if;
21
       end remove_employee;
22
    end employee_api;
23
24
25
26
27
```

# 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

Often if statements containing multiple elsif tend to become complex quickly.

# **EXAMPLE (BAD)**

```
1
    declare
 2
       1_color varchar2(7 char);
 3
    begin
       if l\_color = constants.k\_red then
 4
          my_package.do_red();
 5
       elsif l_color = constants.k_blue then
 6
         my_package.do_blue();
 7
       elsif l_color = constants.k_black then
 8
         my_package.do_black();
 9
       end if;
    end;
10
11
12
```

# **EXAMPLE (GOOD)**

```
1
    declare
 2
       1_color types.color_code_type;
 3
    begin
       case l_color
 4
         when constants.k_red
                                 then
 5
            my_package.do_red();
 6
         when constants.k_blue then
 7
            my_package.do_blue();
 8
          when constants.k_black then
 9
            my_package.do_black();
          else null;
10
       end case;
11
    end;
12
13
14
```

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



Maintainability, Portability

# REASON

DECODE is an ORACLE specific function that can be hard to understand (particularly when not formatted well) and is restricted to SQL only. The CASE function is much more common has a better readability and may be used within PL/SQL too.

# **EXAMPLE (BAD)**

```
1 select decode(dummy, 'x', 1
2 , 'y', 2
3 , 'z', 3
4 , 0)
5 from dual;
```

# EXAMPLE (GOOD)

```
1 select case dummy
2 when 'x' then 1
3 when 'y' then 2
4 when 'z' then 3
5 else 0
6 end
6 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.

```
Critical

Efficiency, Reliability
```

#### REASON

The nv1 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.

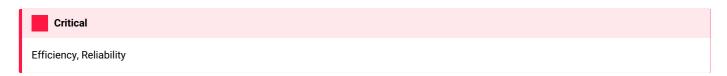
# **EXAMPLE (BAD)**

```
1  select nvl(dummy, my_package.expensive_null(value_in => dummy))
2  from dual;

EXAMPLE (GOOD)

1  select coalesce(dummy, my_package.expensive_null(value_in => dummy))
2  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 nv12 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)**

# EXAMPLE (GOOD)

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



#### REASON

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

Use of gotos is a matter of religion. In modern languages, you can easily replace nine out of ten gotos with equivalent structured constructs. In these simple cases, you should replace gotos out of habit. In the hard cases, you can break the code into smaller routines; 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 exercise.

# **EXAMPLE (BAD)**

```
create or replace package body my_package is
 2
       procedure password_check (in_password in varchar2) is
 3
          k_digitarray constant string(10 char) := '0123456789';
          k_lower_bound constant simple_integer := 1;
 4
                    constant simple_integer := -20501;
          k errno
 5
                        constant string(100 char) := 'Password must contain a
          k_errmsg
 6
    digit.';
 7
          l_isdigit
                        boolean
                                     := false;
 8
          l_password_length pls_integer;
 9
          l_array_length pls_integer;
10
          l_password_length := length(in_password);
11
          l_array_length
                            := length(k_digitarray);
12
13
          <<check_digit>>
14
          for i in k\_lower\_bound .. l\_array\_length
          loop
15
             <<check_pw_char>>
16
             for j in k_lower_bound .. l_password_length
17
             loop
18
                if substr(in\_password, j, 1) = substr(k\_digitarray, i, 1) then
19
                   l_isdigit := true;
                   goto check_other_things;
20
                end if:
21
             end loop check_pw_char;
22
          end loop check_digit;
23
24
          <<check_other_things>>
25
          null:
26
          if not l_{isdigit} then
27
             raise_application_error(k_errno, k_errmsg);
28
          end if;
29
       end password_check;
30
    end my_package;
31
32
33
34
35
```

# EXAMPLE (BETTER)

```
1
   create or replace package body my_package is
2
      procedure password_check (in_password in varchar2) is
3
         k_{digitarray} constant string(10 char) := '0123456789';
         k_lower_bound constant simple_integer := 1;
4
                    constant simple_integer := -20501;
         k_errno
5
                      constant string(100 char) := 'Password must contain a
         k_errmsg
6
   digit.';
7
                          hooloon :- folco:
```

```
___sury_t
                             DUUTEUN .- LUTSE,
 8
          l_password_length pls_integer;
 9
          l_array_length
                            pls_integer;
       begin
10
          l_password_length := length(in_password);
11
          l_array_length
                            := length(k_digitarray);
12
13
          <<check_digit>>
          for i in k_lower_bound .. l_array_length
14
15
              <<check_pw_char>>
16
              for j in k\_lower\_bound .. l\_password\_length
17
             loop
18
                if substr(in\_password, j, 1) = substr(k\_digitarray, i, 1) then
19
                    l_isdigit := true;
                    exit check_digit; -- early exit condition
20
                end if;
21
             end loop check_pw_char;
22
          end loop check_digit;
23
24
          <<check_other_things>>
          null;
25
26
          if not l_{isdigit} then
27
             raise_application_error(k_errno, k_errmsg);
28
          end if;
29
       end password_check;
30
    end my_package;
31
32
33
34
35
EXAMPLE (GOOD)
 1
    create or replace package body my_package is
 2
       procedure password_check (in_password in varchar2) is
 3
          k_{digitpattern} constant string(2 char) := '\d';
                         constant simple_integer := -20501;
 4
                         constant string(100 char) := 'Password must contain a
          k_errmsg
 5
    digit.';
 6
       begin
 7
          if not regexp_like(in_password, k_digitpattern)
 8
 9
             raise_application_error(k_errno, k_errmsg);
          end if;
10
       end password_check;
11
    end my_package;
12
13
```

# G-4320: Always label your loops.



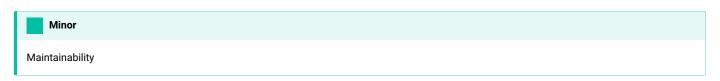
# REASON

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

```
declare
i integer;
k_min_value constant simple_integer := 1;
k_max_value constant simple_integer := 10;
k_increment constant simple_integer := 1;
begin
i := k_min_value;
while (i <= k_max_value)</pre>
```

```
MIITTE (T >- V"IIIQY" AGTRE)
 8
       loop
 9
          i := i + k_increment;
        end loop;
10
11
        loop
12
           exit;
13
       end loop;
14
        for i in k_min_value..k_max_value
15
16
          sys.dbms_output.put_line(i);
17
        end loop;
18
19
        for r_employee in (select last_name from employee)
20
          sys.dbms_output.put_line(r_employee.last_name);
21
        end loop;
22
    end;
23
24
25
26
27
EXAMPLE (GOOD)
 1
    declare
 2
        i integer;
 3
        k_min_value constant simple_integer := 1;
       k_max_value constant simple_integer := 10;
 4
       k_increment constant simple_integer := 1;
 5
    begin
 6
       i := k_min_value;
 7
        <<while_loop>>
 8
       while (i <= k_max_value)</pre>
 9
         i := i + k_increment;
10
        end loop while_loop;
11
12
        <<basic_loop>>
13
        loop
14
           exit basic_loop;
        end loop basic_loop;
15
16
        <<for_loop>>
17
        for i in k_min_value..k_max_value
18
        loop
19
          sys.dbms_output.put_line(i);
       end loop for_loop;
20
21
        <<pre><<pre><<pre>cess_employees>>
22
        for r_employee in (select last_name
23
                             from employee)
24
25
           sys.dbms_output.put_line(r_employee.last_name);
        end loop process_employees;
26
    end;
27
28
29
30
31
32
```

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.

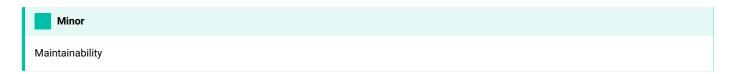
#### **EXAMPLE (BAD)**

```
1
    declare
 2
       cursor employee_cur is
 3
          select employee_id, last_name
            from employee;
 4
       r_employee employee_cur%rowtype;
 5
    begin
 6
       open employee_cur;
 7
 8
       <<output_employee_last_names>>
 9
          fetch employee_cur into r_employee;
10
          exit read_employees when employee_cur%notfound;
11
          sys.dbms_output.put_line(r_employee.last_name);
12
       end loop output_employee_last_names;
13
14
       close employee_cur;
    end;
15
16
17
18
```

# **EXAMPLE (GOOD)**

```
1
    declare
 2
       cursor employee_cur is
 3
          select employee_id, last_name
 4
            from employee;
    begin
 5
       <<output_employee_last_names>>
 6
       for r_employee in employee_cur
 7
       loop
 8
          sys.dbms_output.put_line(r_employee.last_name);
 9
       end loop output_employee_last_names;
    end;
10
11
12
```

# 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.

