Polymorphic Table Functions and Qualified Expressions

Robert Marz

Robert Marz – Independent Consultant

Client

Senior Technical Architect

with database centric view of the world

ORACLE ACE

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Portfolio Manager Database Technologies

Blog Editor

DOAG (German Oracle User Group)

Active Member of Database Community

Responsible for Cloud Topics

@RobbieDatabee

blog.its-people.de

Robert.Marz
@its-people.de


Motivation

PL/SQL: Requirements for Web Development and Microservices

Data Formats
- JSON
- YAML

Business Logic
- Encapsulate
- APIs
- Re-Usability

constant improvements

Release 12:
- JSON Support

Release 18:
- Polymorphic Table Functions
- Qualified Expressions

Qualified Expressions

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Qualified Expressions

Constructors for PL/SQL Types	Associative Arrays	
	Records	
Initialize Types	Function Call	Same Name as Type
	Provide Values	By Name By Position
Syntactical Sugar	Shorter Code	
	Better readability	

Declaring Types

```
type numbers_ty is table of number
   index by pls_integer;

type user_properties_ty is record(
     is_ops boolean
   , is_dev boolean
   , email varchar2(255)
);
type users_ty is table of user_properties_ty
   index by varchar2(32);
```

Initializing Types **before** 18c

```
    numbers   numbers_ty;
    appUsers  users_ty;
begin
    numbers(2) := 10.5;
    numbers(3) := 65;
    numbers(1) := 3.14;

    appUsers('alice').is_ops := false;
    appUsers('alice').is_dev := true;
    appUsers('alice').email  := 'alice@rmoug.org';

    appUsers('bob').is_ops := true;
```

Qualified Expressions: Initializing Types in 18c and up

Index by pls_integer

Index by varchar2

```
-- Qualified Expressions are Constructors
 -- Initialization by Name
 numbers   numbers_ty := numbers_ty(2 => 10.5, 3 => 65, 1 => 3.14);
 appUsers  users_ty := users_ty(
   'alice'    => user_properties_ty(is_ops => false,
                                    is_dev => true,
                                    email  => 'alice@rmoug.org'),
   'robbie'   => user_properties_ty(email  => 'robbie@doag.org',
                                    is_dev => true,
                                    is_ops => true ),
-- Initialization by Position
   'bob'      => user_properties_ty(true, false,'bob@rmoug.org'));
```

Qualified Expressions: Demo

```
-- Qualified Expressions in 18c
declare
  type numbers_ty is table of number
    index by pls_integer;

  type user_properties_ty is record(
    is_ops  boolean
  , is_dev  boolean
  , email   varchar2(255)
  );

  type users_ty is table of user_properties_ty
    index by varchar2(32);
  -- Qualified Expressions are Constructors for Types
  numbers   numbers_ty := numbers_ty(2=>10.5, 3=>65, 1=> 3.14);  --
Initialization by Name
  appUsers  users_ty := users_ty(
      'alice'   => user_properties_ty(is_ops => false, is_dev => true,
email=>'alice@rmoug.org')
    , 'bob'     => user_properties_ty(true, false, 'bob@rmoug.org') --
Initialization by Position
    , 'robbie'  => user_properties_ty(email=>'robbie@doag.org', is_dev =>
true, is_ops => true )
    );
  usr varchar2(32);
begin
  for idx in 1..numbers.count loop
    dbms_output.put_line('Index: '||idx||' value: '||numbers(idx));
  end loop;

  usr := appUsers.first;
  while usr is not null loop
    dbms_output.put_line(case appUsers(usr).is_dev when true then 'Dev' else
'' end
                         ||case appUsers(usr).is_ops when true then 'Ops   '
else '   ' end
                         ||' User: '||usr|| ' email: '||appUsers(usr).email
                          );
    usr := appUsers.next(usr);
  end loop;
end;
/
```

