WELCOME

Extending the Oracle Data Dictionary for Fine-Grained PL/SQL and SQL Analysis

ODTUG Kscope13

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About Me

- With Trivadis since April 2000
  - Senior Principal Consultant
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- Main focus on database centric development with Oracle DB
  - Application Development
  - Business Intelligence
  - Application Performance Management
- Over 20 years experience in using Oracle products

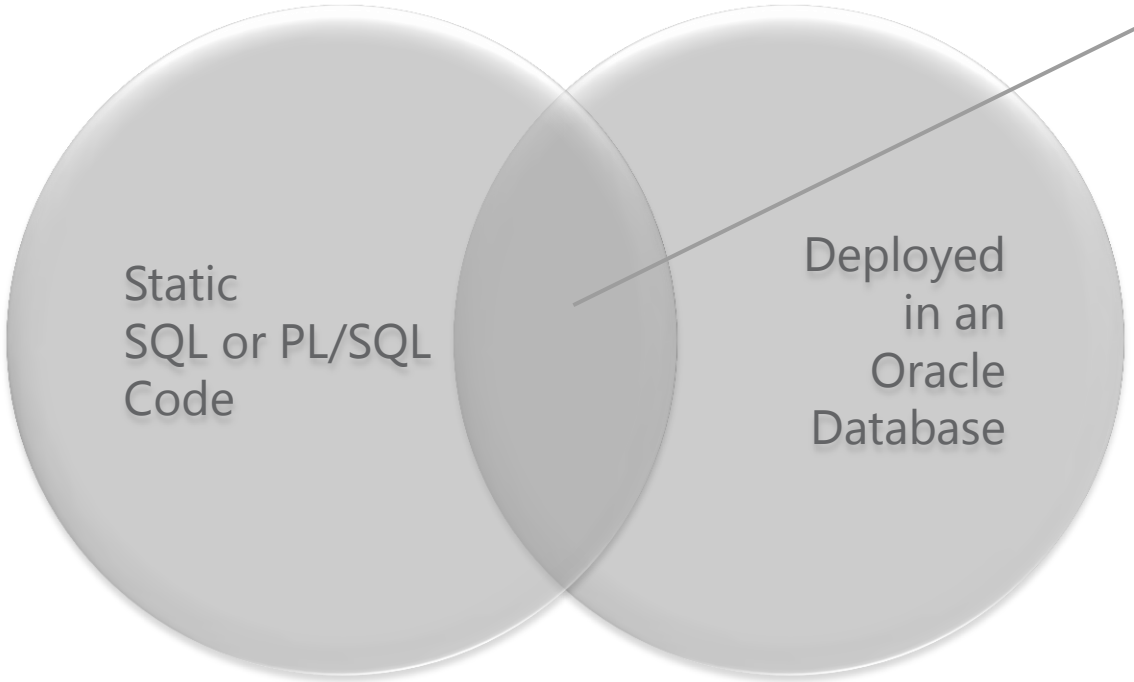
AGENDA

1. Introduction to PL/SQL and SQL Analysis using Oracle Data Dictionary
2. Extending the Oracle Data Dictionary
3. Analysis #1 – SQL Statements using Hints
4. Analysis #2 – Tables, Views used in Queries
5. Analysis #3 – Tables, Views used in DML Statements
6. Analysis #4 – Views exposing specific Table Column
7. Analyzing Dynamic PL/SQL and SQL
8. Core Messages

Reasons for PL/SQL and SQL (Dependency) Analysis

- Evaluate the impact of a change
  - E.g. impact of data model amendments
  - E.g. impact of PL/SQL source code amendments
- Understand the impact of a deployment or recompilation
  - E.g. invalidated objects, requested locks at deployment time
- Understand an application better
  - E.g. after ownership change
- Ensure standards are met
  - E.g. querying or changing tables through a defined API only

Primary Scope



Scope for Oracle Dictionary based Dependency Analysis

- Function
- Procedure
- Package Spec/Body
- Trigger
- Type Spec/Body
- View
- Table

Oracle Data Dictionary Views

before Oracle 11g Release 1

- DBA_DEPENDENCIES
- DBA_SOURCE
- DBA_PROCEDURES
- DBA_ARGUMENTS
- DBA_TYPES
- DBA_TYPE_METHODS
- DBA_TRIGGERS
- DBA_VIEWS
- DBA_TABLES
- …

Oracle 11g Release 1 and newer

- DBA_IDENTIFIERS

```
-- enable PL/SCOPE for a session
ALTER SESSION SET PLSCOPE_SETTINGS =
  'IDENTIFIERS:ALL';

-- enable PL/SCOPE system wide
ALTER SYSTEM SET PLSCOPE_SETTINGS =
  'IDENTIFIERS:ALL' SCOPE = BOTH;

-- recompile PL/SQL objects to
-- populate PL/SCOPE dictionary
…
```

Oracle Data Dictionary Granularity vs. Analysis Needs

DBA_DEPENDENCIES

- Object (Table, View, Package, Package Body, …)
- Internally there's more, but not exposed,
  see Rob van Wijk's post about DBA_DEPENDENCY_COLUMNS
  http://rwijk.blogspot.com/2008/10/dbadependencycolumns.html

DBA_IDENTIFIERS

- PL/SQL identifier (variable, function, …) with usage (call, reference, …)
- Context as hierarchy of usage_id (usage_context_id = parent)
- But no support for SQL (Select, Insert, Update, Delete, Merge)

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Guidelines for SQL and PL/SQL Analysis