```
2
      type t_employee_type is varray(10) of employee.employee_id%type;
      {\tt t\_employee} \quad {\tt t\_employee\_type} \,;
3
                    constant integer := 118;
      k himuro
4
      k_livingston constant integer := 177;
5
      k_{min}value constant simple_integer := 1;
6
      k_increment constant simple_integer := 1;
7
      i pls_integer;
8
   begin
      t_employee := t_employee_type(k_himuro, k_livingston);
```

```
:= k_min_value;
10
11
        <<pre><<pre><<pre>cess_employees>>
12
13
          exit process_employees when i > t_employee.count();
14
           sys.dbms_output.put_line(t_employee(i));
          i := i + k_increment;
15
        end loop process_employees;
16
     end;
17
18
19
20
EXAMPLE (GOOD)
 1
     declare
 2
       type t_employee_type is varray(10) of employee.employee_id%type;
 3
        t_employee t_employee_type;
       k_himuro
                    constant integer := 118;
 4
       k_{livingston} constant integer := 177;
 5
    begin
 6
        t_employee := t_employee_type(k_himuro, k_livingston);
 7
 8
        <<pre><<pre><<pre>cess employees>>
 9
        for i in 1..t_employee.count()
       loop
10
          sys.dbms_output.put_line(t_employee(i));
11
        end loop process_employees;
12
    end:
13
14
15
```

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



# REASON

Doing so will not raise a value\_error if the array you are looping through is empty. If you want to usefirst()..last() you need to check the array for emptiness beforehand to avoid the raise of  $value_error$ .

# EXAMPLE (BAD)

```
1
 2
       type t_employee_type is table of employee.employee_id%type;
 3
       t_employee t_employee_type := t_employee_type();
    begin
 4
       <<pre><<pre><<pre>cess_employees>>
 5
       for i in t_employee.first()..t_employee.last()
 6
       loop
 7
          sys.dbms_output.put_line(t_employee(i)); -- some processing
 8
       end loop process_employees;
 9
    end;
    /
10
11
```

# **EXAMPLE (BETTER)**

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

```
1 declare
2     type t_employee_type is table of employee.employee_id%type;
3     t_employee t_employee_type := t_employee_type();
4     begin
```

```
for i in 1..t_employees.count()
loop
sys.dbms_output.put_line(t_employee(i)); -- some processing
end loop process_employees;
end;
//
11
```

# **EXAMPLE (GOOD)**

Raises neither an error nor checking whether the array is empty.t\_employee.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.

```
1
    declare
2
       type t_employee_type is table of employee.employee_id%type;
3
       t_employee t_employee_type := t_employee_type();
    begin
 4
       if t_employee is not null then
 5
           <<pre><<pre><<pre>cess_employees>>
 6
           for i in 1..t_employee.count()
 7
 8
             sys.dbms_output.put_line(t_employee(i)); -- some processing
 9
          end loop process_employees;
       end if;
10
    end;
11
12
13
```

# 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 -- raises no_data_found when processing 2nd record
 2
       type t_employee_type is table of employee.employee_id%type;
 3
       t_employee t_employee_type;
       k_rogers
                      constant integer := 134;
 4
       k_matos
                     constant integer := 143;
 5
       k_mcewen
                     constant integer := 158;
 6
       k_index_matos constant integer := 2;
 7
 8
       t_employee := t_employee_type(k_rogers, k_matos, k_mcewen);
 q
       t_employee.delete(k_index_matos);
10
       if t_employee is not null then
11
          <<pre><<pre><<pre>cess_employees>>
12
          for i in 1..t_employee.count()
13
14
              sys.dbms_output.put_line(t_employee(i));
          end loop process_employees;
15
       end if:
16
    end;
17
18
19
20
```

# **EXAMPLE (GOOD)**

```
2
        type t_employee_type is table of employee.employee_id%type;
 3
        t_employee t_employee_type;
        k_rogers constant integer := 143;
k_matos constant integer := 158;
constant integer := 158;
 4
 5
 6
        k_index_matos constant integer := 2;
 7
        l_{index}
                   pls_integer;
 8
     begin
 9
        t_employee := t_employee_type(k_rogers, k_matos, k_mcewen);
10
        t_employee.delete(k_index_matos);
11
        l_index := t_employee.first();
12
13
        <<pre><<pre><<pre>cess_employees>>
        while l_{\text{index}} is not null
14
15
            sys.dbms\_output.put\_line(t\_employee(l\_index));\\
16
            l_index := t_employee.next(l_index);
17
        end loop process_employees;
18
     end:
19
20
21
22
```

# 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.

```
1
    declare
 2
       i integer;
 3
       k_min_value constant simple_integer := 1;
       k_max_value constant simple_integer := 10;
 4
       k_increment constant simple_integer := 1;
 5
    begin
 6
       i := k_min_value;
 7
        <<while_loop>>
 8
       while (i <= k_max_value)</pre>
 9
       loop
          i := i + k_increment;
10
          exit while_loop when i > k_max_value;
11
       end loop while_loop;
12
13
        <<basic_loop>>
14
       loop
          exit basic_loop;
15
        end loop basic_loop;
16
17
        <<for_loop>>
18
        for i in k_min_value..k_max_value
19
       loop
20
          exit for_loop when i = k_max_value;
21
        end loop for_loop;
22
23
        <<pre><<pre>cess_employees>>
24
        for r_employee in (select last_name
25
                             from employee)
26
          sys.dbms\_output.put\_line(r\_employee.last\_name);\\
27
          null; -- some processing
28
```

```
exit process_employees;
end loop process_employees;
end;

/

22

33

34

35

36
```

# **EXAMPLE (GOOD)**

```
1
     declare
 2
        i integer;
 3
       k_min_value constant simple_integer := 1;
        k_max_value constant simple_integer := 10;
 4
       k_increment constant simple_integer := 1;
 5
    begin
 6
       i := k_min_value;
 7
        <<while_loop>>
 8
        while (i <= k_max_value)
 9
          i := i + k_increment;
10
        end loop while_loop;
11
12
        <<basic_loop>>
13
        loop
14
           exit basic_loop;
        end loop basic_loop;
15
16
        <<for_loop>>
17
        for i in k_{min\_value..k\_max\_value}
18
19
           {\tt sys.dbms\_output.put\_line(i);}
        end loop for_loop;
20
21
        <<pre><<pre><<pre>cess_employees>>
22
        for r_employee in (select last_name
23
                              from employee)
24
           sys.dbms_output.put_line(r_employee.last_name); -- some processing
25
        end loop process_employees;
26
    end;
27
28
29
30
31
32
```

# 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.

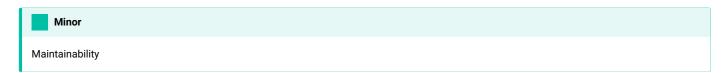
```
declare
k_first_year constant pls_integer := 1900;
begin

<<pre>
<<pre>
pegin
constant pls_integer := 1900;

pegin
co
```

```
if extract(year from sysdate) > k_first_year then
 8
              exit process_employees;
 9
           end if;
10
          my_package.some_further_processing();
11
        end loop process_employees;
12
    end;
13
14
15
EXAMPLE (GOOD)
 1
    declare
 2
       k_first_year constant pls_integer := 1900;
 3
    begin
 4
        <<pre><<pre><<pre>cemployees>>
 5
          my_package.some_processing();
 6
 7
          exit process_employees when extract(year from sysdate) > k_first_year;
 8
 9
          my_package.some_further_processing();
        end loop process_employees;
10
11
12
13
```