Demo

Not on 18c, yet? Try LiveSQL

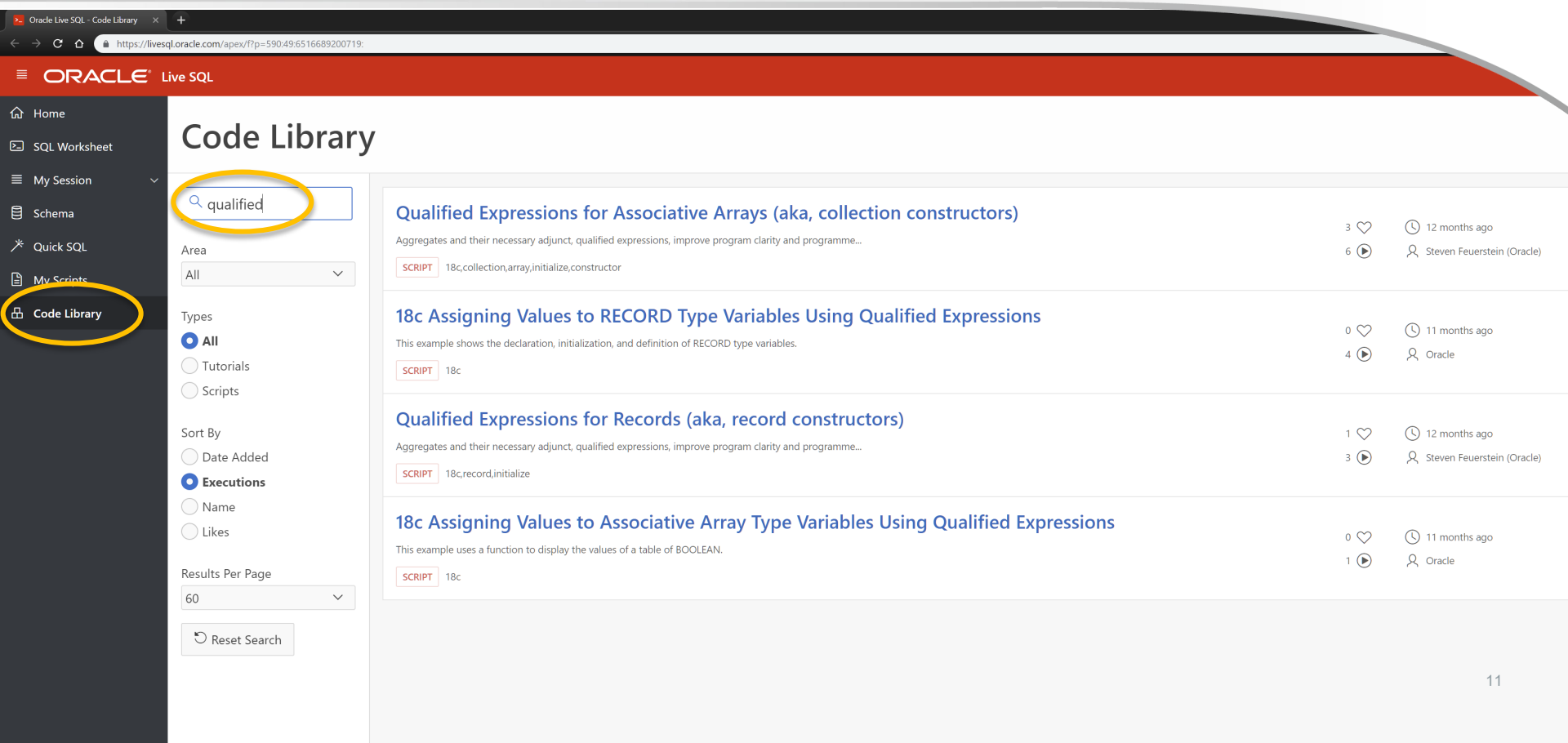