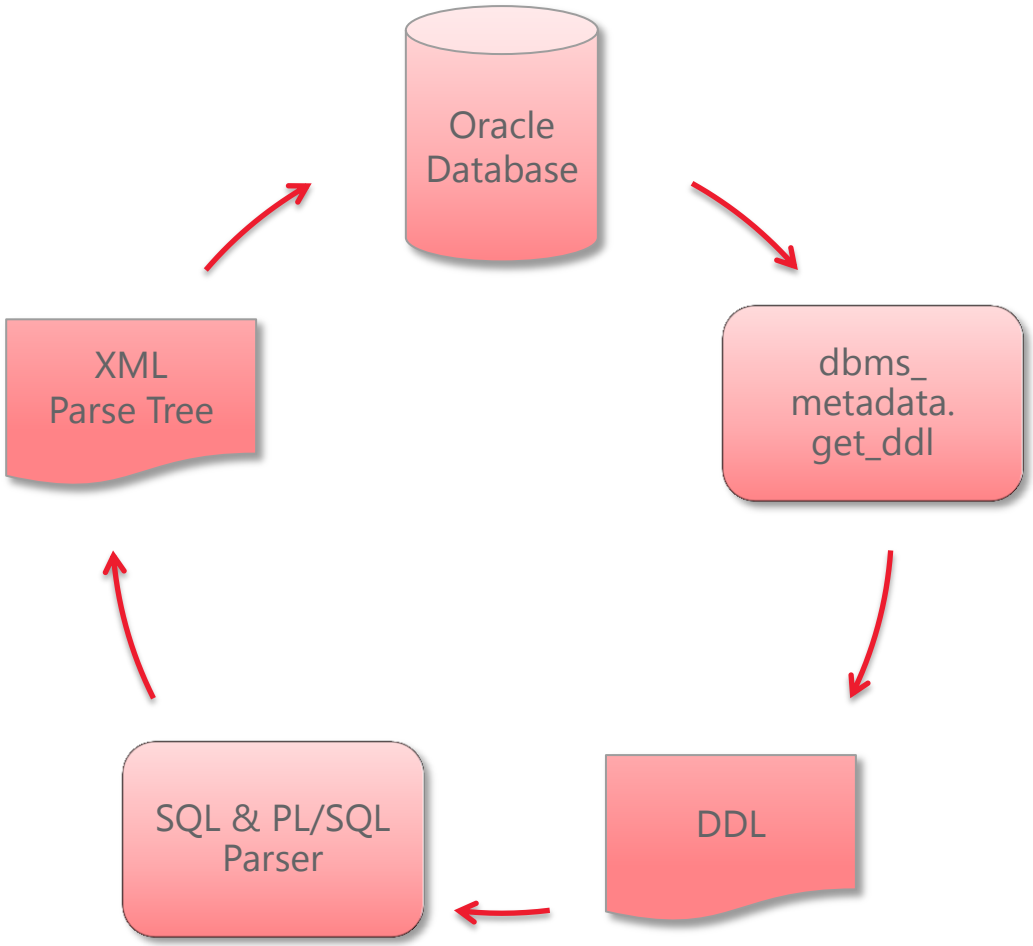
Apply the guidelines in the given priority:

1. Use DBA_DEPENDENCIES if feasible
2. Use other data dictionary views and combine them
3. Use PL/Scope if feasible
4. Create the DBA_DEPENDENCY_COLUMNS view if feasible
   - See http://rwijk.blogspot.com/2008/10/dbadependencycolumns.html
5. Use an Oracle parser if applicable for missing information only
   - E.g. UTL_XML.PARSEQUERY for SELECT statements
6. Use own or 3rd party parser as the last resort for missing information

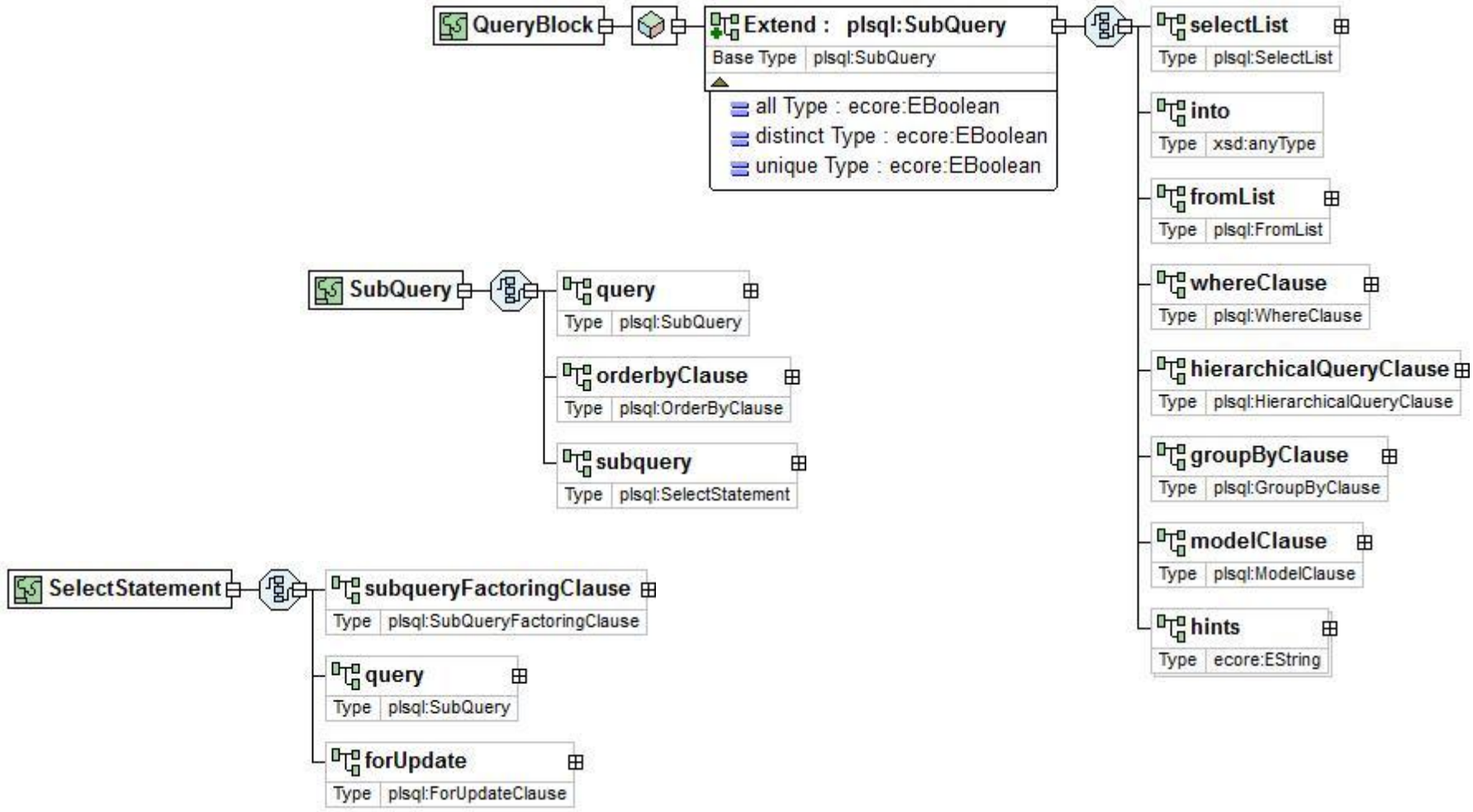
Parsed Objects – Extend Oracle Data Dictionary

```
SQL> desc tvd_parsed_objects_t

Name            Type
--------------- ------------------
OBJECT_ID       NUMBER
OWNER           VARCHAR2(30)
OBJECT_NAME     VARCHAR2(128)
OBJECT_TYPE     VARCHAR2(30)
LAST_DDL_TIME   DATE
DDL_SOURCE      CLOB
PARSE_TREE      XMLTYPE
```