# 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.

```
1
    declare
 2
       k_init_loop constant simple_integer
 3
                                                     := 1;
       k_increment constant simple_integer
       k_{\text{exit\_value}} constant simple_integer
                                                     := 3;
 4
       k_outer_text constant types.short_text_type := 'outer loop counter is ';
 5
       k_inner_text constant types.short_text_type := ' inner loop counter is
 6
 7
       1_outerloop
                       pls_integer;
 8
       l\_innerloop
                       pls_integer;
 9
    begin
       l_outerloop := k_init_loop;
10
       <<outerloop>>
11
       loop
12
          l_innerloop := k_init_loop;
13
          1_outerloop := nvl(1_outerloop,k_init_loop) + k_increment;
14
          <<innerloop>>
          loop
15
             1_innerloop := nvl(l_innerloop, k_init_loop) + k_increment;
16
             sys.dbms_output.put_line(k_outer_text || l_outerloop ||
17
                                       k_inner_text || l_innerloop);
18
19
             exit when l_innerloop = k_exit_value;
20
          end loop innerloop;
21
          exit when l_innerloop = k_exit_value;
22
       end loop outerloop;
23
    end:
24
25
26
27
```

ر ۲

#### **EXAMPLE (GOOD)**

```
1
     declare
 2
        k_init_loop constant simple_integer
                                                              := 0;
 3
        k\_increment \quad constant \ simple\_integer
                                                              := 1;
         k_{\text{exit\_value}} constant simple_{\text{integer}}
                                                             := 3;
 4
        k\_outer\_text\ constant\ types.short\_text\_type\ :=\ 'outer\ loop\ counter\ is\ ';\\ k\_inner\_text\ constant\ types.short\_text\_type\ :=\ '\ inner\ loop\ counter\ is
 5
 6
 7
         l_outerloop pls_integer;
 8
        l_innerloop
                          pls_integer;
 9
     begin
        l_outerloop := k_init_loop;
10
         <<outerloop>>
11
12
            l_innerloop := k_init_loop;
13
            1_outerloop := nvl(1_outerloop,k_init_loop) + k_increment;
14
            loop
15
                1_innerloop := nvl(l_innerloop, k_init_loop) + k_increment;
16
                sys.dbms_output.put_line(k_outer_text || l_outerloop ||
17
                                              k_inner_text || l_innerloop);
18
19
                exit outerloop when l_innerloop = k_exit_value;
            end loop innerloop;
20
         end loop outerloop;
21
     end;
22
23
24
25
```

# 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.

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

# **EXAMPLE (BAD)**

```
1
    declare
 2
       l_employee_found boolean := false;
 3
       cursor employee_cur is
          select employee_id, last_name
 4
            from employee;
 5
       r_employee employee_cur%rowtype;
 6
    begin
 7
       <<check_employees>>
 8
       for r_employee in employee_cur
 9
          1_employee_found := true;
10
       end loop check_employees;
11
    end;
12
13
14
```

# EXAMPLE (GOOD)

```
1 declare
2 l_employee_found boolean := false;
3 cursor employee_cur is
```

```
select employee_id, last_name
 4
            from employee;
 5
       r_employee employee_cur%rowtype;
 6
    begin
 7
       open employee_cur;
 8
       fetch employee_cur into r_employee;
 9
       1_employee_found := employee_cur%found;
       close employee_cur;
10
    end:
11
12
13
```

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

```
Major

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
 2
       1_row
              pls_integer;
 3
       l_value pls_integer;
                                                        := 1;
 4
       k_lower_bound constant simple_integer
                                                        := 5;
       k_upper_bound constant simple_integer
 5
                                                        := 1:
       k_row_incr constant simple_integer
 6
                                                        := 10;
       k_value_incr constant simple_integer
 7
       k_delimiter constant types.short_text_type
                                                       := ' '
 8
                                                       := 100;
       k_first_value constant simple_integer
 9
    begin
       1_row := k_lower_bound;
10
       l_value := k_first_value;
11
       <<for_loop>>
12
       for i in k_lower_bound .. k_upper_bound
13
       loop
14
          sys.dbms_output.put_line(l_row || k_delimiter || l_value);
          1_row := 1_row + k_row_incr;
15
          l_value := l_value + k_value_incr;
16
       end loop for_loop;
17
    end:
18
19
20
21
```

# **EXAMPLE (GOOD)**

```
1
 2
         k_lower_bound constant simple_integer
                                                                         := 1;
 3
         k_upper_bound constant simple_integer
                                                                         := 5;
         \label{eq:kvalue_incr} \begin{array}{ll} k\_value\_incr & constant \ simple\_integer \\ k\_delimiter & constant \ types.short\_text\_type \end{array}
                                                                         := 10;
:= ' '
 4
 5
         k_first_value constant simple_integer
                                                                         := 100;
 6
     begin
 7
          <<for_loop>>
 8
          for i in k\_lower\_bound .. k\_upper\_bound
 9
             sys.dbms_output.put_line(i || k_delimiter ||
10
                                               to_char(k_first_value + i * k_value_incr));
11
          end loop for_loop;
12
     end;
13
14
15
```

٠.

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



# 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

coutput_loop>>
for i in 1..5

loop
sys.dbms_output.put_line(i);
end loop output_loop;
end;

//
8
```

# **EXAMPLE (GOOD)**

```
1
    declare
 2
       k_lower_bound constant simple_integer := 1;
 3
       k_upper_bound constant simple_integer := 5;
 4
    begin
       <<output_loop>>
 5
       for i in k_lower_bound..k_upper_bound
 6
 7
          sys.dbms_output.put_line(i);
 8
       end loop output_loop;
 9
    end;
10
11
```

# **Exception Handling**

G-5010: Always use an error/logging framework for your application.



# 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

By far, the best logging framework available is Logger from OraOpenSource.

# Example (bad)

```
begin
sys.dbms_output.put_line('start');
-- some processing
sys.dbms_output.put_line('end');
end;
//
```

# Example (good)

```
1
   declare
2
     -- see
3
  https://github.com/oraopensource/logger
    1_scope logger_logs.scope%type := 'demo';
4
  begin
5
    logger.log('start', l_scope);
6
     -- some processing
7
    logger.log('end', l_scope);
8 end;
9
```

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



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)

```
1
    declare
 2
       k_no_data_found constant integer := -1;
 3
    begin
       my_package.some_processing(); -- some code which raises an exception
 4
    exception
 5
       when too_many_rows then
 6
          my_package.some_further_processing();
 7
       when others then
 8
          if sqlcode = k_no_data_found then
 9
            null;
          end if;
10
    end;
11
12
13
```

# Example (good)

```
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.
```

```
8 /
9
```

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 theselect 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.

```
1
    declare
 2
       1 dummv
                       dual.dummy%type;
 3
       no_data_found exception;
                       constant simple_integer
                                                       := 0;
       k rownum
 4
       k_no_data_found constant types.short_text_type := 'no_data_found';
 5
    begin
 6
       select dummy
 7
         into l_dummy
 8
         from dual
 9
        where rownum = k_rownum;
10
       if l_{dummy} is null then
11
          raise no_data_found;
12
       end if:
13
    exception
14
       when no_data_found then
          sys.dbms_output.put_line(k_no_data_found);
15
    end;
16
17
18
    Error report -
19
    ORA-01403: no data found
    ORA-06512: at line 5
20
    01403. 00000 - "no data found"
21
    *Cause:
               No data was found from the objects.
22
    *Action: There was no data from the objects which may be due to end of fetch.
23
24
25
26
```

# Example (good)

```
1
    declare
 2
       1_dummy
                        dual.dummy%type;
 3
        empty_value
                        exception;
        k_rownum
                        constant simple_integer
                                                          := 0;
 4
       k\_empty\_value \quad constant \ types.short\_text\_type \ := \ 'empty\_value';
 5
       k_no_data_found constant types.short_text_type := 'no_data_found';
 6
    begin
 7
        select dummy
 8
         into l_dummy
 9
         from dual
        where rownum = k_rownum;
10
11
        if l_dummy is null then
12
```

