Introducing Oracle Pipelined Table Functions

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Using Oracle since 1997

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SQL Query – get data from a table

Two required clauses: SELECT & FROM

```
SELECT first_name, last_name
FROM employees;
```

Query the dictionary for the built-in functions

```
SELECT DISTINCT object_name
FROM all_arguments
WHERE package_name = ‘STANDARD’
ORDER BY object_name;
```

Manipulating the column data by invoking a function

Built-in functions UPPER & TO_DATE

SELECT first_name, UPPER(last_name) FROM employees;

SELECT TO_DATE('20140228','YYYYMMDD') FROM dual;

User-defined functions

Let’s move to PL/SQL, and use it to encapsulate code with our own function.

Anonymously: no stored object created

```
DECLARE FUNCTION tomorrowdate
   RETURN DATE IS
  BEGIN
RETURN trunc(sysdate+1);
END;
BEGIN
   DBMS_OUTPUT.PUT_LINE(tomorrowdate);
END;
/
```

Creating a function in PL/SQL

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

http://www.tutorialspoint.com/plsql/plsql_functions.htm

Basic function – returns text string

```
CREATE OR REPLACE FUNCTION basicfunc
RETURN VARCHAR2 IS
BEGIN
  RETURN 'a basic user-defined function';
END basicfunc;

SELECT 'This is ' || basicfunc FROM dual;
```

Output: “This is a basic user-defined function”

Basic Function – returns tomorrow's date

```
CREATE OR REPLACE FUNCTION tomorrowdatefunc
(todaydate IN date)
RETURN date IS
BEGIN
  RETURN trunc(todaydate + 1);
END tomorrowdatefunc;

SELECT 'Tomorrow is ' || tomorrowdatefunc(sysdate) FROM dual;
```

Output: "Tomorrow is 25-FEB-14"

Recap

- SQL SELECT queries can be manipulated
  - Functions
    - Built-in
    - User defined functions

- Stored Functions are invoked by a calling process
- Functions as anonymous blocks, stand-alone or inside packages.

SQL Standards

SQL1999 is when user-defined functions were added to the ANSI standards for SQL.

SQL2003 New in SQL were SQL invoked functions that return a "table". Table functions give increased functionality by allowing sets of tuples from any external data sources to be invoked (as if they were a table).

Dr. Yingshi Li

What is a table function?

- PL/SQL stored object
- Returns a collection type instance
  - VARRAY
  - Nested Table
- Query a table function in the FROM clause

SQL and PL/SQL tables – what?

PL/SQL can contain execution statements which directly SELECT from SQL tables

SQL cannot select from PL/SQL tables without TABLE operator

Table functions

- We invoke table functions in SQL
  - Needs a collection type or REF cursor as input argument
  - The table function returns a collection
  - Used to generate a list that can be used by Java or other languages

```
SELECT * FROM
TABLE( CAST(employee_nt  AS  employee_nt_t));
```

Nested tables

Because nested tables are shared by both SQL &PL/SQL, they enable us to use table functions in SQL

```
SELECT * FROM
        TABLE( CAST(employee_nt  AS  employee_nt_t) )
```

TABLE Operator

Tells Oracle to act as though the variable is an SQL Table

CAST Operator

Explicitly converts the data type

Table functions benefit from pipelining

With a regular table function, the data is accumulated in the variable during processing. A cursor returns all at one time and can result in a large result set. Add in the pipelined option to push each processed row as soon at it's ready.

Pipelined Table Functions

- Return the rows right after generated
- Produce smaller sized batches of rows
- Need the PIPELINED keyword added to code
- Need the PIPE ROW operator added to execute statements

Oracle bringing in pipelined table functions

8i: Able to use "SELECT FROM TABLE(CAST(plsql_function AS collection_type))" for binding user-generated lists of data.

Problem: large memory footprint.

9i Release 1 (9.0), Oracle has introduced pipelined table functions (pipelined functions). Can pipe (or stream) data in small arrays of prepared data, rather than fully materialized.