XML Schema / Documentation for XML Parse Tree



Populate and Refresh TVD_PARSED_OBJECTS_T

- Parser in Oracle Database, PL/SQL package to refresh
  - Pro: refresh available to all users via grant, ad-hoc parsing
  - Con: installation is slow and error-prone, inefficient use of DB server resources
- Parser as Web Service, PL/SQL package to refresh
  - Pro: refresh available to all users via grant, ad-hoc parsing
  - Con: needs a application server reachable from the database
- Parser as Standalone Application, OS script to refresh
  - Pro: easy setup, suitable for restricted environments
  - Con: needs access to standalone application for refresh, no ad-hoc parsing

WebService – Produce XML Parse Tree

- Create Web Service in Eclipse using Axis2
  - See http://www.softwareagility.gr/index.php?q=node/29
- Serialize Ecore model to XML (for Xtext grammars only)

```
private String serialize(PLSQLFile plsql) throws IOException {
   URI fileURI = URI.createFileURI("example.xml");
   Resource res = new XMLResourceFactoryImpl().createResource(fileURI);
   ByteOutputStream os = new ByteOutputStream();
   res.getContents().add(plsql);
   res.save(os, null);
   return new String(os.getBytes());
}
```

WebService – Get & Store XML Parse Tree

DEMO

- Use UTL_HTTP to call a web service
  see http://martin-mares.com/2010/08/oracle-db-consume-wsdl-webservice-in-plsql/
- Get Parse Tree from DDL

```
CREATE OR REPLACE PACKAGE tvd_parser_pkg IS
   FUNCTION parse_plsql(p_source_in CLOB) RETURN XMLTYPE;
END tvd_parser_pkg;
/
```

- Refresh TVD_PARSED_OBJECTS_T (according LAST_DDL_TIME)

```
CREATE OR REPLACE PACKAGE tvd_parsed_objects_pkg  authid CURRENT_USER IS
   PROCEDURE refresh(p_owner_in       IN VARCHAR2 DEFAULT NULL,
                     p_object_type_in IN VARCHAR2 DEFAULT NULL,
                     p_object_name_in IN VARCHAR2 DEFAULT NULL);
END tvd_parsed_objects_pkg;
/
```

Standalone Application – Store XML Parse Tree

DEMO

```
$ tvdca.sh user=tvdca password=tvdca host=groemitz sid=phs112 schema=TVDCC

Trivadis PL/SQL & SQL Code Analyzer Version 0.3.4 Beta…

Deleting extinct objects from tvd_parsed_objects_t (cleanup)... 0 rows
deleted.

Refreshing table tvd_parsed_objects_t:
- Reading dba_objects... 0 outdated rows found.

Updating table tvd_captured_sql_t:
- Reading tvd_captured_sql_t... 0 unprocessed rows found.

Refresh completed within 1.365 seconds.
```

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Analysis #1 – SQL Statements using Hints

DEMO

- Usage within Select, Insert, Update, Delete, Merge
  - Consider all query blocks
  - Distinguish between hints and comments
- Example

```
SQL> SELECT object_name, object_type, position, hints, usage
  2    FROM tvd_object_hint_usage_v t
  3   WHERE owner = 'TVDCC';

OBJECT_NAME          OBJECT_TYPE   POSITION HINTS     USAGE
-------------------- ------------ -------- -------- ---------------
TVD_SAMPLE_PACKAGE PACKAGE BODY          1 /*+ a */ DeleteStatement
TVD_SAMPLE_PACKAGE PACKAGE BODY          2 /*+ c */ QueryBlock
TVD_SAMPLE_PACKAGE PACKAGE BODY          3 /*+ b */ InsertStatement
TVD_SAMPLE_PACKAGE PACKAGE BODY          4 /*+ d */ UpdateStatement
TVD_SAMPLE_PACKAGE PACKAGE BODY          5 /*+ e */ MergeStatement
```