```
raise empty_vaiue;
13
       end if;
14 exception
       when empty_value then
15
          sys.dbms_output.put_line(k_empty_value);
16
       when no_data_found then
17
          sys.dbms_output.put_line(k_no_data_found);
18
    end:
19
20
21
22
```

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;
//
```

# Example (good)

```
begin
my_package.some_processing();
exception
when dup_val_on_index then
my_package.some_further_processing();
end;
7
```

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 <code>raise\_application\_error</code>. If you are raising a "system" exception like <code>no\_data\_found</code>, you must use RAISE. However, when you want to raise an application-specific error, you use <code>raise\_application\_error</code>. 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)

```
1 begin
2 raise_application_error(-20501,'invalid employee_id');
3 end;
4 /
```

# Example (good)

```
begin
errors.raise(in_error => errors.k_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)

```
1
    create or replace package body department_api is
 2
       function name_by_id (in_id in department.department_id%type)
 3
          return department.department_name%type is
          1_department_name department.department_name%type;
 4
       begin
 5
          select department_name
 6
            into l_department_name
 7
             from department
 8
           where department_id = in_id;
 9
          return 1 department name:
10
       end name_by_id;
11
    end department_api;
12
13
14
```

# Example (good)

```
1 create or replace package body department_api is
2 function name_by_id (in_id in department.department_id%type)
3 return department.department_name%type is
4 l department_name department_department_name%type:
```

```
4
       begin
 5
          select department_name
 6
            into l_department_name
 7
            from department
 8
           where department_id = in_id;
 9
          return l_department_name;
10
       exception
11
          when no_data_found then return null;
12
          when too_many_rows then raise;
13
       end name_by_id;
14
   end department_api;
15
16
17
```

G-5070: Avoid using Oracle predefined exceptions.



# 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;
// /
```

# Example (good)

# 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)

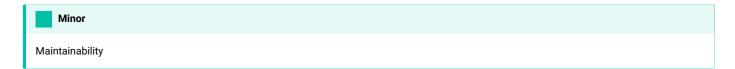
```
procedure trx_to_collection(
 2
       p_appendix_id in px_mandate_appendix.id%TYPE
 3
    is
 4
       k_trx_collection constant varchar2(10) := 'TRX_LINES';
 5
 6
       1_param_names
                                 apex_application_global.vc_arr2;
 7
       l_param_values
                                 apex_application_global.vc_arr2;
 8
    begin
 9
       1_param_names(1_param_names.count + 1) := 'APPENDIX_ID';
       1_param_values(1_param_names.count) := p_appendix_id;
10
11
       apex_collection.create_collection_from_query_b
12
13
           p_collection_name => k_trx_collection
14
         , p_query
               q'[select t.id, 'Y' include_flag, 'TRX' type
15
                    from px_billing_transactions t
16
                    where t.appendix_id = :APPENDIX_ID
17
                     and t.pending_invoice_flag = 'Y']'
18
         , p_names
                           => l_param_names
19
         , p_values
                            => l_param_values
20
    end;
21
22
23
24
25
```

# Example (good)

```
procedure trx_to_collection(
    2
                          p_appendix_id in px_mandate_appendix.id%TYPE
    3
               )
               is
    4
                          k_{trx} = 100 := TRX_{trx} : TRX_{trx} :
    5
    6
                          k\_sql\ constant\ types.big\_string\_type :=
    7
                                                       q'[select t.id, 'Y' include_flag, 'TRX' type
    8
                                                                           from px_billing_transactions t
    9
                                                                           where t.appendix_id = :APPENDIX_ID
                                                                                and t.pending_invoice_flag = 'Y']';
10
11
                                                                                                                        apex_application_global.vc_arr2;
                           1_param_names
12
                                                                                                                        apex_application_global.vc_arr2;
                          l_param_values
13
               begin
                           1_param_names(1_param_names.count + 1) := 'APPENDIX_ID';
14
                           1_param_values(1_param_names.count) := p_appendix_id;
15
16
                           apex_collection.create_collection_from_query_b
17
18
                                         p_collection_name => k_trx_collection
                                , p_query => k_sql
, p_names => l_param_names
19
20
                                  , p_values => l_param_values
21
22
23
                 end;
24
25
26
27
28
```

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)

```
1
    create or replace package body employee_api is
 2
       procedure upd_salary (in_employee_id in employee.employee_id%type
 3
                            ,in_increase_pct in types.percentage
                            ,out_new_salary out employee.salary%type)
 4
 5
          k\_sql\_stmt\ constant\ types.big\_string\_type\ :=
 6
              'update employee set salary = salary + (salary / 100 * :1)
 7
               where employee_id = :2
 8
            returning salary into :3';
 9
       begin
         execute immediate k_sql_stmt
10
               using in_increase_pct, in_employee_id, out out_new_salary;
11
       end upd_salary;
12
    end employee_api;
13
14
15
```

# Example (good)

```
create or replace package body employee_api is
2
      3
                        ,out_new_salary out employee.salary%type)
4
5
        k_sql_stmt constant types.big_string_type :=
6
            'update employee set salary = salary + (salary / 100 * :1)
7
              where employee_id = :2
8
          returning salary into :3';
9
      begin
        execute immediate k\_sql\_stmt
10
             using in_increase_pct, in_employee_id
11
             returning into out_new_salary;
12
      end upd_salary;
13
   end employee_api;
14
15
16
```

G-6030: Always verify parameters that will be used in dynamic SQL with DBMS\_ASSERT



# Reason

Parameters used with dynamic sql are subject to SQL injection. The DBMS\_ASSERT package provides an interface to validate properties of parameters.

# Example (bad)

```
1
    procedure schedule_refresh_data_job (p_user varchar2) is
 2
        1_job_action varchar2(4000);
 3
        1_scope logger_logs.scope%type := gc_scope_prefix || 'Create refresh job';
    begin
 4
        logger.log('START',l_scope);
 5
        l_job_action := 'begin hr.hr_utils.refresh_read_only_data_from_source; end;';
 6
       dbms_scheduler.create_job
 7
          (job_name => gk_on_demand_job_name
          ,job_type => 'PLSQL_BLOCK'
 8
 9
          ,job_action => l_job_action
          ,start_date => sysdate
10
          ,enabled => true
11
          ,auto_drop => true
12
          ,job_class => 'DEFAULT_JOB_CLASS'
13
           , comments \Rightarrow 'Refresh data from Source to Destination by ' \mid\mid p_user \mid\mid ' created on ' \mid\mid to_char(sysdate)
14
    ,'mm/dd/yyyy hh:mi:ss am')
          );
15
16
       logger.log('END ',l_scope);
17
    exception
18
       when others then
19
               logger.log_error('Unable to execute: '|| sqlerrm,l_scope);
               raise_application_error(-20001, 'Unable to create refresh job :'||sqlerrm);
20
    end schedule_refresh_data_job;
21
22
23
```

# Example (good)

```
1
    procedure schedule_refresh_data_job (p_user varchar2) is
 2
       1_job_action varchar2(4000);
 3
       1_scope logger_logs.scope%type := gc_scope_prefix || 'Create refresh job';
 4
    begin
       logger.log('START',l_scope);
 5
       l_job_action := 'begin hr.hr_utils.refresh_read_only_data_from_source; end;';
 6
       dbms_scheduler.create_job
 7
          (job_name => gk_on_demand_job_name
 8
          ,job_type => 'PLSQL_BLOCK'
 9
          ,job_action => l_job_action
          ,start_date => sysdate
10
          ,enabled => true
11
          ,auto_drop => true
12
          ,job_class => 'DEFAULT_JOB_CLASS'
13
          comments => 'Refresh data from Source to Destination by ' || dbms_assert.simple_sql_name(p_user) || '
14
    created on ' || to_char(sysdate ,'YYYY-MM-DD hh24:mi:ss')
          );
15
16
       logger.log('END ',l_scope);
17
    exception
18
       when others then
              logger.log_error('Unable to execute: '|| sqlerrm,l_scope);
19
              raise_application_error(-20001, 'Unable to create refresh job :'||sqlerrm);
20
    end schedule_refresh_data_job;
21
22
23
```