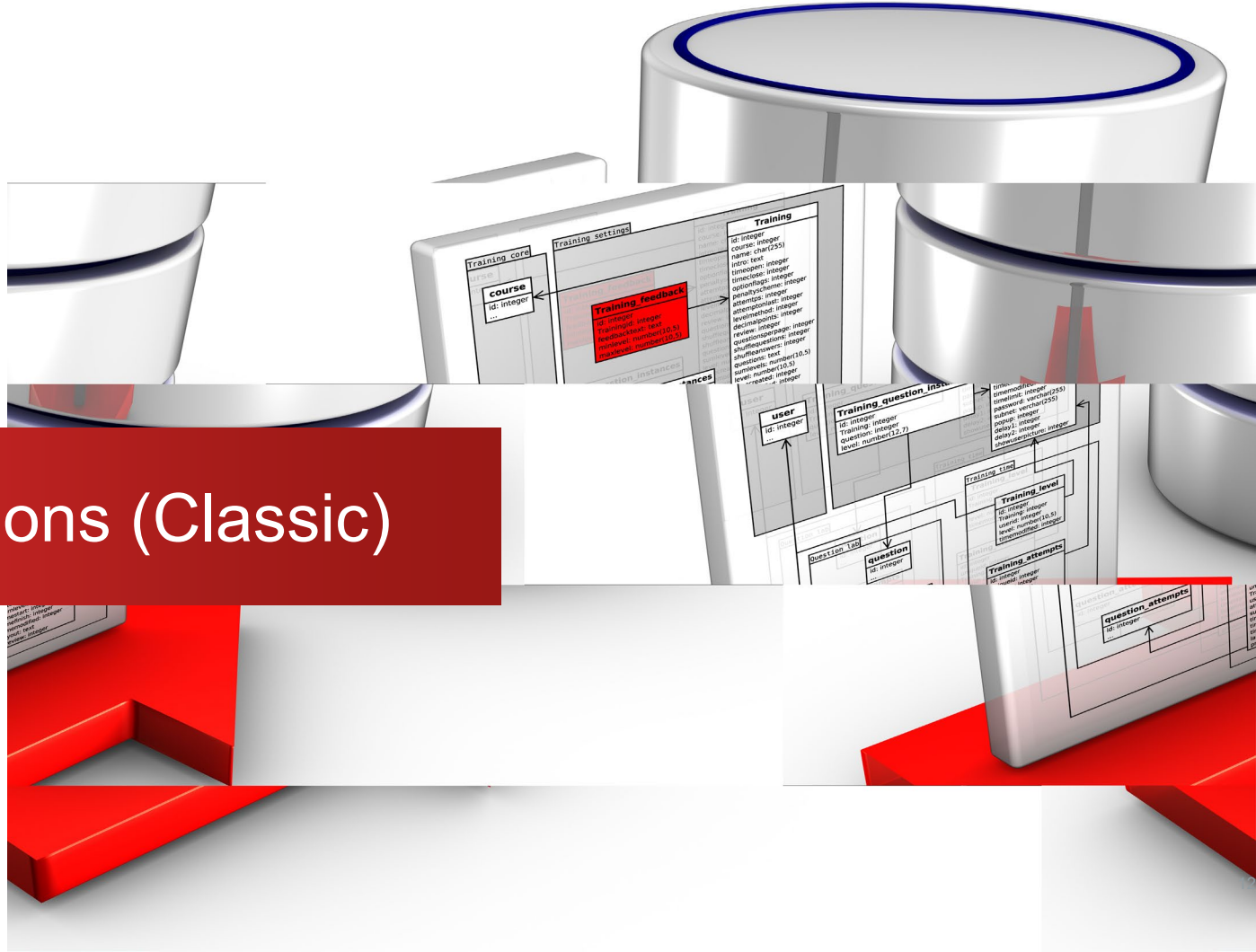