Easily combine the complex procedures of PL/SQL with SQL for bulk operations. For example transforming data through a pipeline or chained pipeline functions.

http://www.oracle-developer.net/display.php?id=207

How are pipelined table functions being used?

ETL Tools: External Tables, Table Functions and Merge
http://www.akadia.com/services/ora_etl.html

Generating a range of dates to use as though it were a table.
http://www.akadia.com/services/ora_pipe_functions.html

Data transformations: improved time between table function and pipelined table function.
http://oracle-study-notes.blogspot.com/2007/07/table-function-pipleined-vs-non.html

Transformation Pipelines

In traditional Extract Transform Load (ETL) processes you may be required to load data into a staging area, then make several passes over it to transform it into a state where it can be loaded into your destination schema. Passing the data through staging tables can represent a significant amount of disk I/O for both the data and the redo generated. An alternative is to perform the transformations in pipelined table functions so data can be read from an external table and inserted directly into the destination table, removing much of the disk I/O.

http://www.oracle-base.com/articles/misc/pipelined-table-functions.php

Table function – can extract, transform and load in a single step. Add pipelining to speed up.

Back in Oracle8i

SQL*Loader reads external file, writes to staging table

Read from staging table with PL/SQL Procedure, write to target table

Since Oracle 9i

Insert into target table using pipelined table function as source

Recap

- ANSI standard
- SELECT (invoke) table functions
- Nested tables
- Benefits of pipelined functions
- How are they being used?

External table data to transform

```
CREATE TABLE stock_ext
( ticker VARCHAR2(13),
  open_price VARCHAR2(6),
  close_price VARCHAR2(6))
ORGANIZATION EXTERNAL
...
```

	stock_ext	
ticker	**open_price**	**close_price**
WMB	39.94	39.85
SPY	174.78	175.17
GLD	121.76	121.29

adapted from
http://examples.oreilly.com/oraclep3/individual_files/tabfunc.sql

Pivot the data

	stock_ext	
ticker	**open_price**	**close_price**
WMB	39.94	39.85
SPY	174.78	175.17
GLD	121.76	121.29

Each row in stock_ext becomes 2 rows in Nested Table

Ticker	**PriceType**	**Price**
WMB	O	39.94
WMB	C	39.85
SPY	O	174.78
SPY	C	175.17
GLD	O	121.76
GLD	C	121.29

Create the TYPEs in the schema

```
CREATE TYPE TickerType AS OBJECT
( ticker VARCHAR2(20),
 PriceType VARCHAR2(1),
 price NUMBER);

CREATE TYPE TickerTypeSet AS TABLE OF TickerType;
```

Verify the collection type definitions

```
TYPE_NAME                      TYPECODE                       INCOMPLETE FINAL INSTANTIABLE
------------------------------ ------------------------------ ---------- ----- ------------
TICKERTYPE                     OBJECT                         NO         YES   YES
TICKERTYPESET                  COLLECTION                     NO         YES   YES
```