# 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)**

```
1
   declare
2
      r_employee employee%rowtype;
3
      k_id constant employee.employee_id%type := 107;
4
      employee_api.employee_by_id(r_employee, k_id);
5
   end;
6
7
EXAMPLE (GOOD)
   declare
2
      r_employee employee%rowtype;
3
      k_id constant employee.employee_id%type := 107;
4
      employee_api.employee_by_id(out_row => r_employee, in_employee_id => k_id);
5
```

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



end;

6 7

Minor

Maintainability

# REASON

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

# **EXAMPLE (BAD)**

```
1
    create or replace package body employee_api is
 2
       function employee_by_id (in_employee_id in employee.employee_id%type)
 3
          return employee%rowtype is
          r_employee employee%rowtype;
 4
       begin
 5
          select *
 6
            into r_employee
 7
            from employee
 8
           where employee_id = in_employee_id;
 9
          return r_employee;
10
       exception
11
          when no_data_found then
12
             null;
13
          when too_many_rows then
14
             raise;
       end;
15
    end;
16
17
18
19
```

# **EXAMPLE (GOOD)**

1 create or replace package body employee\_api is

```
2
       function employee_by_id (in_employee_id in employee.employee_id%type)
 3
          return employee%rowtype is
          r_employee employee%rowtype;
 4
       begin
 5
          select *
 6
            into r_employee
 7
            from employee
 8
           where employee_id = in_employee_id;
 9
          return r_employee;
10
       exception
11
          when no_data_found then
12
             null:
13
          when too_many_rows then
14
             raise:
       end employee_by_id;
15
    end employee_api;
16
17
18
19
```

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



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.

```
1
    create or replace package body employee_api is
 2
       procedure calc_salary (in_employee_id in employee.employee_id%type) is
 3
          r_employee employee%rowtype;
 4
          function commission return number is
 5
             l_commission employee.salary%type := 0;
 6
          beain
 7
             if r_employee.commission_pct is not null
 8
 9
                1_commission := r_employee.salary * r_employee.commission_pct;
             end if;
10
11
             return l_commission;
12
          end commission:
13
       begin
14
          select *
            into r_employee
15
             from employee
16
           where employee_id = in_employee_id;
17
18
          sys.dbms_output.put_line(r_employee.salary + commission());
19
       exception
          when no_data_found then
20
             null;
21
          when too_many_rows then
22
             null:
23
       end calc_salary;
24
    end employee_api;
25
26
27
വ
```

#### **EXAMPLE (GOOD)**

```
create or replace package body employee_api is
 2
       procedure calc_salary (in_employee_id in employee.employee_id%type) is
 3
          r_employee employee%rowtype;
 4
          function commission (in_salary in employee.salary%type
 5
                               ,in_comm_pct in employee.commission_pct%type)
 6
              return number is
 7
             l_commission employee.salary%type := 0;
 8
          begin
 9
              if in_comm_pct is not null then
                l_commission := in_salary * in_comm_pct;
10
              end if;
11
12
             return l_commission;
13
          end commission;
14
       begin
          select *
15
            into r_employee
16
            from employee
17
           where employee_id = in_employee_id;
18
19
          sys.dbms_output.put_line(
              r_employee.salary + commission(in_salary => r_employee.salary
20
                                       ,in_comm_pct => r_employee.commission_pct)
21
          ):
22
       exception
23
          when no_data_found then
24
             null;
25
          when too_many_rows then
             null;
26
       end calc_salary;
27
    end employee_api;
28
29
30
31
32
33
```

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



# 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.

```
create or replace package body my_package is
procedure my_procedure is
function my_func return number is
k_true constant integer := 1;
```

```
beain
 5
              return k_true;
 6
          end my_func;
 7
       begin
 8
           null;
 9
       end my_procedure;
    end my_package;
10
11
12
EXAMPLE (GOOD)
 1
    create or replace package body my_package is
 2
       procedure my_procedure is
 3
          function my_func return number is
 4
             k_true constant integer := 1;
          begin
 5
             return k_true;
 6
          end my_func;
 7
       beain
 8
           sys.dbms_output.put_line(my_func());
 9
       end my_procedure;
    end my_package;
10
11
12
```

# G-7150: Try to remove unused parameters.



# REASON

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

# **EXAMPLE (BAD)**

```
1
    create or replace package body department_api is
 2
       function name_by_id (in_department_id in department.department_id%type
 3
                           ,in_manager_id
                                           in department.manager_id%type)
 4
          return department.department_name%type is
          1_department_name department.department_name%type;
 5
 6
          <<find_department>>
 7
          begin
 8
             select department_name
 9
               into l_department_name
               from department
10
              where department_id = in_department_id;
11
          exception
12
             when no_data_found or too_many_rows then
13
                1_department_name := null;
          end find_department;
14
15
          return l_department_name;
16
       end name_by_id;
17
    end department_api;
18
19
20
21
```

```
1_department_name department.department_name%type;
 4
       begin
 5
          <<find_department>>
 6
          begin
 7
             select department_name
 8
               into l_department_name
 9
               from department
              where department_id = in_department_id;
10
          exception
11
             when no_data_found or too_many_rows then
12
                 1_department_name := null;
13
          end find_department;
14
          return l_department_name;
15
       end name_by_id;
16
    end department_api;
17
18
19
20
```

# **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.

```
Minor
Changeability
```

### 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
 2
       procedure del (in_department_id in department.department_id%type);
 3
    end department_api;
 4
 5
    create or replace package body department_api is
 6
       function does_exist (in_department_id in department.department_id%type)
 7
          return boolean is
 8
          l_return pls_integer;
 9
       begin
          <<check_row_exists>>
10
          begin
11
             select 1
12
               into l_return
13
               from department
14
              where department_id = in_department_id;
          exception
15
             when no_data_found or too_many_rows then
16
                1_return := 0;
17
          end check_row_exists;
18
19
          return l_return = 1;
       end does_exist;
20
```

```
21
       procedure del (in_department_id in department.department_id%type) is
22
       begin
23
          if does_exist(in_department_id) then
24
            null;
          end if;
25
       end del;
26
    end department_api;
27
28
29
30
31
32
EXAMPLE (GOOD)
 1
    create or replace package department_api is
 2
       procedure del (in_department_id in department.department_id%type);
 3
    end department_api;
 4
 5
    create or replace package body department_api is
 6
       function does_exist (in_department_id in department.department_id%type)
 7
          return boolean;
 8
       procedure del (in_department_id in department.department_id%type) is
 9
       begin
10
          if does_exist(in_department_id) then
11
12
          end if:
13
       end del;
14
15
       function does_exist (in_department_id in department.department_id%type)
          return boolean is
16
          1_return
                             pls_integer;
17
                             constant pls_integer := 1;
          k_exists
18
          k_something_wrong constant pls_integer := 0;
19
          <<check_row_exists>>
20
          begin
21
             select k_exists
22
               into l_return
23
                from department
24
              where department_id = in_department_id;
25
          exception
             when no_data_found or too_many_rows then
26
                1_return := k_something_wrong;
27
          end check_row_exists;
28
29
          return l_return = k_exists;
30
       end does_exist;
    end department_api;
31
32
33
34
35
36
37
```

# G-7230: Avoid declaring global variables public.



### 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)**

```
1
    create or replace package employee_api as
 2
       k_min_increase constant types.sal_increase_type := 0.01;
 3
       k_max_increase constant types.sal_increase_type := 0.5;
       g_salary_increase types.sal_increase_type := k_min_increase;
 4
 5
       procedure set_salary_increase (in_increase in types.sal_increase_type);
 6
       function salary_increase return types.sal_increase_type;
 7
    end employee_api;
 8
 q
    create or replace package body employee_api as
10
       procedure set_salary_increase (in_increase in types.sal_increase_type) is
11
       beain
12
          g_salary_increase := greatest(least(in_increase,k_max_increase)
13
                                        ,k_min_increase);
14
       end set_salary_increase;
15
       function salary_increase return types.sal_increase_type is
16
17
          return g_salary_increase;
18
       end salary_increase;
19
    end employee_api;
20
21
22
23
```

