Dynamic SQL in a Dynamic World

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NYOUG

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The Truth… let’s be fair…

- I’ve never seen:
  - 100% perfect analysis
  - 100% complete set of requirements
  - 100% adequate hardware

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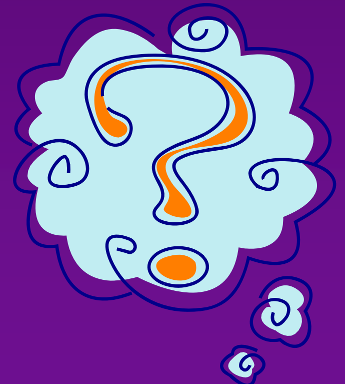
Unknowns

- What elements are involved?
- What do you do with the elements you have?
- How you should proceed?
- Do you know whether or not you can proceed?



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The Hero

- Dynamic SQL:
  - Makes it possible to build and process complete SQL and PL/SQL statements as strings at runtime.

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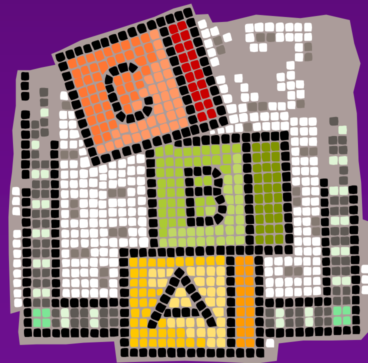
Yes, but…

- I’ve never seen:
  - 100% perfect analysis
  - 100% complete set of requirements
  - 100% adequate hardware
  - 100% avoidance of Murphy's Law:

IF SOMETHING CAN BE MISUSED IT WILL BE MISUSED!!!

Back to Basics:
What are we talking about?



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Dynamic SQL & PL/SQL

- What does "dynamic" mean?
  - Build a text string on the fly and execute it
  - Very powerful technique
  - Useful in many contexts
- What techniques exist?
  - EXECUTE IMMEDIATE
  - Dynamic cursors
  - DBMS_SQL

Dynamic SQL Core

- About 90% of dynamic SQL is covered by a single command (with variations):

```
declare
   v_variable_tx varchar2(32000);
begin
   v_variable_tx:='whatever_you_want';
   EXECUTE IMMEDIATE v_variable_tx;
end;
```

OR

```
begin
   EXECUTE IMMEDIATE 'whatever_you_want';
end;
```

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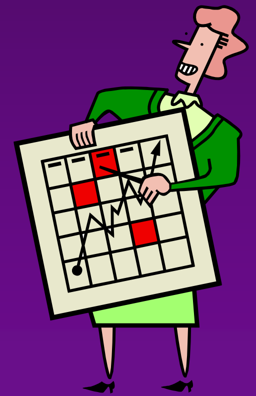
Dynamic Cursors

- Syntax

```
declare
    v_cur SYS_REFCURSOR;
    v_sql_tx varchar2(32000):=...
    v_rec ...%rowtype; -- or record type
begin
    open v_cur for v_sql_tx;
    fetch v_cur into v_rec;
    close v_cur;
end;
```



- Most common use:
  - Processing large datasets with unknown structure

DBMS_SQL package

Predecessor of native dynamic SQL

- Pros:
  - Goes above 32K in all versions
  - Separates PARSE and EXECUTE
    - The same query can be reused with different bind variables.
  - Works with unknown number/type of INPUT/OUTPUT values
- Cons:
  - Significantly slower (up to 5 times)
  - No user-defined datatypes or output to the record
  - More difficult to use

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Things to know (1)

- The code can be passed as a variable/string.
- The variable/string cannot exceed 32K, except
  - In 11*g* – passing CLOB as input
  - If the database is using fonts where 1 byte=1 char –up to 64K when concatenate a number of strings:

```
execute immediate
  v1_txt||v2_txt||v3_txt||…;
```

  - In 8*i* and below – no limit on concatenation (undocumented feature - not supported by Oracle!)