Table Functions (Classic)



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Classic Table Functions

Generate Data	arbitrary number of Rows
Row Structure	defined at compile time
	PL/SQL Types
Nesting Possible	Pipelining
PL/SQL Function	Package OK
	arbitrary Parameters

Classic Table Functions - Definition

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```
-- Classic Table Functions (9i and up)

create or replace package tf
as
    type fibo_rec is record (fibo number, ind number, tmp number);
    type fibo_tab is table of fibo_rec;

    function fibonacci(fibolimes in number)
        return tf.fibo_tab pipelined;
end tf;
/
```

Classic Table Functions - Implementation

```
create or replace package body tf
as
    function fibonacci(fibolimes in number)
        return tf.fibo_tab pipelined
    is
        fibo fibo_rec; -- Type with column definition
    begin
        fibo.ind := 1; fibo.fibo := 1; -- Pre 18c Init
        while fibo.fibo <= fibolimes
        loop
            pipe row (fibo);
            fibo.tmp := fibo.ind + fibo.fibo;
            fibo.fibo := fibo.ind; fibo.ind := fibo.tmp;
        end loop;
    end fibonacci;
end tf;
```

Classic Table Functions - Implementation

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```
create or replace package body tf
as
    function fibonacci(fibolimes in number)
        return tf.fibo_tab pipelined
    is
         fibo fibo_rec := fibo_rec(1,1,null); -- Qualified Expression
    begin
        -- fibo.ind := 1; fibo.fibo := 1; -- Pre 18c Init
        while fibo.fibo <= fibolimes
        loop
            pipe row (fibo);
            fibo.tmp := fibo.ind + fibo.fibo;
            fibo.fibo := fibo.ind; fibo.ind := fibo.tmp;
        end loop;
    end fibonacci;
end tf;
```

Classic Table Functions - Implementation

```
select fibo
    from table(tf.fibonacci(15));


 -- Since Oracle 12.2
 -- the table()-Operator
 -- is obsolete

 select fibo
     from tf.fibonacci(15);
```

```
      FIBO
---------
         1
         1
         2
         3
         5
         8
        13

7 rows selected.
```

Polymorphic Table Functions

Polymorphic Table Functions: The Idea

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Polymorphic Table Functions (PTF)

Modify Source Table	Add / Remove / Modify
	Rows & Columns
Generic Extension	Like a View but more procedural
	Works for arbitrary input tables
Business Logic	API for Analysts
	Hide complexity
	make dynamic SQL available
SQL 2016 Standard	Not (yet) completely implemented
	Some (minor) discrepancies

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PTF Benefits

Minimal data-movement	Only columns of interest are passed to PTF
Predicates, Projections, Partitioning	pushed into underlying table/query (where semantically possible)
Bulk data transfer	Into and out of PTF
Parallelism based on	type of PTF query specified partitioning (if any)

PTF: Basic Patterns

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Taking an existing rowset and…

- Column-based **EXPANSION**
  - Calculating/deriving a new column value
- Row-based **EXPANSION**
  - Data pivot operation
- Column-based **REDUCTION**
  - Data unpivot operation
- Row-based **REDUTION**
  - Data aggregation/reduction operation

No existing rowset to process…

- Rowset **GENERATOR**
  - Creates new rows and columns
  - Importing a CSV file

Thanks to Keith Laker, Oracle @SQLBarista

Polymorphic Table Functions: The Implementation

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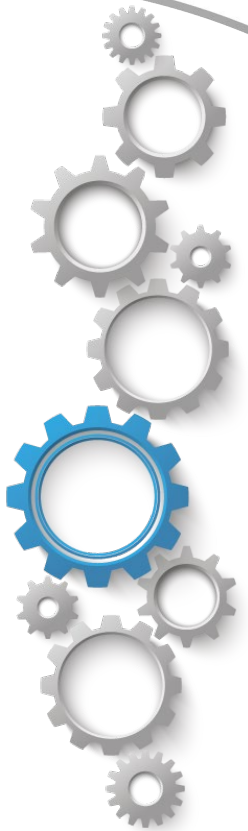
PTF Implementation

Input	Oracle: exactly one Table
	Column Lists
	arbitrary additional Parameters
Row Structure “Describe”	Fixed at SQL-Execution Time
	PL/SQL Function
Implementation	PL/SQL Package per PTF
	Heavy use of PL/SQL Tables
	DBMS_TF – Helper & Utilites
Performance	New Execution Plan operation
	Not always needed