```
1
    create or replace package employee_api as
 2
       procedure set_salary_increase (in_increase in types.sal_increase_type);
 3
       function salary_increase return types.sal_increase_type;
 4
    end employee_api;
 5
 6
    create or replace package body employee_api as
 7
       g_salary_increase types.sal_increase_type(4,2);
 8
 9
       procedure init;
10
       procedure set_salary_increase (in_increase in types.sal_increase_type) is
11
12
          g_salary_increase := greatest(least(in_increase
13
                                              ,constants.max_salary_increase())
14
                                        ,constants.min_salary_increase());
       end set_salary_increase;
15
16
       function salary_increase return types.sal_increase_type is
17
18
          return g_salary_increase;
19
       end salary_increase;
20
       procedure init
21
       is
22
23
          g_salary_increase := constants.min_salary_increase();
24
       end init;
25 begin
       init();
26
    end employee_api;
27
28
29
```

# 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 isin. 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.

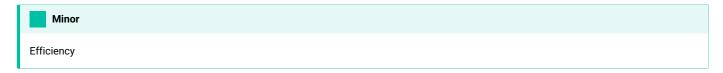
### **EXAMPLE (BAD)**

```
create or replace package body employee_up is
 2
       procedure rcv_emp (io_first_name in out employee.first_name%type
                         ,io_last_name
 3
                                           in out employee.last_name%type
                         ,io_email
 4
                                            in out employee.email%type
                         ,io_phone_number in out employee.phone_number%type
 5
                         ,io_hire_date
                                          in out employee.hire_date%type
 6
                         ,io_job_id
                                            in out employee.job_id%type
 7
                         ,io_salary
                                           in out employee.salary%type
 8
                         ,io_commission_pct in out employee.commission_pct%type
 9
                         ,io_manager_id
                                            in out employee.manager_id%type
10
                         ,io_department_id in out employee.department_id%type
                         ,in_wait
                                                   integer) is
11
          l_status pls_integer;
12
          k_pipe_name constant string(6 char) := 'mypipe';
13
          k_ok constant pls_integer := 1;
14
       begin
           - receive next message and unpack for each column.
15
          1_status := sys.dbms_pipe.receive_message(pipename => k_pipe_name
16
                                                   ,timeout => in_wait);
17
          if l_status = k_ok then
18
             sys.dbms_pipe.unpack_message (io_first_name);
19
             sys.dbms_pipe.unpack_message (io_last_name);
20
             sys.dbms_pipe.unpack_message (io_email);
             sys.dbms_pipe.unpack_message (io_phone_number);
21
             sys.dbms_pipe.unpack_message (io_hire_date);
22
             sys.dbms_pipe.unpack_message (io_job_id);
23
             sys.dbms_pipe.unpack_message (io_salary);
24
             sys.dbms_pipe.unpack_message (io_commission_pct);
             sys.dbms_pipe.unpack_message (io_manager_id);
25
             sys.dbms_pipe.unpack_message (io_department_id);
26
          end if;
27
       end rcv_emp;
28
    end employee_up;
29
30
31
32
33
34
```

```
create or replace package body employee_up is
2
      \verb|procedure rcv_emp (out\_first_name & out employee.first_name\%type \\
3
                         ,out_last_name
                                            out employee.last_name%type
                        ,out_email
                                            out employee.email%type
4
                        ,out_phone_number out employee.phone_number%type
5
                        ,out_hire_date
                                            out employee.hire_date%type
6
                                            out employee.job_id%type
                        ,out_job_id
7
                        ,out_salary
                                            out employee.salary%type
8
                        ,out_commission_pct out employee.commission_pct%type
9
                         ,out_manager_id
                                            out employee.manager_id%type
```

```
,out_department_id out employee.department_id%type
10
                          .in wait
                                             in integer) is
11
          l_status pls_integer;
12
          k_pipe_name constant string(6 char) := 'mypipe';
13
          k_ok constant pls_integer := 1;
14
       begin
           -- receive next message and unpack for each column.
15
          1_status := sys.dbms_pipe.receive_message(pipename => k_pipe_name
16
                                                    ,timeout => in_wait);
17
          if l_status = k_ok then
18
             sys.dbms_pipe.unpack_message (out_first_name);
19
             sys.dbms_pipe.unpack_message (out_last_name);
             sys.dbms_pipe.unpack_message (out_email);
20
             sys.dbms_pipe.unpack_message (out_phone_number);
21
             sys.dbms_pipe.unpack_message (out_hire_date);
22
             sys.dbms_pipe.unpack_message (out_job_id);
23
             sys.dbms_pipe.unpack_message (out_salary);
24
             sys.dbms_pipe.unpack_message (out_commission_pct);
             sys.dbms_pipe.unpack_message (out_manager_id);
25
             sys.dbms_pipe.unpack_message (out_department_id);
26
          end if;
27
       end rcv_emp;
28
    end employee_up;
29
30
31
32
33
34
```

# G-7250: Always use NOCOPY when appropriate



### REASON

When we pass OUT or IN OUT parameters in PL/SQL the Oracle Database supports two methods of passing data: By Value and By Reference.

The default, By Value, will copy all the data passed into a temporary buffer. This buffer is passed to the procedure and used during the life of the procedure. Then when processing is complete, the data in the buffer is copied to the original variable.

Passing By Reference is achieved by the NOCOPY hint, and, in contrast, it will pass a reference to the variable's data. Think of a pointer in the C language. This means that no temporary buffer is required. When passing significant amounts of data, the effects of passing values by reference can be significant.

# **EXAMPLE (BAD)**

```
procedure add_message(
 2
                        in out message_tbl_type
         p_msg
 3
        , p_message_text in varchar2
 4
       , p_severity
                        in varchar2 default 'E'
    )
 5
    is
 6
      l_index pls_integer;
 7
    begin
 8
 9
      l_index := p_msq.count + 1;
      p_msg(l_index).message_text := p_message_text;
10
      p_msg(l_index).severity := p_severity;
11
12
    end add_message;
13
14
```

# EXAMPLE (GOOD)

1 . .. .

```
procedure add_message(
2
                in out nocopy message_tbl_type
        p_msq
 3
       , p_message_text in varchar2
       , p_severity in varchar2 default 'E'
 4
    )
 5
    is
 6
      l_index pls_integer;
 7
    begin
 8
 9
      l_index := p_msg.count + 1;
      p_msg(l_index).message_text := p_message_text;
10
      p_msg(l_index).severity := p_severity;
11
12
    end add_message;
13
14
```

# **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)**

```
1  create or replace procedure my_procedure is
2  begin
3  null;
4  end my_procedure;
5  /
```

### EXAMPLE (GOOD)

```
1
    create or replace package my_package is
 2
       procedure my_procedure;
 3
    end my_package;
 4
 5
    create or replace package body my_package is
 6
       procedure my_procedure is
 7
       begin
 8
          null;
       end my_procedure;
 9
   end my_package;
10
11
12
```

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



# REASON

Use of the return statement is legal within a procedure in PL/SQL, but it is very similar to agoto , 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
 3
          l_idx simple_integer := 1;
 4
          k_modulo constant simple_integer := 7;
       begin
 5
          <<mod7_loop>>
 6
          loop
 7
            if mod(l_idx, k_modulo) = 0 then
 8
               return;
 9
            end if;
10
            l_{idx} := l_{idx} + 1;
11
          end loop mod7_loop;
12
       end my_procedure;
13
    end my_package;
14
15
16
```

# **EXAMPLE (GOOD)**

```
create or replace package body my_package is
 2
       procedure my_procedure is
 3
          l_idx simple_integer := 1;
          k_modulo constant simple_integer := 7;
 4
       beain
 5
          <<mod7_loop>>
 6
          loop
 7
            exit mod7\_loop when mod(l\_idx,k\_modulo) = 0;
 8
 9
            l_{idx} := l_{idx} + 1;
          end loop mod7_loop;
10
       end my_procedure;
11
    end my_package;
12
13
14
```