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Things to know (2)

- The variable/string can contain bind variables
  - Start with a colon (:)
  - Placeholders for values that will be supplied at runtime (USING and RETURNING clauses)
  - No validation when compiled
    - No check for datatypes
    - No check for passing enough values
  - No direct limit on the number of bind variables.
  - Like any other variables, they may be IN (default), OUT, or IN/OUT

Things to know (3)

- Bind variables are limited:
  - CAN only be used to supply values to be passed to the code
  - CANNOT be used to define the structural elements of queries or PL/SQL blocks.
- Special cases:
  - You cannot pass NULL as a literal.
  - If statement has a RETURNING clause, it should also be used in dynamic SQL.
- Bind variables may or may not be reusable.
  - ARE NOT reusable in dynamic SQL – the number of variables is equal to the number of parameters.
  - ARE reusable in dynamic PL/SQL – the number of UNIQUE variables is equal to the number of parameters.

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!!!REMEMBER!!!

- 1. Use bind variables
- 2. Use bind variables
- 3. Use bind variables
- 4. Use bind variables
- 5. Use bind variables
- 6. Use bind variables
- 7. Use bind variables

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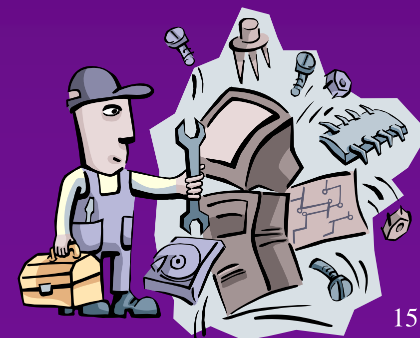
Nightmare of SOX auditor (1)

```
function F_GET_col_TX
 (i_table_tx,i_showcol_tx,i_pkcol_tx,i_pkValue_nr)
return varchar2 is
  v_out_tx varchar2(4000);
  v_sql_tx varchar2(32000);
Begin
  v_sql_tx:=
      'select to_char('||i_showcol_tx||')'||
      ' from '||i_table_tx||
      ' where '||i_pkcol_tx||'=:v01';
  EXECUTE IMMEDIATE v_sql_tx INTO v_out_tx
  USING i_pkValue_nr;

   return v_out_tx;
end;
```



Security

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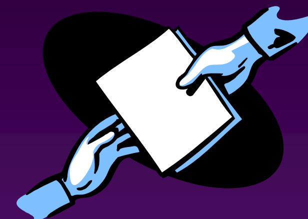
Security Concerns

- What privileges do you need to use dynamic SQL?
- How can you guard against misuse of dynamic SQL?

Granting Privileges (1)

- All privileges have to be granted explicitly (Not via ROLES):
  - System privileges



```
create or replace procedure p_makeTable
  (i_name_tx varchar2) is
begin
  execute immediate 'create table '
  ||i_name_tx||' (a_tx varchar2(256))';
end;
```

  - GRANT DBA to SCOTT … wrong!!!
  - GRANT CREATE TABLE to SCOTT – correct!

Granting Privileges (2)

- Object privileges

```
function f_getCount_nr (i_user_tx varchar2,
  i_table_tx varchar2) return number is
begin
  execute immediate 'select count(*) from '
  ||i_user_tx||'.'||i_table_tx;
end;
```

  - GRANT DBA to SCOTT … wrong!!!
  - GRANT SELECT on EMPLOYEE to SCOTT – correct!

Fighting Code Injections

- DBA protection
  - End users should not see administration tools
- UI protection
  - User input should always be passed via bind variables (no concatenation!)
    - Bind variables cannot affect the structure of the query.
  - All structural selections should be made from the limited list of options (repository)
    - Power users/developers populate the repository.
    - End users only access whatever is already in the repository.