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What makes a PTF

Function	without	body
	references	Package
Package	required function	`describe`

	optional procedures	`open`
		`fetch_rows`
		`close`

```
create or replace
  function add_lables
      (tabname table,
       colnames columns)
  return
    table pipelined
    row polymorphic
    using lables; -- Package Name

select *
  from add_lables(
         emp, columns(empno, mgr));
```

PTF SQL Enhancement: Varadic Pseudo Operators

```
select *
  from add_lables(emp, columns(empno, mgr) );
```

Variadic Pseudo Operators columns()

- operates with a variable number(>= 1) of operands
- introduced in 18c to support PTF
- can only appear in argument lists of PTF
- parsed by SQL Engine
- converted to corresponding DBMS_TF-types
- passed as Input parameter to the DESCRIBE-Function

PTF API Package: Describe Function

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Describe Function

invoked by SQL-Engine at parse-time

determines the row_type

new & removed columns
returns dbms_tf.describe_t Table

marks columns for processing

“pass-through” – unchanged, not moved
“for read” - passed to fetch_rows procedure
via dbms_tf.table_t (IN OUT Parameter)

PTF API Package: Open & Close

Open & Close Procedures

- Setup and Teardown of Environment
- Your instrumentation Code goes here
- Both are optional

Open

- called before first fetch_rows execution
- Initialize Variables

Close

- called at the end, after all fetch_rows
- do cleanup stuff

PTF API Package: Fetch_Rows Procedure

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Fetch_rows is the worker

- processes rowsets (chunks of Table Data)
- only columns marked for read
- Needs same scalar parameters as PTF

Database can call multiple times

- for each rowset
- in parallel

Produce & Reduce Data

- fill new columns
- generate new rows
- suppress rows

Polymorphic Table Functions: Flavors

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PTF Semantic Types

Determine execution Plan
Impact Performance

Row Semantic PTF

new columns can be derived from current row

```
return table pipelined row polymorphic
```

Table Semantic PTF

works on whole table or partition

```
return table pipelined table polymorphic
```

Polymorphic Table Functions: Restrictions

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Datatype Restrictions

passthrough is possible with any type
“for read” and new columns must be scalar datatypes
dbms_tf.supported_type function

Invocation and Execution Restrictions

PTF cannot be nested in from clause
  workaround: Use with-clause
PTF cannot be an argument to a (classic) table function
PTF yields no rowids
PARTITION BY and ORDER BY only work with Table Semantics PTF
DESCRIBE function cannot be called directly

Polymorphic Table Functions: Reading List

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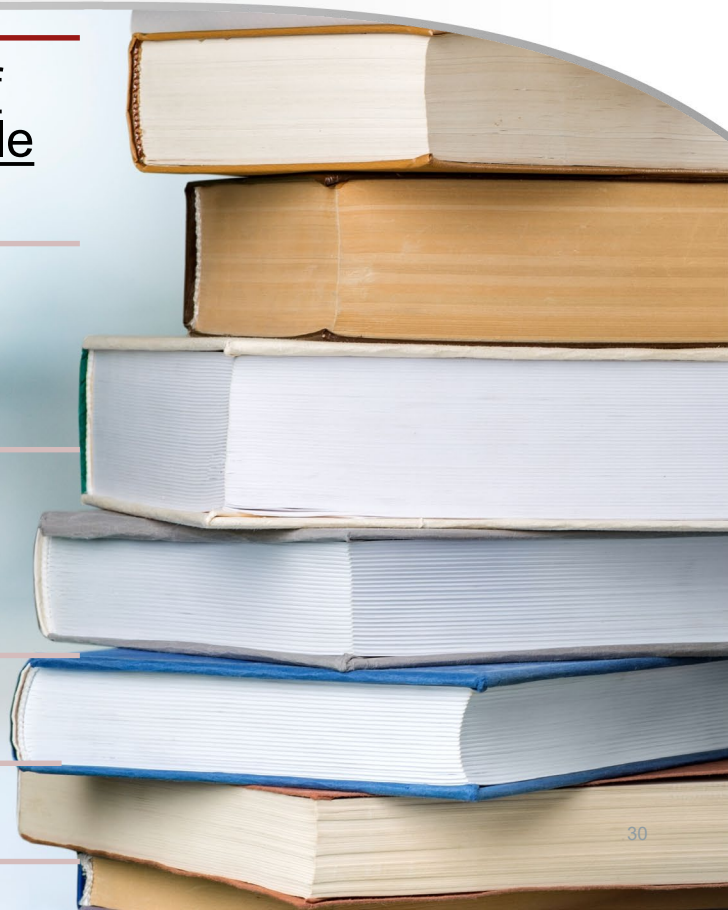
Want to know more?