Analysis #1 – View TVD_OBJECT_HINT_USAGE_V

DEMO

```
CREATE OR REPLACE VIEW tvd_object_hint_usage_v AS
SELECT /*+ no_xml_query_rewrite */
       tobj.owner,
       tobj.object_name,
       tobj.object_type,
       tab.position,
       tab.hints,
       tab.usage
  FROM tvd_parsed_objects_t tobj,
       XMLTABLE('for $i in //hints
                 where substring($i/text(),3,1) = "+"
                 return <hints
                           usage="{($i/..)/@xsi:type}">{$i/text()}</hints>'
        PASSING tobj.parse_tree
        COLUMNS "HINTS" VARCHAR2(1000) PATH 'text()',
                "USAGE" VARCHAR2(30)   PATH 'substring(@usage,7)',
               position FOR ORDINALITY) tab;
```

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Analysis #2 – Tables, Views used in Queries

DEMO

- Usage within View, Function, Procedure, Trigger, Package Spec/Body, Type Body
  - Consider inner query blocks for subqueries
  - Procedure_name semantics according DBA_PROCEDURES
- Example

```
SQL> SELECT object_type, object_name, position AS pos, procedure_name,
  2         table_owner AS t_own, table_name
  3    FROM tvd_object_query_usage_v t
  4   WHERE owner = 'TVDCC'
  5   ORDER BY object_name, object_type;

OBJECT_TYPE  OBJECT_NAME                POS PROCEDURE_NAME    T_OWN TABLE_NAME
------------ ------------------------ --- ----------------- ----- --------------------
VIEW         TVD_OBJECT_QUERY_USAGE_V   1                         TVD_PARSED_OBJECTS_T
PACKAGE BODY TVD_PARSED_OBJECTS_PKG     1 REFRESH           SYS   DBA_OBJECTS
PACKAGE BODY TVD_PARSED_OBJECTS_PKG     2 REFRESH                 TVD_PARSED_OBJECTS_T
PACKAGE BODY TVD_PARSED_OBJECTS_PKG     3 REFRESH                 DBA_OBJECTS
FUNCTION     TVD_SAMPLE_FUNCTION        1 INNER_PROCEDURE   TVDCC TVD_PARSED_OBJECTS_T
…
```

Analysis #2 – View TVD_OBJECT_QUERY_USAGE_V DEMO

```
CREATE OR REPLACE VIEW tvd_object_query_usage_v AS
SELECT /*+ no_xml_query_rewrite */ tobj.object_id, tobj.owner, tobj.object_type,
       tobj.object_name, 'SELECT' AS operation, tab.position,
       upper(tab.procedure_name) AS procedure_name,
       upper(tab.table_owner) AS table_owner, upper(tab.table_name) AS table_name
  FROM tvd_parsed_objects_t tobj,
       xmltable('for $i in //queryTableExpression[@qteName]
                 let $items := ($i/ancestor::items[
                                not(@xsi:type="plsql:CursorDeclarationOrDefinition")
                                and heading])[position()=last()]
                 let $elements := ($i/ancestor::elements[
                                not(@xsi:type="plsql:TableReference")])[position=last()]
                 let $proc :=  if ($items) then
                                  concat($items/heading/sqlObject/@value,
                                  $items/heading/function/@value)
                               else
                                  concat($elements/function/function/@value,
                                  $elements/procedure/procedure/@value,
                                  $elements/datatype/@value)
return <result table="{$i/@qteName}" schema="{$i/@schema}" proc="{$proc}"/>'
        passing tobj.parse_tree
        columns "TABLE_NAME"  VARCHAR2(30) path '@table',
                "TABLE_OWNER" VARCHAR2(30) path '@schema',
                "PROCEDURE_NAME" VARCHAR2(30) PATH '@proc',
                position FOR ordinality) tab;
```

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Analysis #3 – Tables, Views used in DML Statements

- Usage within Function, Procedure, Trigger, Package Spec/Body, Type Body
  - Consider Insert, Update, Delete, Merge statements
  - Procedure_name semantics according DBA_PROCEDURES
- Example

```
SQL> SELECT object_type, object_name, operation AS op, position AS pos, procedure_name,
  2         table_owner AS t_own, table_name
  3    FROM tvd_object_dml_usage_v t
  4   WHERE owner = 'TVDCC';

OBJECT_TYPE  OBJECT_NAME             OP      POS PROCEDURE_NAME       T_OWN TABLE_NAME
------------ ---------------------- ------ --- -------------------- ----- --------------------
PACKAGE BODY TVD_PARSED_OBJECTS_PKG INSERT   1 REFRESH              TVDCC TVD_PARSED_OBJECTS_T
FUNCTION     TVD_SAMPLE_FUNCTION    INSERT   1 INNER_PROCEDURE     TVDCC TVD_PARSED_OBJECTS_T
FUNCTION     TVD_SAMPLE_FUNCTION    INSERT   2 INNER_FUNCTION      TVDCC TVD_PARSED_OBJECTS_T
FUNCTION     TVD_SAMPLE_FUNCTION    INSERT   3                     TVDCC TVD_PARSED_OBJECTS_T
PACKAGE BODY TVD_SAMPLE_PACKAGE     INSERT   1 MOST_INNER_PROCEDURE TVDCC TVD_PARSED_OBJECTS_T
…
```

