Oracle collections

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Purpose

The goal of this article is to show the principal features about the collections.

We will see how to declare, initialize and handle collection with SQL and PL/SQL.

All the examples have been runned on a 10.1.0.2.0 database release.

1. Definition

This is what the documentation says about collections:

“A *collection* is an ordered group of elements, all of the same type. It is a general concept that encompasses lists, arrays, and other familiar datatypes.
Each element has a unique subscript that determines its position in the collection.

PL/SQL offers these collection types:

- **Index-by tables**, also known as **associative arrays**, let you look up elements using arbitrary numbers and strings for subscript values.
  (They are similar to *hash tables* in other programming languages.)
- **Nested tables** hold an arbitrary number of elements. They use sequential numbers as subscripts.
  You can define equivalent SQL types, allowing nested tables to be stored in database tables and manipulated through SQL.
- **Varrays** (short for variable-size arrays) hold a fixed number of elements (although you can change the number of elements at runtime).
  They use sequential numbers as subscripts. You can define equivalent SQL types, allowing varrays to be stored in database tables.
  They can be stored and retrieved through SQL, but with less flexibility than nested tables.

Although collections can have only one dimension, you can model multi-dimensional arrays by creating collections whose elements are also collections.

To use collections in an application, you define one or more PL/SQL types, then define variables of those types.
You can define collection types in a procedure, function, or package.
You can pass collection variables as parameters, to move data between client-side applications and stored subprograms.

To look up data that is more complex than single values, you can store PL/SQL records or SQL object types in collections. Nested tables and varrays can also be attributes of object types.”

2. Persistent and non-persistent collections

Index-by tables cannot be stored in database tables, so they are non-persistent.
You cannot use them in a SQL statement and are available only in PL/SQL blocks.

Nested tables and **Varrays** are persistent. You can use the CREATE TYPE statement to create them in the database, you can read and write them from/to a database column.

Nested tables and Varrays must have been initialized before you can use them.

3. Declarations

3.1 Nested tables

```
TYPE type_name IS TABLE OF element_type [NOT NULL];
```

With nested tables declared within PL/SQL, *element_type* can be any PL/SQL datatype except : REF CURSOR

Nested tables declared in SQL (CREATE TYPE) have additional restrictions. They cannot use the following element types:

- BINARY_INTEGER, PLS_INTEGER
- BOOLEAN
- LONG, LONG RAW
- NATURAL, NATURALN
- POSITIVE, POSITIVEN
- REF CURSOR
- SIGNTYPE
- STRING

PL/SQL

```
Declare
   TYPE TYP_NT_NUM IS TABLE OF NUMBER ;
```

SQL

```
   CREATE [OR REPLACE] TYPE TYP_NT_NUM IS TABLE OF NUMBER ;
```

3.2 Varrays

```
TYPE type_name IS {VARRAY | VARYING ARRAY} (size_limit)
   OF element_type [NOT NULL];
```

size_limit is a positive integer literal representing the maximum number of elements in the array.

PL/SQL

```
Declare
   TYPE TYP_V_CHAR IS VARRAY(10) OF VARCHAR2(20) ;
```

SQL

```
   CREATE [OR REPLACE] TYPE TYP_V_CHAR IS VARRAY(10) OF VARCHAR2(20) ;
```

3.3 Index-by tables

```
TYPE type_name IS TABLE OF element_type [NOT NULL]
   INDEX BY [BINARY_INTEGER | PLS_INTEGER | VARCHAR2(size_limit)];
INDEX BY key_type;
```

The *key_type* can be numeric, either BINARY_INTEGER or PLS_INTEGER(^{9i}).
It can also be VARCHAR2 or one of its subtypes VARCHAR, STRING, or LONG. You must specify the length of a VARCHAR2-based key, except for LONG which is equivalent to declaring a key type of VARCHAR2(32760).
The types RAW, LONG RAW, ROWID, CHAR, and CHARACTER are not allowed as keys for an associative array.

```
Declare
   TYPE TYP_TAB_VAR IS TABLE OF VARCHAR2(50) INDEX BY BINARY_INTEGER ;
```

4. Initalization

Only Nested tables and varrays need initialization.
To initialize a collection, you use the “constructor” of the collection which name is the same as the collection.