Database PL/SQL Language Reference	12.6 Overview of Polymorphic Table Functions
PL/SQL Packages and Types Reference	173 DBMS_TF
LiveSQL	Code Library
Google	Blog Posts
	Presentations



Polymorphic Table Functions: LiveSQL

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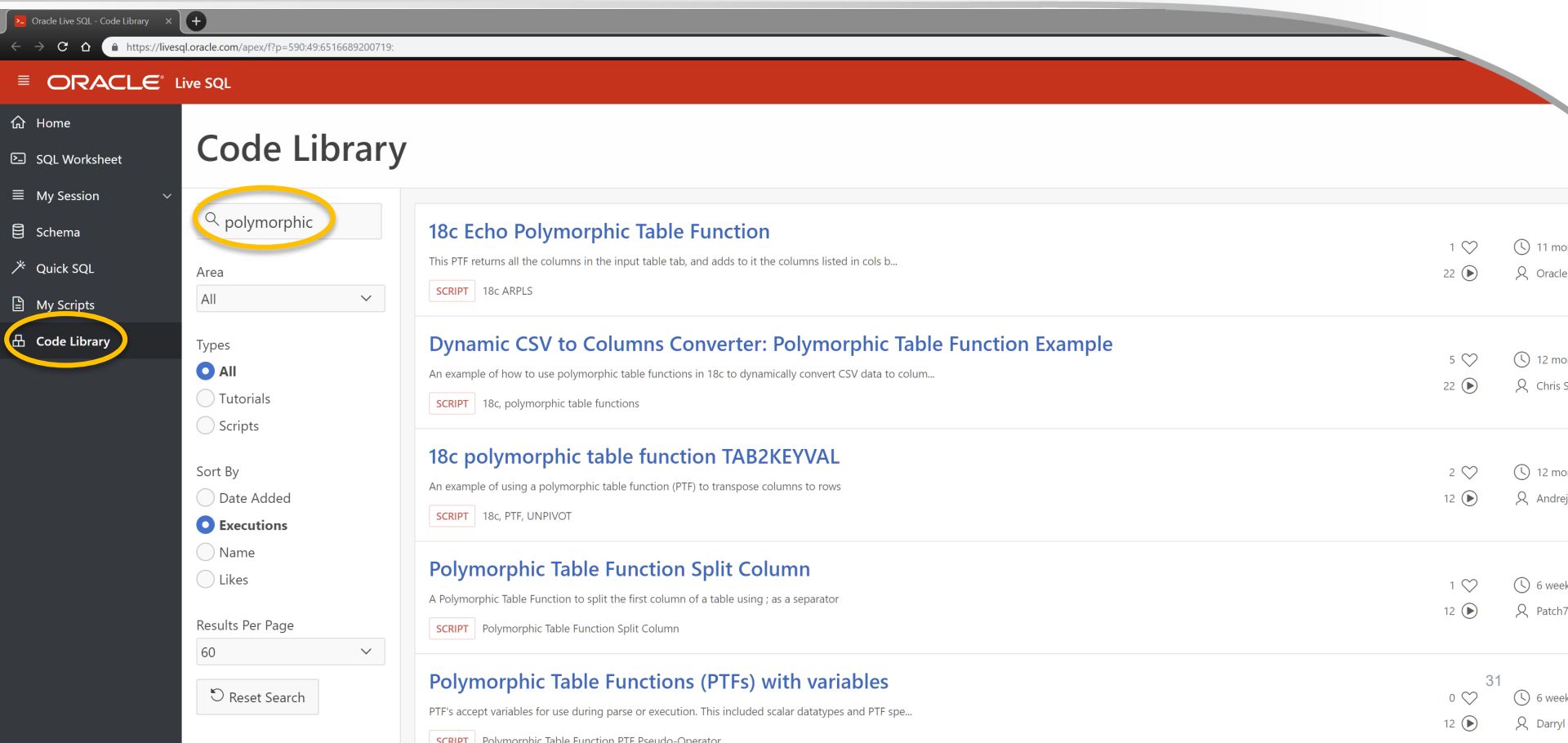