Analysis #3 – View TVD_OBJECT_DML_USAGE_V (1)

```
CREATE OR REPLACE VIEW TVD_OBJECT_DML_USAGE_V AS
SELECT /*+ no_xml_query_rewrite */ tobj.object_id,
       tobj.owner,
       tobj.object_type,
       tobj.object_name,
       'INSERT' AS operation,
       tab.position,
       upper(tab.procedure_name) AS procedure_name,
       upper(tab.table_owner) AS table_owner,
       upper(tab.table_name) AS table_name
  FROM tvd_parsed_objects_t tobj,
       xmltable('for $i in //dmlExpressionClause[dmlName/@value
                           and ancestor::statements/@xsi:type="plsql:InsertStatement"]
                 let $items := $i/ancestor::items[1]
                 let $elements := $i/ancestor::elements[1]
                 let $proc := if ($items) then
                                 concat($items/heading/sqlObject/@value,
                                        $items/heading/function/@value)
                              else
                                 concat($elements/function/function/@value,
                                        $elements/procedure/procedure/@value,
                                        $elements/datatype/@value)
            return <result table="{$i/dmlName/@value}" schema="{$i/@schema}" proc="{$proc}"/>'
        passing tobj.parse_tree
        columns "TABLE_NAME"  VARCHAR2(30) path '@table',
                "TABLE_OWNER" VARCHAR2(30) path '@schema',
                "PROCEDURE_NAME" VARCHAR2(30) PATH '@proc',
                position FOR ordinality) tab …
```

Analysis #3 – View TVD_OBJECT_DML_USAGE_V (2)

```
… UNION ALL
SELECT /*+ no_xml_query_rewrite */ tobj.object_id,
       tobj.owner,
       tobj.object_type,
       tobj.object_name,
       'UPDATE' AS operation,
       tab.position,
       upper(tab.procedure_name) AS procedure_name,
       upper(tab.table_owner) AS table_owner,
       upper(tab.table_name) AS table_name
  FROM tvd_parsed_objects_t tobj,
       xmltable('for $i in //dmlTableExpressionClause[dmlName/@value
                            and ancestor::statements/@xsi:type="plsql:UpdateStatement"]
                 let $items := $i/ancestor::items[1]
                 let $elements := $i/ancestor::elements[1]
                 let $proc := if ($items) then
                                 concat($items/heading/sqlObject/@value,
                                        $items/heading/function/@value)
                              else
                                 concat($elements/function/function/@value,
                                        $elements/procedure/procedure/@value,
                                        $elements/datatype/@value)
            return <result table="{$i/dmlName/@value}" schema="{$i/@schema}" proc="{$proc}"/>'
        passing tobj.parse_tree
        columns "TABLE_NAME"  VARCHAR2(30) path '@table',
                "TABLE_OWNER" VARCHAR2(30) path '@schema',
                "PROCEDURE_NAME" VARCHAR2(30) PATH '@proc',
                position FOR ordinality) tab …
```

Analysis #3 – View TVD_OBJECT_DML_USAGE_V (3)

```
… UNION ALL
SELECT /*+ no_xml_query_rewrite */ tobj.object_id,
       tobj.owner,
       tobj.object_type,
       tobj.object_name,
       'DELETE' AS operation,
       tab.position,
       upper(tab.procedure_name) AS procedure_name,
       upper(tab.table_owner) AS table_owner,
       upper(tab.table_name) AS table_name
  FROM tvd_parsed_objects_t tobj,
       xmltable('for $i in //dmlTableExpressionClause[dmlName/@value
                            and ancestor::statements/@xsi:type="plsql:DeleteStatement"]
                 let $items := $i/ancestor::items[1]
                 let $elements := $i/ancestor::elements[1]
                 let $proc := if ($items) then
                                 concat($items/heading/sqlObject/@value,
                                        $items/heading/function/@value)
                              else
                                 concat($elements/function/function/@value,
                                        $elements/procedure/procedure/@value,
                                        $elements/datatype/@value)
            return <result table="{$i/dmlName/@value}" schema="{$i/@schema}" proc="{$proc}"/>'
        passing tobj.parse_tree
        columns "TABLE_NAME"  VARCHAR2(30) path '@table',
                "TABLE_OWNER" VARCHAR2(30) path '@schema',
                "PROCEDURE_NAME" VARCHAR2(30) PATH '@proc',
                position FOR ordinality) tab …
```

Analysis #3 – View TVD_OBJECT_DML_USAGE_V (4)

```
… UNION ALL
SELECT /*+ no_xml_query_rewrite */ tobj.object_id,
       tobj.owner,
       tobj.object_type,
       tobj.object_name,
       'MERGE' AS operation,
       tab.position,
       upper(tab.procedure_name) AS procedure_name,
       upper(tab.table_owner) AS table_owner,
       upper(tab.table_name) AS table_name
  FROM tvd_parsed_objects_t tobj,
       xmltable('for $i in //intoClause[@table
                           and ancestor::statements/@xsi:type="plsql:MergeStatement"]
                 let $items := $i/ancestor::items[1]
                 let $elements := $i/ancestor::elements[1]
                 let $proc := if ($items) then
                                 concat($items/heading/sqlObject/@value,
                                        $items/heading/function/@value)
                              else
                                 concat($elements/function/function/@value,
                                        $elements/procedure/procedure/@value,
                                        $elements/datatype/@value)
                 return <result table="{$i/@table}" schema="{$i/@schema}" proc="{$proc}"/>'
        passing tobj.parse_tree
        columns "TABLE_NAME"  VARCHAR2(30) path '@table',
                "TABLE_OWNER" VARCHAR2(30) path '@schema',
                "PROCEDURE_NAME" VARCHAR2(30) PATH '@proc',
                position FOR ordinality) tab;
```