4.1 Nested tables

```
Declare
   TYPE TYP_NT_NUM IS TABLE OF NUMBER ;
    Nt_tab TYP_NT_NUM ;
Begin
   Nt_tab := TYP_NT_NUM( 5, 10, 15, 20 ) ;
End ;
```

4.2 Varrays

```
Declare
   TYPE TYP_V_DAY IS VARRAY(7) OF VARCHAR2(15) ;
   v_tab TYP_V_DAY ;
Begin
   v_tab := TYP_NT_NUM( ‘Sunday’,’Monday’,’Tuesday’,’Wedneday’,’Thursday’,’Friday’,’Saturday’ ) ;
End ;
```

It is not required to initialize all the elements of a collection. You can either initialize no element. In this case, use an empty constructor.

```
v_tab := TYP_NT_NUM() ;
```

This collection is empty, which is different than a NULL collection (not initialized).

4.3 Index-by tables

```
Declare
   TYPE TYP_TAB IS TABLE OF NUMBER INDEX BY PLS_INTEGER ;
   my_tab  TYP_TAB ;
Begin
   my_tab(1) := 5 ;
   my_tab(2) := 10 ;
   my_tab(3) := 15 ;
End ;
```

5. Handle the collection

While the collection is not initialized (Nested tables and Varrays), it is not possible to manipulate it.

You can test if a collection is initialized:

```
Declare
  TYPE TYP_VAR_TAB is VARRAY(30) of varchar2(100) ;
  tab1 TYP_VAR_TAB ; -- declared but not initialized
Begin
  If Tab1 IS NULL Then
```

```
       -- NULL collection, have to initialize it --
      Tab1 := TYP_VAR_TAB('','','','','','','','','','');
  End if ;
  -- Now, we can handle the collection --
End ;
```

To access an element of a collection, we need to use a subscript value that indicates the unique element of the collection.
The subscript is of type integer or varchar2.

```
Declare
   Type    TYPE_TAB_EMP IS TABLE OF Varchar2(60) INDEX BY BINARY_INTEGER ;
   emp_tab TYPE_TAB_EMP ;
   i       pls_integer ;
Begin
   For i in 0..10 Loop
     emp_tab( i+1 ) := 'Emp ' || ltrim( to_char( i ) ) ;
   End loop ;
End ;

Declare
  Type    TYPE_TAB_DAYS IS TABLE OF PLS_INTEGER INDEX BY VARCHAR2(20) ;
  day_tab TYPE_TAB_DAYS ;
Begin
   day_tab( 'Monday' )    := 10 ;
   day_tab( 'Tuesday' )   := 20 ;
   day_tab( 'Wednesday' ) := 30 ;
End ;
```

It is possible to assign values of a collection to another collection if they are of the same type.

```
Declare
  Type TYPE_TAB_EMP  IS TABLE OF EMP%ROWTYPE INDEX BY BINARY_INTEGER ;
  Type TYPE_TAB_EMP2 IS TABLE OF EMP%ROWTYPE INDEX BY BINARY_INTEGER ;
  tab1 TYPE_TAB_EMP  := TYPE_TAB_EMP( ... );
  tab2 TYPE_TAB_EMP  := TYPE_TAB_EMP( ... );
  tab3 TYPE_TAB_EMP2 := TYPE_TAB_EMP2( ... );
Begin
    tab2 := tab1 ; -- OK
    tab3 := tab1 ; -- Error : types not similar
    ...
End ;
```

Comparing collections

Until the 10g release, collections cannot be directly compared for equality or inequality.

The 10g release allows to do some comparaisons between collections:

You can compare collections of same type to verify if they ar equals or not equals

```
DECLARE
   TYPE      Colors IS TABLE OF VARCHAR2(64);
   primaries     Colors := Colors('Blue','Green','Red');
   rgb           Colors := Colors('Red','Green','Blue');
   traffic_light Colors := Colors('Red','Green','Amber');
BEGIN
    -- We can use = or !=, but not < or >.
    -- 2 collections are equal even if the membersare not in the same order.
   IF primaries = rgb THEN
      dbms_output.put_line('OK, PRIMARIES & RGB have same members.');
   END IF;
   IF rgb != traffic_light THEN
      dbms_output.put_line('RGB & TRAFFIC_LIGHT have different members');
   END IF;
END;
```