SELECT type_name, typecode, incomplete, final, instantiable

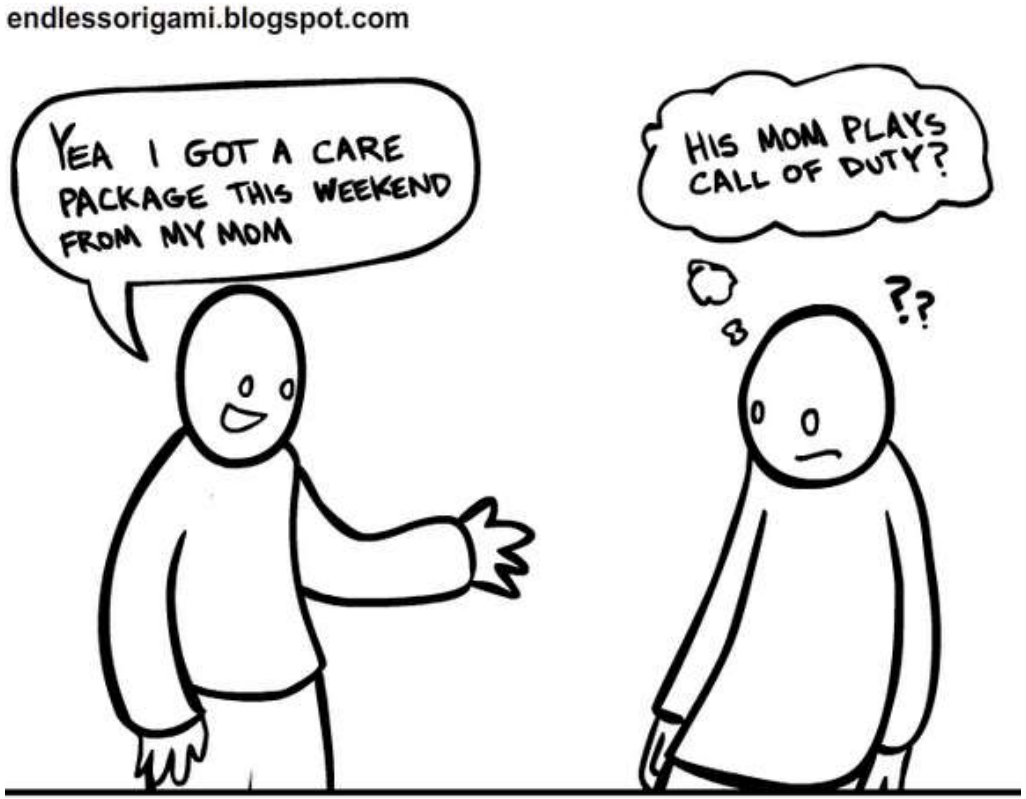
FROM user_types;

Details of the collection types

```
TYPE_NAME                      COLL_TYPE                      ELEM_TYPE_NAME
------------------------------ ------------------------------ --------------------
TICKERTYPESET                  TABLE                          TICKERTYPE
```

```
SELECT type_name, coll_type, elem_type_name
FROM user_coll_types;
```

Packaging


endlessorigami.blogspot.com
YEA I GOT A CARE PACKAGE THIS WEEKEND FROM MY MOM
HIS MOM PLAYS CALL OF DUTY?
??
You know you're geeky when you hear care package and immediately think of Call of Duty.

Create package, define the ref cursor type

```
CREATE OR REPLACE PACKAGE refcur_pkg IS
 TYPE refcur_t IS REF CURSOR RETURN stock_ext%ROWTYPE;
END refcur_pkg;
/
```

Pipelined Table Function

```
CREATE OR REPLACE FUNCTION StockPivot(p refcur_pkg.refcur_t)
RETURN TickerTypeSet

PIPELINED IS
 out_rec TickerType := TickerType(NULL,NULL,NULL);
 in_rec p%ROWTYPE;
```

BEGIN and END BLOCK

```
BEGIN
  LOOP
  FETCH p INTO in_rec;
  EXIT WHEN p%NOTFOUND;
     -- first row
     out_rec.ticker := in_rec.Ticker;
     out_rec.PriceType := 'O';
     out_rec.price := in_rec.open_price;
     PIPE ROW(out_rec);
     -- second row
     out_rec.PriceType := 'C';
     out_rec.Price := in_rec.close_price;
     PIPE ROW(out_rec);
  END LOOP;
  CLOSE p;
  RETURN;
END;
```

Transform rows from external table

```
SELECT *
FROM TABLE(StockPivot(CURSOR(SELECT * FROM STOCK_EXT))) x;
```

A view, so I don’t forget the syntax ;)

```
CREATE VIEW stock_close AS
SELECT x.Ticker, x.Price
FROM TABLE(StockPivot(CURSOR(SELECT * FROM STOCK_EXT))) x
WHERE x.PriceType='C';
```