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Analysis #4 – Views exposing specific Table Column

- Usage in Select List (column expression) is relevant only
- Consider recursivity and column name changes
- Example

```
SQL> SELECT schema_name, view_name, column_name FROM
  2  TABLE(tvd_coldep_pkg.get_dep('sh', 'costs', 'unit_cost'));

SCHEMA_NAME VIEW_NAME     COLUMN_NAME
----------- ------------- --------------------
SH          PROFITS       UNIT_COST
SH          PROFITS       TOTAL_COST
SH          GROSS_MARGINS GROSS_MARGIN
SH          GROSS_MARGINS GROSS_MARGIN_PERCENT
```

- This is solvable using an Oracle parser
  - E.g. UTL_XML.PARSEQUERY, see http://www.salvis.com/blog/?p=117

Analysis #4 – View SH.PROFITS (existing)

Which view columns use COSTS.UNIT_COST?

```
CREATE OR REPLACE VIEW PROFITS AS
SELECT s.channel_id,
       s.cust_id,
       s.prod_id,
       s.promo_id,
       s.time_id,
       c.unit_cost,
       c.unit_price,
       s.amount_sold,
       s.quantity_sold,
       c.unit_cost * s.quantity_sold TOTAL_COST
 FROM  costs c, sales s
 WHERE c.prod_id = s.prod_id
   AND c.time_id = s.time_id
   AND c.channel_id = s.channel_id
   AND c.promo_id = s.promo_id;
```

Analysis #4 – View SH.GROSS_MARGINS (new)

Which view columns use PROFITS.UNIT_COST, PROFITS.TOTAL_COST?

```
CREATE OR REPLACE VIEW GROSS_MARGINS AS
WITH gm AS
 (SELECT time_id, revenue, revenue - cost AS gross_margin
    FROM (SELECT time_id,
                 unit_price * quantity_sold AS revenue,
                 total_cost AS cost
            FROM profits))
SELECT t.fiscal_year,
       SUM(revenue) AS revenue,
       SUM(gross_margin) AS gross_margin,
       round(100 * SUM(gross_margin) / SUM(revenue), 2)
            AS gross_margin_percent
  FROM gm
 INNER JOIN times t ON t.time_id = gm.time_id
 GROUP BY t.fiscal_year
 ORDER BY t.fiscal_year;
```

Analysis #4 – View SH.REVENUES (new)

Which view columns use GROSS_MARGINS.GROSS_MARGIN, GROSS_MARGINS.GROSS_MARGIN_PERCENT?

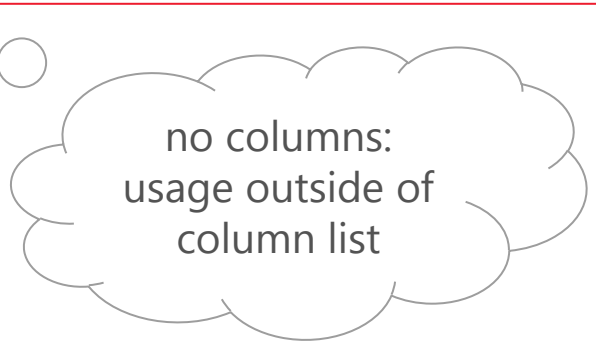
```
CREATE OR REPLACE VIEW REVENUES AS
SELECT fiscal_year, revenue
  FROM gross_margins;
```

no columns:
table used but no
sensitive column

Analysis #4 – View SH.SALES_ORDERED_BY_GM (new)

Which view columns use PROFITS.UNIT_COST, PROFITS.TOTAL_COST?

```
CREATE OR REPLACE VIEW SALES_ORDERED_BY_GM AS
SELECT channel_id,
       cust_id,
       prod_id,
       promo_id,
       time_id,
       amount_sold,
       quantity_sold
  FROM profits
 ORDER BY (unit_price - unit_cost) DESC;
```



Analysis #4 – Package Body tvd_coldep_pkg (1)

```
CREATE OR REPLACE PACKAGE BODY tvd_coldep_pkg IS
   FUNCTION get_dep(p_schema_name IN VARCHAR2,
                    p_object_name IN VARCHAR2,
                    p_column_name IN VARCHAR2) RETURN tvd_coldep_l
      PIPELINED IS
   BEGIN
      -- query dictionary dependencies
      FOR v_dep IN (SELECT d.owner      AS schema_name,
                           d.name       AS view_name,
                           v.parse_tree AS parse_tree
                      FROM all_dependencies d
                     INNER JOIN tvd_parsed_objects_t v
                        ON v.owner = d.owner
                           AND v.object_name = d.name
                           AND v.object_type = d.type
                     WHERE d.referenced_owner = upper(p_schema_name)
                           AND d.referenced_name = upper(p_object_name)
                           AND d.type = 'VIEW')
      LOOP
         -- process every fetched view
         FOR v_views IN (SELECT VALUE(pv) coldep
                           FROM TABLE(process_view(v_dep.schema_name,
                                                   v_dep.view_name,
                                                   p_column_name,
                                                   v_dep.parse_tree)) pv)
         LOOP …
```