DEMO
delete

Demo: PTF addTags – Package Spec

```
create or replace package ptf_tags
as
  function describe(tabname in out dbms_tf.table_t,
                    colnames in dbms_tf.columns_t,
                    tag_string in varchar2)
    return dbms_tf.describe_t;

  procedure fetch_rows(tag_string in varchar2);
end ptf_tags;
/
```

Demo

Demo: PTF addTags – PTF Definition

```
create or replace
function add_tags(tabname table,
                  colnames columns,
                  tag_string varchar2)
  return
    table pipelined
    row polymorphic
    using ptf_tags; -- Package Name
/
```

Demo

Demo: PTF addTags – Package Body – Function define

```
function describe(tabname in out dbms_tf.table_t, colnames in dbms_tf.columns_t, tag_string in varchar2)
  return dbms_tf.describe_t
as
  new_cols dbms_tf.columns_new_t;
  begin
    for i in 1 .. tabname.column.count -- loop over all table columns
    loop -- skip columns with unsupported data types
      continue when not dbms_tf.supported_type(tabname.column(i).description.type);
      for j in 1 .. colnames.count
      loop
        if (tabname.column(i).description.name = colnames(j)) -- is the column in the colnames table?
        then
          tabname.column(i).for_read := true;
          tabname.column(i).pass_through := true;
          new_cols(i) := tabname.column(i).description; -- copy column in new_cols()
          -- set datatype to varchar2
          new_cols(i).type := dbms_tf.type_varchar2;
          new_cols(i).max_len := 4000;
          new_cols(i).name := '"TAGGED_' -- set new column name
                           || regexp_replace(new_cols(i).name, '^"|"$') -- remove trailing or leading ‚„‘
                           || '„‘';
          exit;
        end if;
      end loop;
    end loop;
    return dbms_tf.describe_t(new_columns => new_cols);
end describe;
```