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Use Case

- The problem:
  - Large number of requests from the user interface
    - Take some number of parameters
    - Return something (search, extra info, status, etc.)
  - The whole set of requests is not clear and may change each time.
- The solution:
  - Universal wrapper
    - Process all requests dynamically

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Storage (1)

- Single table for both UI and server:

```
create table t_extra_ui
(id_nr number primary key,
 displayName_tx varchar2(256),
 function_tx    varchar2(50),
 v1_label_tx    varchar2(100),
 v1_type_tx     varchar2(50),
 v1_required_yn varchar2(1),
 v1_lov_tx      varchar2(50),
 v1_convert_tx   varchar2(50),
  ... )
```

- Example:

```
insert into t_extra_ui (…)
values (1, 'Filter Employees', 'f_getEmp_cl',
       'Job','TEXT','N',null,null)
```

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Storage (2)

- Published function
  - **ID_NR** – unique ID of the function
  - **DisplayName_tx** – header of the screen
    - ID and display are shown to users as LOV
  - **Function_tx** – real function to be called

- Parameters (never needed more than 10)
  - **Vx_Label_tx** – label for the parameter
    - if null – parameter is disabled
  - **Vx_Type_tx** – helps UI to build the screen – can be:
    - LOV – value list
    - TEXT – free text
    - DATE – attached calendar is needed
  - **Vx_Required_yn** – helps UI enforce needed parameters
  - **Vx_LOV_tx** –name of the corresponding value list
  - **Vx_Convert_Tx** – any expression with one input
    - Example - 'to_date(:1, "YYYYMMDD")' – transformation to the real date
    - Should always use bind variable with correct ID

The Registered Function

```
function f_getEmp_CL (i_job_tx varchar2) return CLOB is
  v_out_cl CLOB;
  procedure p_add(pi_tx varchar2) is
  begin
    dbms_lob.writeappend(v_out_cl,length(pi_tx),pi_tx);
  end;
begin
  dbms_lob.createtemporary(v_out_cl,true,dbms_lob.call);
  p_add('<html><table>');
  for c in (select '<tr>'||'<td>'||empno||'</td>'||
                           '<td>'||ename||'</td>'||
                   '</tr>' row_tx
            from emp where job = i_job_tx)
  loop
      p_add(c.row_tx);
  end loop;
  p_add('</table></html>');
  return v_out_cl;
end;
```

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The Wrapper (1)

```
function f_wrapper_cl (i_id_nr,
  v1_tx varchar2:=null,...,v5_tx varchar2:=null)
return CLOB is
  v_out_cl CLOB;
  v_sql_tx varchar2(2000);
  v_rec t_extra_ui%rowtype;
begin
  select * into v_rec from t_extra_ui where id_nr=i_id_nr;

  if v_rec.v1_label_tx is not null then
    v_sql_tx:=nvl(v_rec.v1_convert_tx,':1');
  end if;
  ...
  if v_rec.v5_label_tx is not null then
    v_sql_tx:=v_sql_tx||','||
       nvl(v_rec.v5_convert_tx,':5');
  end if;
```

The Wrapper (2)

```
v_sql_tx:=
 'begin :out:='||v_rec.function_tx||
               '('||v_sql_tx||'); end;';

if v5_tx is not null then
  execute immediate v_sql_tx
    using out v_out_cl, v1_tx,…,v5_tx;
...
elsif v1_tx is not null then
  execute immediate v_sql_tx
    using out v_out_cl, v1_tx;
else
  execute immediate v_sql_tx using out v_out_cl;
end if;

return v_out_cl;
end;
```

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11*g* – Critical Addition

- DBMS_ASSERT – validating strings:
  - SQL_OBJECT_NAME (string) – checks whether or not string is a valid object
  - SIMPLE _SQL_NAME – checks whether or not string is a valid SQL name
  - SCHEMA_NAME – validate that passed string is a valid schema
  - ENQUOTE_NAME – add a second quote to every instance in the name (and double quotes around)
  - ENQOUTE_LITERAL – add single quotes

Exists in 10g – but not documented!!!