Analysis #4 – Package Body tvd_coldep_pkg (2)

```
      … LOOP
           -- return column usages in v_dep.view_name
           PIPE ROW(v_views.coldep);
           -- get column usages of views using v_dep.view_name (recursive calls)
           FOR v_recursive IN (SELECT VALUE(dep) coldep
                                 FROM TABLE(get_dep(v_views.coldep.schema_name,
                                                    v_views.coldep.view_name,
                                                    v_views.coldep.column_name)) dep)
           LOOP
              -- return column usages of recursive call
              PIPE ROW(v_recursive.coldep);
           END LOOP;
        END LOOP;
     END LOOP;
  END get_dep;

  FUNCTION process_view(p_schema_name IN VARCHAR2,
                        p_view_name   IN VARCHAR2,
                        p_column_name IN VARCHAR2,
                        p_parse_tree  IN xmltype) RETURN tvd_coldep_l IS
     v_search_l       tvd_coldep_l := tvd_coldep_l(tvd_coldep_typ(NULL,
                                                                  NULL,
                                                                  p_column_name));
     v_previous_count INTEGER := 0;
     v_coldep_l       tvd_coldep_l := tvd_coldep_l();
  BEGIN …
```

Analysis #4 – Package Body tvd_coldep_pkg (3)

```
… BEGIN
    -- get inline dependencies from secondary select lists, TODO: source/wildcard
    WHILE v_previous_count < v_search_l.count
    LOOP
       v_previous_count := v_search_l.count;
       FOR v_secondary IN (
          SELECT DISTINCT nvl(alias_name,
                              column_reference) AS alias_name
            FROM xmltable('for    $i in //selected//*
                           where  ($i/ancestor::fromList
                                  or $i/ancestor::subqueryFactoringClause)
                                  and $i/@value and not($i/self::alias)
                           return <ret column="{$i/@value}"
                                  alias="{$i/ancestor::selected[1]//alias/@value}"/>'
                          passing p_parse_tree
                          columns column_reference VARCHAR2(1000) path '@column',
                                  alias_name VARCHAR2(30) path '@alias') x
           WHERE upper(column_reference) IN
                    (SELECT upper(column_name) FROM TABLE(v_search_l))
             AND upper(alias_name) NOT IN
                    (SELECT upper(column_name) FROM TABLE(v_search_l)))
       LOOP
          -- add internal column usage
          v_search_l.extend;
          v_search_l(v_search_l.count) :=
             tvd_coldep_typ(NULL, NULL, v_secondary.alias_name); …
```

Analysis #4 – Package Body tvd_coldep_pkg (4)

```
      … v_search_l(v_search_l.count) :=
           tvd_coldep_typ(NULL, NULL, v_secondary.alias_name);
   END LOOP;
END LOOP;
-- analyze primary select list
-- TODO: handle table/view source and wildcard properly
FOR v_primary IN (
   SELECT DISTINCT x.column_id, atc.column_name
     FROM xmltable('for    $i in //selected//*
                    where  not($i/ancestor::fromList
                           or $i/ancestor::subqueryFactoringClause)
                           and $i/@value and not($i/self::alias)
                   return <ret column="{$i/@value}"
                     id="{count($i/ancestor::selected/preceding-sibling::*)+1}"/>'
           passing p_parse_tree
           columns column_reference VARCHAR2(1000) path '@column',
                   column_id NUMBER path '@id') x
     INNER JOIN all_tab_columns atc
        ON atc.owner = p_schema_name
           AND atc.table_name = p_view_name
           AND atc.column_id = x.column_id
     WHERE upper(x.column_reference) IN
              (SELECT upper(column_name) FROM TABLE(v_search_l))
     ORDER BY x.column_id)
LOOP …
```

Analysis #4 – Package Body tvd_coldep_pkg (5)

```
    … LOOP
        -- add external column usage
        v_coldep_l.extend;
        v_coldep_l(v_coldep_l.count) := tvd_coldep_typ(p_schema_name,
                                                       p_view_name,
                                                       v_primary.column_name);
      END LOOP;
      -- return column dependencies
      RETURN v_coldep_l;
   END process_view;
END tvd_coldep_pkg;
```

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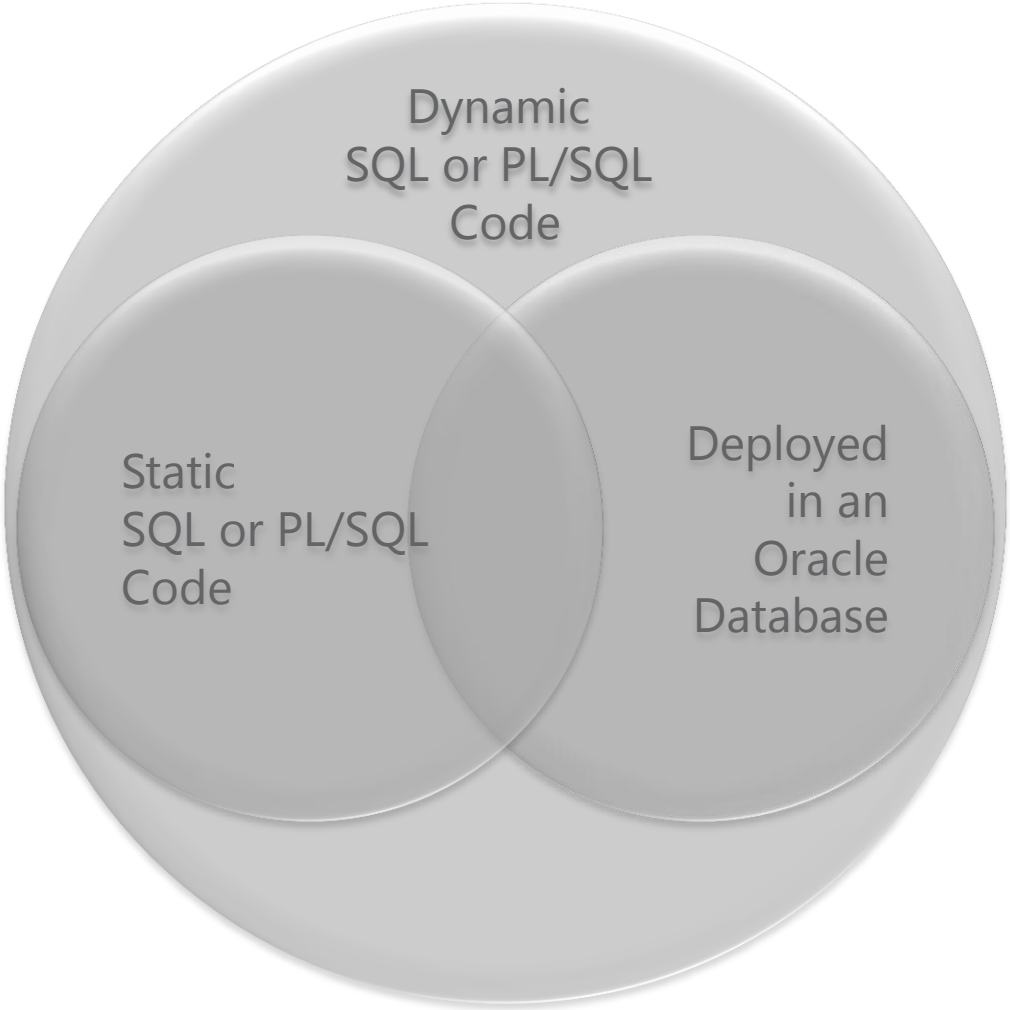
7. Analyzing Dynamic PL/SQL and SQL
8. Core Messages