You can also apply some operators on the collections:

```
DECLARE
  TYPE nested_typ IS TABLE OF NUMBER;
  nt1 nested_typ := nested_typ(1,2,3);
  nt2 nested_typ := nested_typ(3,2,1);
  nt3 nested_typ := nested_typ(2,3,1,3);
  nt4 nested_typ := nested_typ(1,2,4);
  reponse BOOLEAN;
  combien NUMBER;
  PROCEDURE verif(test BOOLEAN DEFAULT NULL, label IN VARCHAR2 DEFAULT NULL, quantity NUMBER DEFAULT NULL) IS
  BEGIN
     IF test IS NOT NULL THEN
        dbms_output.put_line(label || ' -> ' || CASE test WHEN TRUE THEN 'True' WHEN FALSE THEN 'False' END);
```

```
      END IF;
      IF quantity IS NOT NULL THEN
         dbms_output.put_line(quantity);
      END IF;
   END;
BEGIN
  reponse := nt1 IN (nt2,nt3,nt4); -- true, nt1 correspond to nt2
  verif(test => reponse, label => 'nt1 IN (nt2,nt3,nt4)');
  reponse := nt1 SUBMULTISET OF nt3; -- true, all elements correpond
  verif(test => reponse, label => 'nt1 SUBMULTISET OF nt3');
  reponse := nt1 NOT SUBMULTISET OF nt4; -- true
  verif(test => reponse, label => 'nt1 NOT SUBMULTISET OF nt4');

  combien := CARDINALITY(nt3); -- number of elements of nt3
  verif(quantity => combien);
  combien := CARDINALITY(SET(nt3)); -- number of distinct elements
  verif(quantity => combien);

  reponse := 4 MEMBER OF nt1; -- false, no corresponding element
  verif(test => reponse, label => '4 MEMBER OF nt1');
  reponse := nt3 IS A SET; -- false, nt3 have duplicated elements
  verif(test => reponse, label => 'nt3 IS A SET' );
  reponse := nt3 IS NOT A SET; -- true, nt3 have diplicated elements
  verif(test => reponse, label => 'nt3 IS NOT A SET' );
  reponse := nt1 IS EMPTY; -- false, nt1 have elements
  verif(test => reponse, label => 'nt1 IS EMPTY' );
END;
```

```
nt1 IN (nt2,nt3,nt4) -> True
nt1 SUBMULTISET OF nt3 -> True
nt1 NOT SUBMULTISET OF nt4 -> True
4
3
4 MEMBER OF nt1 -> False
nt3 IS A SET -> False
nt3 IS NOT A SET -> True
nt1 IS EMPTY -> False
```

6. Methods

We can use the following methods on a collection:

- EXISTS
- COUNT
- LIMIT
- FIRST and LAST
- PRIOR and NEXT
- EXTEND
- TRIM
- DELETE

A collection method is a built-in function or procedure that operates on collections and is called using dot notation.

```
collection_name.method_name[(parameters)]
```

Collection methods cannot be called from SQL statements.

Only the EXISTS method can be used on a NULL collection.
all other methods applied on a null collection raise the COLLECTION_IS_NULL error.

6.1 EXISTS(index)

Returns TRUE if the *index* element exists in the collection, else it returns FALSE.

Use this method to be sure you are doing a valid operation on the collection.
This method does not raise the SUBSCRIPT_OUTSIDE_LIMIT exception if used on an element that does not exists in the collection.

```
If my_collection.EXISTS(10) Then
   My_collection.DELETE(10) ;
End if ;
```

6.2 COUNT

Returns the number of elements in a collection.

```
SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF NUMBER;
  3     my_tab  TYP_TAB := TYP_TAB( 1, 2, 3, 4, 5 );
  4  Begin
  5     Dbms_output.Put_line( 'COUNT = ' || To_Char( my_tab.COUNT ) ) ;
  6     my_tab.DELETE(2) ;
  7     Dbms_output.Put_line( 'COUNT = ' || To_Char( my_tab.COUNT ) ) ;
  8  End ;
  9  /
COUNT = 5
COUNT = 4

PL/SQL procedure successfully completed.
```

6.3 LIMIT

Returns the maximum number of elements that a varray can contain.
Return NULL for Nested tables and Index-by tables

```
SQL> Declare
  2    TYPE TYP_ARRAY IS ARRAY(30) OF NUMBER ;
  3    my_array  TYP_ARRAY := TYP_ARRAY( 1, 2, 3 ) ;
  4  Begin
  5    dbms_output.put_line( 'Max array size is ' || my_array.LIMIT ) ;
  6  End;
  7  /
Max array size is 30
```

6.4 FIRST and LAST

Returns the first or last subscript of a collection.