Demo

Demo: PTF addTags – Package Body – Procedure fetch_rows

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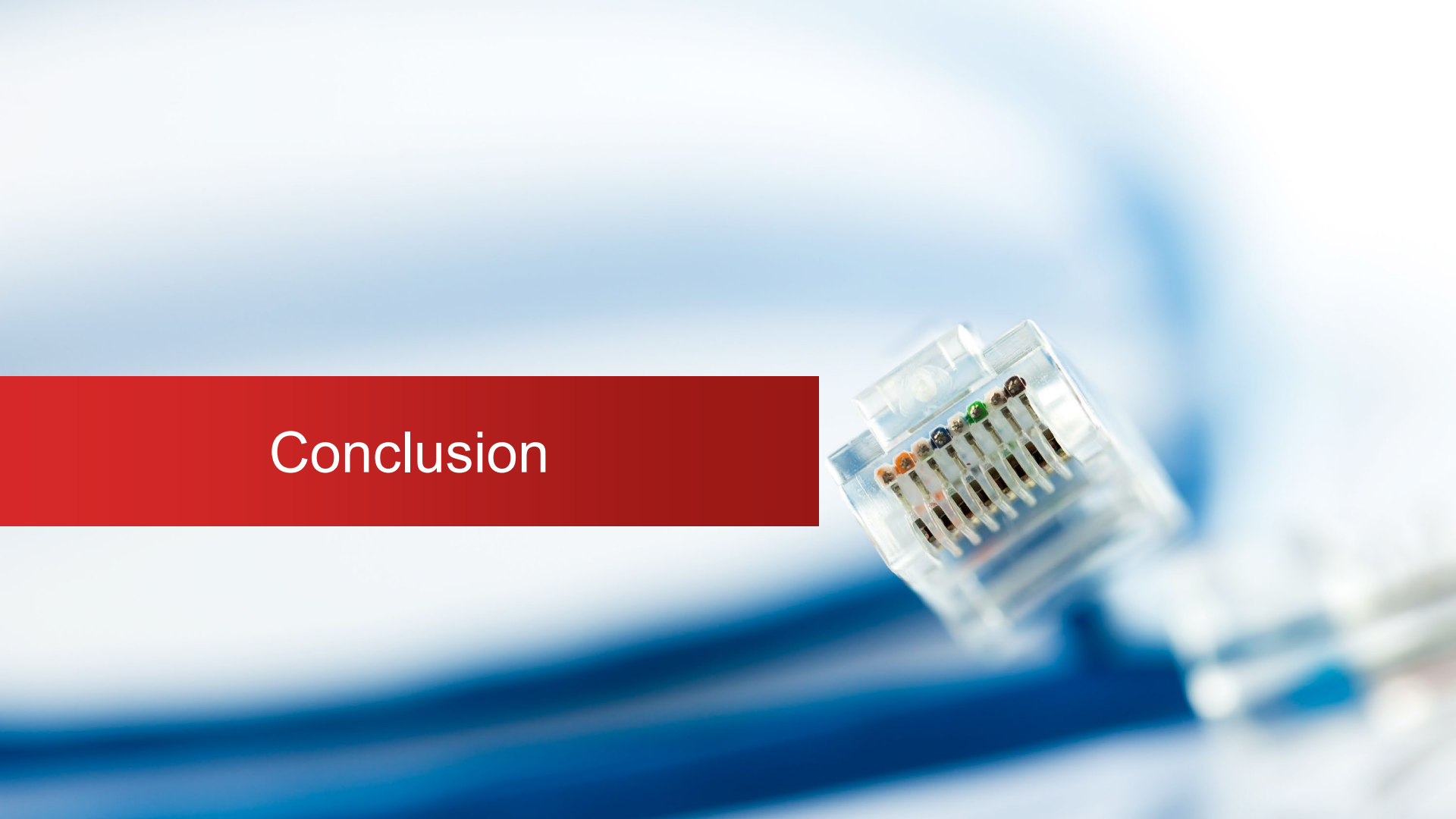
```
procedure fetch_rows(tag_string in varchar2)
as
  rowset dbms_tf.row_set_t;
  rowcount pls_integer;
  colcount pls_integer;
  tag_value varchar2(4000);
begin
  dbms_tf.get_row_set(rowset, rowcount, colcount);
  dbms_output.put_line(rowcount||' - '||colcount);
  for i in 1..rowset.count loop
    dbms_output.put_line(rowset(i).description.name||' - '||rowset(i).tab_varchar2.count||' -
'||rowset(i).tab_number.count);
  end loop;
  for i in 1..rowcount loop
    for j in 1..colcount loop
      -- The new columns are varchar2(4000)
      tag_value:= case rowset(j).description.type
                    when dbms_tf.type_varchar2 then rowset(j).tab_varchar2(i)
                    when dbms_tf.type_number then to_char(rowset(j).tab_number(i))
                    else 'DATATYPE NOT IMPLEMENTED‘
                  end;
      rowset(j).tab_varchar2(i) := replace(tag_string, '%s',tag_value);
    end loop;
  end loop;
  dbms_tf.put_row_set(rowset);
end fetch_rows;
```

Demo

Conclusion



Modern Features for a cool Language

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Qualified Expressions

- more than syntactical sugar
- make code shorter
- improve readability

Polymorphic Table Functions

- Simplifies SQL for non-technical Users
- Great potential
- Powerful & flexible Enhancement to SQL

* or at LiveSQL.oracle.com

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Vielen Dank für Ihre Aufmerksamkeit.