Query to list all pipelined table functions

```
SELECT OWNER, OBJECT_NAME, OBJECT_TYPE, PIPELINED
FROM ALL_PROCEDURES
WHERE PIPELINED='YES' AND OBJECT_TYPE='FUNCTION';
```

Key parts of Pipelined Table Functions

PIPELINED option

RETURN Data Type

PIPE ROW Statement

RETURN Statement

ReCap

- Transform external table rows from 1 to 2.
- Packaging
- Create a view
- Vital parts for pipelined functions

Build and compare regular and pipeline table functions

http://www.dba-oracle.com/plsql/t_plsql_pipelining.htm

Dr. Tim Hall has a chapter in his book that does this nicely.

Create the two TYPES: record and collection

```
CREATE OR REPLACE TYPE t_square_root_row AS OBJECT (
  start_number   NUMBER,
  square_root    NUMBER,
  description    VARCHAR2(50)
);
/
CREATE OR REPLACE TYPE t_square_root_tab AS TABLE OF
t_square_root_row;
/
```

Both type objects are created

SELECT type_name, typecode, incomplete, final, instantiable

FROM user_types;

```
TYPE_NAME                      TYPECODE                       INCOMPLETE FINAL INSTANTIABLE
------------------------------ ------------------------------ ---------- ----- ------------
T_SQUARE_ROOT_ROW              OBJECT                         NO         YES   YES
T_SQUARE_ROOT_TAB              COLLECTION                     NO         YES   YES
```

Details of the collection types

```
SELECT type_name, coll_type, elem_type_name
FROM user_coll_types;
```

```
TYPE_NAME                      COLL_TYPE   ELEM_TYPE_NAME
------------------------------ ---------- ------------------------------
T_SQUARE_ROOT_TAB              TABLE      T_SQUARE_ROOT_ROW
```

Create package specification to be used by both functions

```
CREATE OR REPLACE PACKAGE tf_pk AS
  FUNCTION get_square_roots_tf
        (p_start_range  IN  NUMBER,p_end_range    IN  NUMBER)

  RETURN t_square_root_tab;
  FUNCTION get_square_roots_ptf (p_start_range  IN  NUMBER,
                        p_end_range    IN  NUMBER)
    RETURN t_square_root_tab PIPELINED;
END tf_api;
/
```

PACKAGE BODY tf_api

Regular Table Function

```
FUNCTION get_square_roots_tf (p_start_range  IN  NUMBER,
                              p_end_range    IN  NUMBER)

  RETURN t_square_root_tab
AS
  l_row  t_square_root_row := t_square_root_row(NULL, NULL);
  l_tab  t_square_root_tab := t_square_root_tab();
BEGIN
  FOR i IN p_start_range .. p_end_range LOOP
    -- Build up a new row.
l_row.start_number := i;
l_row.square_root  := ROUND(SQRT(i), 2);
l_row.description  := 'The square root of ' || i || ' is ' ||
l_row.square_root;
    -- Extend the collection (populate the nested table and add
the row.
    l_tab.extend;
    l_tab(l_tab.last) := l_row;
  END LOOP;
  -- Return the collection.
  RETURN l_tab;
END get_square_roots_tf;
```

PACKAGE BODY tf_api

Pipelined Table Function

```
 FUNCTION get_square_roots_ptf (p_start_range  IN  NUMBER,
                                p_end_range    IN  NUMBER)
   RETURN t_square_root_tab PIPELINED
 AS
   l_row  t_square_root_row := t_square_root_row(NULL, NULL);
 BEGIN
   FOR i IN p_start_range .. p_end_range LOOP

     -- Build up a new row.
     l_row.start_number := i;
     l_row.square_root  := ROUND(SQRT(i), 2);
     l_row.description  := 'The square root of ' || i || ' is ' ||
l_row.square_root;
     -- Pipe the row out.
     PIPE ROW (l_row);
   END LOOP;
   -- Perform return.
   RETURN;
 END get_square_roots_ptf;
END tf_api;
/
```