If the collection is empty, FIRST and LAST return NULL

```
SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF NUMBER;
  3     my_tab  TYP_TAB := TYP_TAB( 1, 2, 3, 4, 5 );
  4  Begin
  5     For i IN my_tab.FIRST .. my_tab.LAST Loop
  6        Dbms_output.Put_line( 'my_tab(' || Ltrim(To_Char(i)) || ') = ' || To_Char( my_tab(i) ) ) ;
  7     End loop ;
  8  End ;
  9
 10  /
my_tab(1) = 1
my_tab(2) = 2
my_tab(3) = 3
my_tab(4) = 4
my_tab(5) = 5

PL/SQL procedure successfully completed.

SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF PLS_INTEGER INDEX BY VARCHAR2(1);
  3     my_tab  TYP_TAB;
  4  Begin
  5     For i in 65 .. 69 Loop
  6        my_tab( Chr(i) ) := i ;
  7     End loop ;
  8     Dbms_Output.Put_Line( 'First= ' || my_tab.FIRST || '  Last= ' || my_tab.LAST ) ;
  9  End ;
 10  /
First= A  Last= E

PL/SQL procedure successfully completed.
```

6.5 PRIOR(index) and NEXT(index)

Returns the previous or next subscript of the *index* element.

If the *index* element has no predecessor, PRIOR(index) returns NULL. Likewise, if *index* has no successor, NEXT(index) returns NULL.

```
SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF PLS_INTEGER INDEX BY VARCHAR2(1) ;
  3     my_tab  TYP_TAB ;
  4     c       Varchar2(1) ;
  5  Begin
  6     For i in 65 .. 69 Loop
  7        my_tab( Chr(i) ) := i ;
  8     End loop ;
  9     c := my_tab.FIRST ; -- first element
 10     Loop
 11        Dbms_Output.Put_Line( 'my_tab(' || c || ') = ' || my_tab(c) ) ;
 12        c := my_tab.NEXT(c) ; -- get the successor element
 13        Exit When c IS NULL ; -- end of collection
 14     End loop ;
 15  End ;
 16  /
my_tab(A) = 65
my_tab(B) = 66
my_tab(C) = 67
my_tab(D) = 68
my_tab(E) = 69

PL/SQL procedure successfully completed.
```

Use the PRIOR() or NEXT() method to be sure that you do not access an invalid element:

```
SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF PLS_INTEGER ;
  3     my_tab  TYP_TAB := TYP_TAB( 1, 2, 3, 4, 5 );
  4  Begin
  5     my_tab.DELETE(2) ; -- delete an element of the collection
  6     For i in my_tab.FIRST .. my_tab.LAST Loop
  7        Dbms_Output.Put_Line( 'my_tab(' || Ltrim(To_char(i)) || ') = ' || my_tab(i) ) ;
  8     End loop ;
  9  End ;
 10  /
my_tab(1) = 1
Declare
*
ERROR at line 1:
ORA-01403: no data found
ORA-06512: at line 7
```

In this example, we get an error because one element of the collection was deleted.

One solution is to use the PRIOR()/NEXT() method:

```
SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF PLS_INTEGER ;
  3     my_tab  TYP_TAB := TYP_TAB( 1, 2, 3, 4, 5 );
  4     v       Pls_Integer ;
  5  Begin
  6     my_tab.DELETE(2) ;
  7     v := my_tab.first ;
  8     Loop
  9        Dbms_Output.Put_Line( 'my_tab(' || Ltrim(To_char(v)) || ') = ' || my_tab(v) ) ;
 10        v := my_tab.NEXT(v) ; -- get the next valid subscript
 11        Exit When v IS NULL ;
 12     End loop ;
 13  End ;
 14  /
my_tab(1) = 1
my_tab(3) = 3
my_tab(4) = 4
my_tab(5) = 5

PL/SQL procedure successfully completed.
```

Another solution is to test if the index exists before use it:

```
SQL> Declare
  2     TYPE    TYP_TAB IS TABLE OF PLS_INTEGER ;
  3     my_tab  TYP_TAB := TYP_TAB( 1, 2, 3, 4, 5 );
  4  Begin
  5     my_tab.DELETE(2) ;
  6     For i IN my_tab.FIRST .. my_tab.LAST Loop
```

```
           If my_tab.EXISTS(i) Then
              Dbms_Output.Put_Line( 'my_tab(' || Ltrim(To_char(i)) || ') = ' || my_tab(i) ) ;
           End if ;
        End loop ;
     End ;
     /
my_tab(1) = 1
my_tab(3) = 3
my_tab(4) = 4
my_tab(5) = 5

PL/SQL procedure successfully completed.
```

6.6 EXTEND[(n[,i])]

Used to extend a collection (add new elements)