Nightmare of SOX auditor (2)

```
function F_GET_col_TX
 (i_table_tx,i_showcol_tx,i_pk_tx,i_pkValue_nr)
return varchar2 is
  v_out_tx varchar2(4000);
  v_sql_tx varchar2(32000);
Begin
   v_sql_tx:=
      'select to_char('||i_showcol_tx||') from '||
    dbms_assert.simple_sql_name(i_table_tx)||
      ' where '||
    dbms_assert.simple_sql_name(i_pk_tx)||
          ||'=:v01';
  EXECUTE IMMEDIATE v_sql_tx INTO v_out_tx
  USING i_pkValue_nr;
  return v_out_tx;
end;
```

Object Dependencies

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Critical point

Dynamic SQL is executed at runtime, therefore:

- Bad things
  - No dependencies to follow up.
  - No way to determine exactly what will be executed.
- Good things
  - You can reference objects that may not be in the database (yet).
  - You have a “back door” to resolve logical dead loops or hide existing dependencies.

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Con#1: No dependencies

- What do to:
  - Use repositories
- How:
  - Populate repositories with required information, structured similarly to that of the Oracle data dictionary
  - Generate from the repository using a straightforward, transparent mechanism (so it is clear what becomes what)
  - Compare Oracle data dictionary with your own

Con#2: What is executed?

- What to do:
  - Use samplers
- How:
  - Generate all possible (or as many as possible) permutations of the code to be executed and create PL/SQL modules with that code.
  - Record all dependencies and keep a simple module that references the same set of objects.
  - If sampler becomes invalid, this means that you have problems.

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Pro#1: Reference non-existing objects

- Objects may not exist.
  - Example: Monthly summary table
- Object may be referencing DBlink with a different maintenance cycle.
  - Example: Remote database may be down when you need to recompile a dependent object

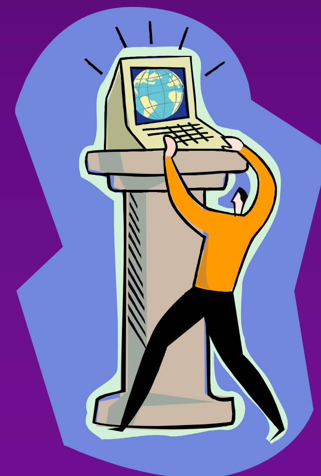
Pro#2: Invalidation issues

- Code generators:
  - Wrap call of generated modules into dynamic SQL
    - Then you can refresh them without invalidating all dependencies
- Logical loops:
  - Sometimes the simplest way out of the dependencies loop is to convert one of the calls to dynamic SQL

Bulk Operations

Supported Features

- Native Dynamic SQL supports object collections and all kinds of operations on object collections:
  - FORALL (Currently only in USING clause)
  - BULK COLLECT
- DBMS_SQL supports only arrays as bulk list of bind variables
  - Fixed in 11*g*!



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FORALL

- FORALL – with limitations:
  - In USING clause:
    - Right:

```
forall i in dept.first..dept.last
execute immediate
'delete from emp where deptno=:1'using dept(i);
```

- Wrong:

```
forall i in dept.first..dept.last
execute immediate 'drop table t_'||dept(i);
```

- The whole object only (fixed in 11*g*!)
  - Right - **dept(i)**
  - Wront - **dept(i).deptno**

BULK COLLECT

- Syntax:

```
EXECUTE IMMEDIATE ...
  BULK COLLECT INTO v_collect_tt;
```

- Major advantage
  - Even Dynamic SQL does not support any PL/SQL datatypes.
    - You can use RECORD as an output of a dynamic query.
  - Dynamic SQL does support all user-defined SQL datatypes.