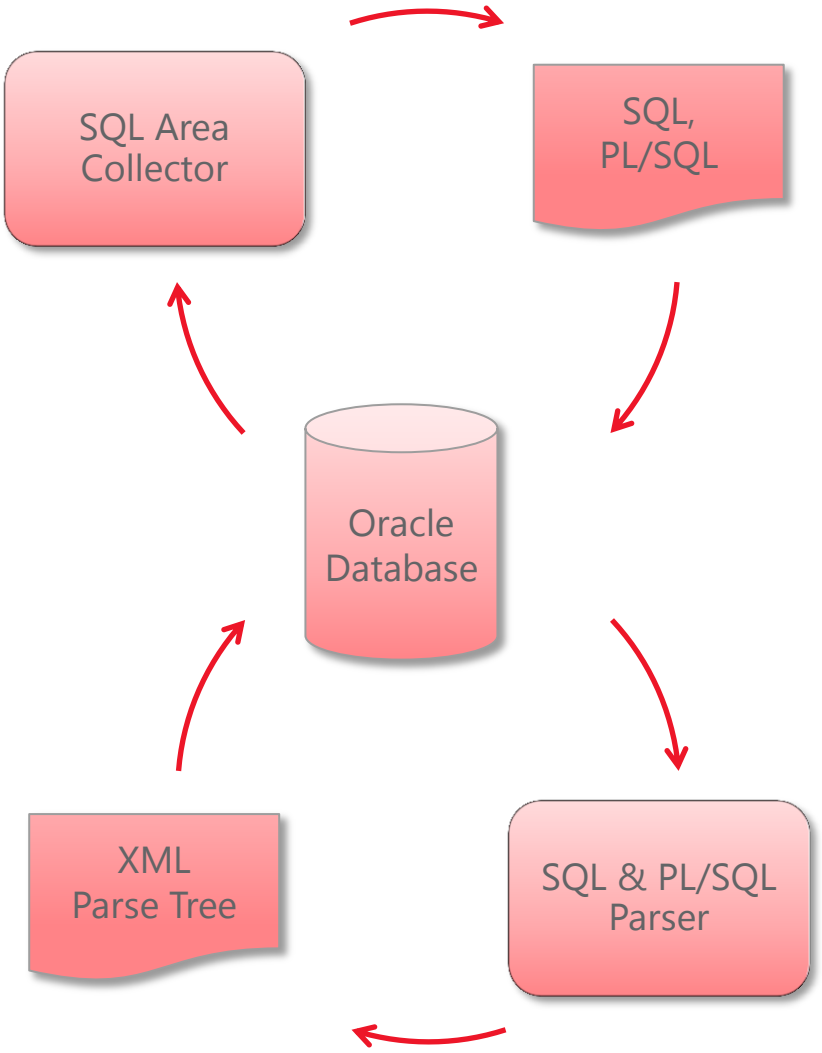
Full Scope of Database Dependency Analysis



Captured SQL – Extend Oracle Data Dictionary

```
SQL> desc tvd_captured_sql_t

Name             Type
---------------  -----------------
CAP_ID           NUMBER
CAP_SOURCE       CLOB
SQL_ID           VARCHAR2(13)
USER_NAME        VARCHAR2(30)
SCHEMA_NAME      VARCHAR2(30)
MODULE           VARCHAR2(64)
ACTION           VARCHAR2(64)
LAST_LOAD_TIME   DATE
...
PARSE_TREE       XMLTYPE
```



Challenges

- Accuracy
  - Environment generating a representative load
  - End of period processing
  - Exceptional cases
  - Irrelevant cases (e.g. generated statements of IDEs, DBMS_STATS, …)
- Context
  - Application
  - End User
- Duplicates
  - Literals instead of binds
  - Captured static code
  - Number of statements to be processed
- Literals
  - XML Features like XQuery, XPath or XSLT

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Core Messages

PL/SQL & SQL

Analysis

- Column based analysis are not yet supported by the Oracle Data Dictionary
- SQL is not yet covered by PL/Scope
- Extend the Oracle Dictionary by gathering and persisting parse trees in XML format for static and dynamic code
- Queries based on the Extended Oracle Dictionary allows fine grained static PL/SQL and SQL code analysis
- Wrap complex queries in Views or Pipelined Table Functions to simplify analysis

THANK YOU.

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