# **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)**

```
1 create or replace function my_function return varchar2 is
2 begin
3 return null;
4 end my_function;
```

5 ′

# **EXAMPLE (GOOD)**

```
1 create or replace package body my_package is
2    function my_function return varchar2 is
3    begin
4    return null;
5    end my_function;
end my_package;
7
```

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



#### REASON

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

# EXAMPLE (BAD)

```
1
    create or replace package body my_package is
 2
       function my_function (in_from in pls_integer
 3
                           , in_to in pls_integer) return pls_integer is
          l_ret pls_integer;
 4
       begin
 5
          1_ret := in_from;
 6
          <<for_loop>>
 7
          for i in in_from .. in_to
 8
          loop
 9
             l_ret := l_ret + i;
             if i = in_to then
10
                return l_ret;
11
             end if;
12
          end loop for_loop;
13
       end my_function;
14
    end my_package;
15
16
17
```

# EXAMPLE (GOOD)

```
create or replace package body my_package is
 2
       function my\_function (in_from in pls_integer
 3
                           , in_to in pls_integer) return pls_integer is
 4
          l_ret pls_integer;
       begin
 5
          l_ret := in_from;
 6
          <<for_loop>>
 7
          for i in in_from .. in_to
 8
          loop
 9
             l_ret := l_ret + i;
          end loop for_loop;
10
          return l_ret;
11
       end my_function;
12
    end my_package;
13
14
15
```

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

```
____
```

ıvıajor

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)**

```
1
    create or replace package body my_package is
 2
       function my_function (in_value in pls_integer) return boolean is
 3
          k_yes constant pls_integer := 1;
       begin
 4
          if in_value = k_yes then
 5
             return true;
 6
          else
 7
            return false;
 8
          end if;
 9
       end my_function;
    end my_package;
10
11
12
```

### **EXAMPLE (BETTER)**

```
create or replace package body my_package is
 2
       function my_function (in_value in pls_integer) return boolean is
 3
          k_yes constant pls_integer := 1;
          1_ret boolean;
 4
       begin
 5
          if in_value = k_yes then
 6
             1_ret := true;
 7
          else
 8
             1_ret := false;
 9
          end if;
10
          return l_ret;
11
       end my_function;
12
    end my_package;
13
14
15
```

# EXAMPLE (GOOD)

```
1 create or replace package body my_package is
2    function my_function (in_value in pls_integer) return boolean is
3    k_yes constant pls_integer := 1;
4    begin
5     return in_value = k_yes;
6    end my_function;
6    end my_package;
7    /
8
```

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



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.

```
create or replace package body my_package is
2
      function my_function (out_date out date) return boolean is
3
         out_date := sysdate;
4
         return true;
5
      end my_function;
6
   end my_package;
7
8
EXAMPLE (GOOD)
1
   create or replace package body my_package is
2
      function my_function return date is
3
      begin
         return sysdate;
4
      end my_function;
5
```

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

```
Major

Reliability, Testability
```

#### REASON

6 7

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

# **EXAMPLE (BAD)**

end my\_package;

```
1    create or replace package body my_package is
2      function my_function return boolean is
3      begin
4      return null;
5      end my_function;
end my_package;
7      //
```

## **EXAMPLE (GOOD)**

```
1  create or replace package body my_package is
2  function my_function return boolean is
3  begin
4  return true;
5  end my_function;
6  end my_package;
7
```

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

```
Major

Efficiency
```

### 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
2
      function name_by_id (in_department_id in departments.department_id%type)
3
         return departments.department_name%type;
   end department_api;
4
5
EXAMPLE (GOOD)
1
   create or replace package department_api is
2
      function name_by_id (in_department_id in departments.department_id%type)
3
         return departments.department_name%type deterministic;
   end department_api;
4
5
```

# **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)

```
1  declare
2    k_hello_world constant string(11 char) := 'Hello World';
3  begin
4    dbms_output.put_line(k_hello_world);
5  end;
6  /

EXAMPLE (GOOD)
```

```
1  declare
2    k_hello_world constant string(11 char) := 'Hello World';
3  begin
4    sys.dbms_output.put_line(k_hello_world);
5  end;
6  /
```

# **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.

Note that the example below is an anti-pattern as Flashback Data Archive should be used for row history instead of history tables.

### **EXAMPLE (BAD)**

```
create or replace trigger dept_br_u
 2
    before update on department for each row
 3
    begin
        insert into department_hist (department_id
 4
                                      , \verb"department_name"
 5
                                      ,manager_id
 6
                                      ,location_id
 7
                                      , modification_date)
 8
             values (:old.department_id
 9
                    ,:old.department_name
                    ,:old.manager_id
10
                    ,:old.location_id
11
                    ,sysdate);
12
    end;
13
    create or replace trigger dept_hist_br_i
14
    before insert on department_hist for each row
15
    begin
16
        insert into department_log (department_id
17
                                     ,department_name
18
                                     ,modification_date)
19
                             values (:new.department_id
                                     ,:new.department_name
20
                                     ,sysdate);
21
    end;
22
23
24
25
26
```

## **EXAMPLE (GOOD)**

Note: Again, don't use triggers to maintain history, use Flashback Data Archive instead.

```
create or replace trigger dept_br_u
 2
    before update on department for each row
 3
       insert into department_hist (department_id
 4
                                      ,department_name
 5
                                      ,manager_id
 6
                                      ,location_id
 7
                                      , modification_date)
 8
            values (:old.department_id
 9
                    ,:old.department_name
                    ,:old.manager_id
10
                    ,:old.location_id
11
                    , sysdate);
12
13
       insert into department_log (department_id
14
                                     ,department_name
                                     ,modification_date)
15
                             values (:old.department_id
16
                                    ,:old.department_name
17
                                    ,sysdate);
18
19
    end;
20
21
22
23
```

# G-7720: Avoid triggers for business logic



Efficiency, Maintainability

# REASON

When business logic is part of a trigger, it becomes obfuscated. In general, maintainers don't look for code in a trigger. More importantly, if the code on the trigger does SQL or worse PL/SQL access, this becomes a context switch or even a nested loop that could significantly affect performance.

### G-7730: If using triggers, use compound triggers



Efficiency, Maintainability

### REASON

A single trigger is better than several

### **EXAMPLE (BAD)**

```
1
    create or replace trigger dept_i_trg
 2
    before insert
 3
   on dept
    for each row
 4
    begin
 5
      :new.id = dept_seq.nextval;
 6
      :new.created_on := sysdate;
 7
      :new.created_by := sys_context('userenv', 'session_user');
 8
   end;
 9
    create or replace trigger dept_u_trg
10
    before update
11
    on dept
12
    for each row
13
    begin
14
      :new.updated_on := sysdate;
      :new.updated_by := sys_context('userenv','session_user');
15
    end;
16
17
18
19
```

# EXAMPLE (GOOD)

```
create or replace trigger dept_ui_trg
 2
    before insert or update
 3
   on dept
 4
   for each row
   begin
 5
      if inserting then
 6
        :new.id = dept_seq.nextval;
 7
        :new.created_on := sysdate;
 8
        :new.created_by := sys_context('userenv', 'session_user');
 9
      elsif updating then
        :new.updated_on := sysdate;
10
         :new.updated_by := sys_context('userenv', 'session_user');
11
      end if;
12
    end;
13
14
15
```

# Sequences



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)**

```
1
   declare
2
      1_sequence_number employees.emloyee_id%type;
3
   begin
      select employees_seq.nextval
4
        into l_sequence_number
5
        from dual;
6
   end;
7
8
```

# **EXAMPLE (GOOD)**

```
1
   declare
2
      l_sequence_number employees.emloyee_id%type;
3
      1_sequence_number := employees_seq.nextval;
4
5
   end;
6
```

# **Patterns**

Checking the Number of Rows

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



Major

# 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. This could have a big performance impact.

If we do a select count(\*) where rownum = 1 there is also some overhead as there are two context switches between the PL/SQL and SQL engines.

See the following example for a better solution.

# **EXAMPLE (BAD)**