And everybody forgets…

- Constructor should be used INSIDE of Dynamic SQL

```
type lov_oty is object (id_nr …, disp_tx…);
type lov_nt as table of lov_oty;

function f_getLov_nt
  (i_table_tx,i_id_tx,i_disp_tx)
return lov_nt is
  v_out_nt lov_nt := lov_nt();
begin
  execute immediate 'select lov_oty('
        ||i_id_tx||','||i_disp_tx||')'||
   ' from '||i_table_tx
  bulk collect into v_out_nt;
  return v_out_nt;
end;
```

Transformation of cursors for DBMS_SQL

11*g* Additions

- Conversion between REF_CURSOR and DBMS_SQL cursor
  - DBMS_SQL.TO_REFCURSOR
  - DBMS_SQL.TO_CURSOR_NUMBER

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Explaining REF Cursor

- The problem:
  - A lot of REF Cursors in the system with no clear way of figuring out what exactly they are
- The solution:
  - Generic routine to describe REF Cursor with minimal impact on the system

Explaining REF Cursor (2)

```
procedure p_expCursor
  (io_ref_cur IN OUT SYS_REFCURSOR) is
    v_cur       integer := dbms_sql.open_cursor;
    v_cols_nr number := 0;
    v_cols_tt dbms_sql.desc_tab;
begin
  v_cur:=dbms_sql.to_cursor_number(io_ref_cur);
  DBMS_SQL.describe_columns
      (v_cur, v_cols_nr, v_cols_tt);
    for i in 1 .. v_cols_nr loop
       dbms_output.put_line
            (v_cols_tt (i).col_name);
    end loop;
  io_ref_cur:=dbms_sql.to_refcursor(v_cur);
end;
```

Performance and Resource Utilization

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Keep in mind (Very Important!)

- EXECUTE IMMEDIATE and dynamic cursors:
  - If you use bind variables – 1 hard + N soft parses
  - If you don't use bind variables – N hard parses
- DBMS_SQL – the same plus:
  - Extra option – only 1 parse

Use Case

- The problem:
  - Users upload CSV-files
    - Name of file defines type
    - Column headers map directly to table columns
    - 1 row of file = 1 logical group (1..N real rows)
    - Group-level validation
- The solution:
  - Universal CSV-loader
    - Build all inserts on the fly

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Build Inserts

```
Declare
  type integer_tt is table of integer;
  v_cur_tt integer_tt;
Begin
for r in v_groupRow_tt.first..v_groupRow_tt.last loop
  v_cur_tt(r):=DBMS_SQL.OPEN_CURSOR;
  for c in c_cols(v_mapRows_tt(r)) loop
    for i in v_header_tt.first..v_header_tt.last loop
      if v_header_tt(i).text=c.name_tx then
        v_col_tt(i):=c;
        v_col_tx:=v_col_tx||','||v_col_tt(i).viewcol_tx;
        v_val_tx:=v_val_tx||',:'||v_col_tt(i).viewcol_tx;
      end if;
    end loop;
  end loop;
  v_sql_tx:='insert into '||v_map_rec.view_tx||
     '('||v_col_tx||') values('||v_value_tx||')';
  DBMS_SQL.PARSE(v_cur_tt(r),v_sql_tx,DBMS_SQL.NATIVE);
end loop;
```

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Process Data

```
for i in 2..v_row_tt.count
loop
  for r in
  v_groupRow_tt.first..v_groupRow_tt.last
  loop
    for c in v_col_tt.first..v_col_tt.last
    loop
      if v_col_tt(c).id  = v_mapRows_tt(r) then
        DBMS_SQL.BIND_VARIABLE(v_cur_tt(r),
         ':'||v_col_tt(c).viewcol_tx,
         v_data_tt(c).text);
      end if;
    end loop;
    v_nr:=dbms_sql.execute(v_cur_tt(r));
  end loop;
end loop;
```

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Best Practices

- Whenever possible:
  - Use BULK operations
  - Minimize parsing
  - Use bind variables
- Options to consider:
  - Build a code repository
  - Use generated code

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Summary

- Dynamic SQL does:
  - Significantly extend the list of available options for resolving many problems
  - Provide extra maneuvering room in production environments
- Dynamic SQL should NOT:
  - be considered a substitute for good analysis
  - be used where “regular” solutions are valid

Contact Information

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Latest book:
Oracle PL/SQL for Dummies