Both table functions generate same output

```
-- Query the regular table function.
SELECT *
FROM   TABLE(tf_api.get_square_roots_tf(1, 100)) a;

-- Query the pipelined table function.
SELECT *
FROM   TABLE(tf_api.get_square_roots_ptf(1, 100)) a;
```

Create a function to retrieve current PGA usage

```
CREATE OR REPLACE FUNCTION get_used_memory RETURN NUMBER AS
  l_used_memory  NUMBER;
BEGIN
  SELECT ms.value
  INTO   l_used_memory
  FROM   v$mystat ms,
         v$statname sn
  WHERE  ms.statistic# = sn.statistic#
  AND    sn.name = 'session pga memory';
  RETURN l_used_memory;
END get_used_memory;
/
```

Run the test from SQLPLUS command line

```
conn test/test
-- Test regular table function.
SET SERVEROUTPUT ON
DECLARE
  l_start  NUMBER;
BEGIN
  l_start := get_used_memory;

  FOR cur_rec IN (SELECT *
                  FROM   TABLE(tf_api.get_square_roots_tf(1, 100000, 'FALSE')))
  LOOP
    NULL;
  END LOOP;

  DBMS_OUTPUT.put_line('Regular table function : ' || (get_used_memory - l_start));
END;
/
```

Run the test from SQLPLUS command line

```
conn test/test
-- Test pipelined table function.
SET SERVEROUTPUT ON
DECLARE
  l_start  NUMBER;
BEGIN
  l_start := get_used_memory;

  FOR cur_rec IN (SELECT *
                  FROM   TABLE(tf_api.get_square_roots_ptf(1, 100000, 'FALSE')))
  LOOP
    NULL;
  END LOOP;

  DBMS_OUTPUT.put_line('Pipelined table function : ' || (get_used_memory - l_start));
END;
/
```

Regular Table Function PGA memory used

```
SQL> SET SERVEROUTPUT ON
SQL>  DECLARE
  2     l_start  NUMBER;
  3   BEGIN
  4     l_start := get_used_memory;
  5
  6    FOR cur_rec IN (SELECT *
  7                      FROM   TABLE(tf_api.get_square_roots_tf(1, 100000, 'FALS
E')))
  8     LOOP
  9       NULL;
 10     END LOOP;
 11
 12    DBMS_OUTPUT.put_line('Regular table function : ' ||
 13                         (get_used_memory - l_start));
 14   END;
 15   /
Regular table function : 19791872

PL/SQL procedure successfully completed.
```

Pipelined table function PGA memory used

```
SQL> SET SERVEROUTPUT ON
SQL>  DECLARE
  2     l_start  NUMBER;
  3   BEGIN
  4     l_start := get_used_memory;
  5
  6
  7     FOR cur_rec IN (SELECT *
  8                     FROM   TABLE(tf_api.get_square_roots_ptf(1, 100000, 'FAL
SE')))
  9     LOOP
 10       NULL;
 11     END LOOP;
 12
 13    DBMS_OUTPUT.put_line('Pipelined table function : ' ||
 14                         (get_used_memory - l_start));
 15   END;
 16   /
Pipelined table function : 131072

PL/SQL procedure successfully completed.
```

The pipeline used less PGA memory

The regular table function uses over 150 times the memory used by the pipelined table function.

Regular Table Function used 19,791,872

Pipelined Table Function used 131,072

Pipelined table functions

- Used when must loop through each row of data
- Types
  - Records
  - Collections
- Compare original code to pipelined

Useful resources

Oracle Documentation

www.oracle.com/pls/db112/homepage

Tom Kyte

http://asktom.oracle.com

Mike McLaughlin

http://blog.mclaughlinsoftware.com

Burleson Consulting with Tim Hall book excerpt

http://www.dba-oracle.com/plsql/t_plsql_pipelining.htm

Thank you