```
1
    declare
 2
       l_count pls_integer;
 3
       k_zero constant simple_integer := 0;
       k_salary constant employee.salary%type := 5000;
 4
    begin
 5
       select count(*)
 6
         into l_count
 7
        from employee
 8
        where salary < k_salary;
 9
       if l_{count} > k_{zero} then
           <<emp_loop>>
10
```

```
for r_emp in (select employee_id
11
                            from employee)
12
           loop
13
               if r_{emp.salary} < k_{salary} then
14
                 my_package.my_proc(in_employee_id => r_emp.employee_id);
               end if;
15
           end loop emp_loop;
16
         end if;
17
    end;
18
19
20
21
EXAMPLE (GOOD)
 1
    declare
 2
       k_salary constant employee.salary%type := 5000;
 3
    begin
         <<emp_loop>>
 4
         for r_{emp} in (select e1.employee_id
 5
                         from employee e1
 6
                        where exists(select e2.salary
 7
                                       from employee e2
 8
                                       where e2.salary < k_salary))
 9
           my_package.my_proc(in_employee_id => r_emp.employee_id);
10
        end loop emp_loop;
11
    end;
12
13
14
```

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



### 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
 2
       procedure ins (in_r_department in department%rowtype) is
 3
          l_count pls_integer;
 4
       begin
          select count(*)
 5
            into l_count
 6
            from department
 7
           where department_id = in_r_department.department_id;
 8
           if l_{count} = 0 then
 9
              insert into department
10
                    values in_r_department;
11
           end if;
12
       end ins;
13
    end department_api;
14
15
16
```

```
create or replace package body department_ap1 is
2
       procedure ins (in_r_department in department%rowtype) is
3
       begin
          insert into department
4
               values in_r_department;
5
6
         when dup_val_on_index then null; -- handle exception
7
       end ins;
8
    end department_api;
9
10
```

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)**

```
1
    declare
2
       1_product_name oe.product.product_name%type;
 3
       k_price constant oe.product.list_price%type := 1000;
    begin
 4
       select product_name
 5
         into l_product_name
 6
         from oe.product
 7
        where list_price > k_price;
 8
    exception
 9
       when no_data_found then
         null; -- handle_no_data_found;
10
       when too_many_rows then
11
          null; -- handle_too_many_rows;
12
    end:
13
14
15
```

```
create synonym oe_product for oe.product;
 2
 3
       1_product_name oe_product.product_name%type;
 4
       k_price constant oe_product.list_price%type := 1000;
 5
    begin
 6
       select product_name
 7
         into l_product_name
 8
         from oe_product
 9
        where list_price > k_price;
    exception
10
       when no\_data\_found then
11
          null; -- handle_no_data_found;
12
       when too_many_rows then
13
          null; -- handle_too_many_rows;
14
    end:
15
16
```

# 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 department.department_name%type)
 3
          return department%rowtype is
 4
          1_return department%rowtype;
       begin
 5
                 in_dept_name is null
           if
 6
              or length(in_dept_name) > 20
 7
           then
 8
              raise err.e_param_to_large;
 9
           end if;
           -- get the department by name
10
           select *
11
            from department
12
            where department_name = in_dept_name;
13
14
           return l_return;
       end dept_by_name;
15
    end department_api;
16
17
18
19
```

# **EXAMPLE (GOOD)**

```
create or replace package body department_api is
 2
       function dept_by_name (in_dept_name in department.department_name%type)
 3
          return department%rowtype is
          1_dept_name department.department_name%type not null := in_dept_name;
 4
          1_return department%rowtype;
 5
 6
           -- get the department by name
 7
           select *
 8
             from department
 9
            where department_name = l_dept_name;
10
           return l_return;
11
       end dept_by_name;
12
    end department_api;
13
14
15
```

### **FUNCTION CALL**

```
1 ...
2    r_deparment := department_api.dept_by_name('Far to long name of a
3    department');
4    ...
5    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)**

```
1
    /* bad example */
 2
    create or replace package body lock_up is
 3
       -- manage locks in a dedicated table created as follows:
            create table app_locks (
 4
               lock_name varchar2(128 char) not null primary key
 5
 6
 7
       procedure request_lock (in_lock_name in varchar2) is
 8
 9
          -- raises dup_val_on_index
          insert into app_locks (lock_name) values (in_lock_name);
10
       end request_lock;
11
12
       procedure release_lock(in_lock_name in varchar2) is
13
14
          delete from app_locks where lock_name = in_lock_name;
       end release_lock;
15
    end lock_up;
16
17
18
    /* call bad example */
19
    declare
       k_lock_name constant varchar2(30 char) := 'APPLICATION_LOCK';
20
    begin
21
       lock_up.request_lock(in_lock_name => k_lock_name);
22
        -- processing
23
       lock_up.release_lock(in_lock_handle => l_handle);
24
    exception
25
       when others then
          -- log error
26
          lock_up.release_lock(in_lock_handle => l_handle);
27
28
    end;
29
30
31
32
33
34
```

```
1  /* good example */
2  create or replace package body lock_up is
3  function request_lock(
4  in_lock_name in varchar2,
5  in_release_on_commit in boolean := false)
6  return varchar2 is
7  l_lock_handle varchar2(128 char);
begin
```

```
8
          sys.dbms_lock.allocate_unique(
                          => in_lock_name,
 9
             lockname
             lockhandle
                             => l_lock_handle,
10
             expiration_secs => constants.k_one_week
11
12
          if sys.dbms_lock.request(
13
                                => l_lock_handle,
                lockhandle
14
                lockmode
                                  => sys.dbms_lock.x_mode,
                                  => sys.dbms_lock.maxwait,
                timeout
15
                release_on_commit => coalesce(in_release_on_commit, false)
16
             ) > 0
17
          then
18
             raise errors.e_lock_request_failed;
19
          end if:
          return l_lock_handle;
20
       end request_lock;
21
22
       procedure release_lock(in_lock_handle in varchar2) is
23
24
          if sys.dbms_lock.release(lockhandle => in_lock_handle) > 0 then
25
             raise errors.e_lock_request_failed;
          end if;
26
       end release_lock;
27
    end lock_up;
28
29
30
    /* Call good example */
    declare
31
       1_handle varchar2(128 char);
32
       k_lock_name constant varchar2(30 char) := 'APPLICATION_LOCK';
33
    begin
34
       1_handle := lock_up.request_lock(in_lock_name => k_lock_name);
35
       -- processing
36
       lock_up.release_lock(in_lock_handle => l_handle);
    exception
37
       when others then
38
            - log error
39
          lock_up.release_lock(in_lock_handle => l_handle);
40
          raise;
41
    end:
42
43
44
45
46
47
48
49
```

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)**

```
create or replace package body employee_api is
procedure process_emps is
begin
cemployees>>
for emp_rec in (select employee_id
from employee
```

```
7 loop
8 null; -- some processing
9 end loop employees;
10 end process_emps;
11 end employee_api;
12
13
```

### **EXAMPLE (GOOD)**

```
create or replace package body employee_api is
 2
       procedure process_emps is
 3
       begin
          sys.dbms_application_info.set_module(module_name => $$plsql_unit
 4
                                               ,action_name => 'init');
 5
          <<employees>>
 6
          for emp_rec in (select employee_id
 7
                            from employee
 8
                            order by employee_id)
 9
             sys.dbms_application_info.set_action('processing ' || emp_rec.employee_id);
10
          end loop employees;
11
       end process_emps;
12
    end employee_api;
13
14
15
```

# 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:

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

Precheck

Developers should complete the following checklist prior to requesting a peer code review.

- Can I answer "Yes" to each of these questions?
- Did I take time to think about what I wanted to do before doing it?
- · Would I pay for this?
- Can I defend my work / decisions I made?
- NO sloppiness.
- Code is well formatted.
- Code is not duplicated in multiple places.
- Named variables.
- Tables have foreign keys (and associated indexes)...
- Run the APEX Advisor (if using APEX).
- Code is well commented.
- Package specs includes a description of what the procedure does and what the input variables represent.
- Package body includes comments throughout the code to indicate what is happening.
- The application includes end user help.