- EXTEND appends one null element to a collection.
- EXTEND(n) appends n null elements to a collection.
- EXTEND(n,i) appends n copies of the *i*th element to a collection.

```
SQL> Declare
        TYPE TYP_NES_TAB is table of Varchar2(20) ;
        tab1 TYP_NES_TAB ;
        i    Pls_Integer ;
        Procedure Print( i in Pls_Integer ) IS
        BEGIN Dbms_Output.Put_Line( 'tab1(' || ltrim(to_char(i)) ||') = ' || tab1(i) ) ; END ;
        Procedure PrintAll IS
        Begin
          Dbms_Output.Put_Line( '* Print all collection *' ) ;
       For i IN tab1.FIRST..tab1.LAST Loop
             If tab1.EXISTS(i) Then
             Dbms_Output.Put_Line( 'tab1(' || ltrim(to_char(i)) ||') = ' || tab1(i) ) ;
       End if ;
       End loop ;
        End ;
     Begin
        tab1 := TYP_NES_TAB('One') ;
        i := tab1.COUNT ;
        Dbms_Output.Put_Line( 'tab1.COUNT = ' || i ) ;
        Print(i) ;
        -- the following line raise an error because the second index does not exists in the collection --
        -- tab1(2) := 'Two' ;
        -- Add one empty element --
        tab1.EXTEND ;
        i := tab1.COUNT ;
        tab1(i) := 'Two' ; Printall ;
        -- Add two empty elements --
        tab1.EXTEND(2) ;
        i := i + 1 ;
        tab1(i) := 'Three' ;
        i := i + 1 ;
        tab1(i) := 'Four' ; Printall ;
        -- Add three elements with the same value as element 4 --
        tab1.EXTEND(3,1) ;
        i := i + 3 ; Printall ;
     End;
/
tab1.COUNT = 1
tab1(1) = One
* Print all collection *
tab1(1) = One
tab1(2) = Two
* Print all collection *
tab1(1) = One
tab1(2) = Two
tab1(3) = Three
tab1(4) = Four
* Print all collection *
tab1(1) = One
tab1(2) = Two
tab1(3) = Three
tab1(4) = Four
tab1(5) = One
tab1(6) = One
```

```
tab1(7) = One

PL/SQL procedure successfully completed.
```

6.7 TRIM[(n)]

Used to decrease the size of a collection

- `TRIM` removes one element from the end of a collection.
- `TRIM(n)` removes n elements from the end of a collection.

```
SQL> Declare
        TYPE TYP_TAB is table of varchar2(100) ;
        tab  TYP_TAB ;
     Begin
        tab := TYP_TAB( 'One','Two','Three' ) ;
        For i in tab.first..tab.last Loop
          dbms_output.put_line( 'tab(' || ltrim( to_char( i ) ) || ') = ' || tab(i) ) ;
        End loop ;
        -- add 3 element with second element value --
        dbms_output.put_line( '* add 3 elements *' ) ;
        tab.EXTEND(3,2) ;
        For i in tab.first..tab.last Loop
          dbms_output.put_line( 'tab(' || ltrim( to_char( i ) ) || ') = ' || tab(i) ) ;
        End loop ;
        -- suppress the last element --
        dbms_output.put_line( '* suppress the last element *' ) ;
        tab.TRIM ;
        For i in tab.first..tab.last Loop
          dbms_output.put_line( 'tab(' || ltrim( to_char( i ) ) || ') = ' || tab(i) ) ;
        End loop ;
     End;
     /
tab(1) = One
tab(2) = Two
tab(3) = Three
* add 3 elements *
tab(1) = One
tab(2) = Two
tab(3) = Three
tab(4) = Two
tab(5) = Two
tab(6) = Two
* suppress the last element *
tab(1) = One
tab(2) = Two
tab(3) = Three
tab(4) = Two
tab(5) = Two

PL/SQL procedure successfully completed.
```

If you try to suppress more elements than the collection contents, you get a SUBSCRIPT_BEYOND_COUNT exception.

6.8 DELETE[(n[,m])]

- `DELETE` removes all elements from a collection.
- `DELETE(n)` removes the *n*th element from an associative array with a numeric key or a nested table. If the associative array has a string key, the element corresponding to the key value is deleted. If n is null, `DELETE(n)` does nothing.
- `DELETE(n,m)` removes all elements in the range `m..n` from an associative array or nested table. If `m` is larger than n or if `m` or n is null, `DELETE(n,m)` does nothing

Caution :
LAST returns the greatest subscript of a collection and COUNT returns the number of elements of a collection.
If you delete some elements, LAST != COUNT.

Suppression of all the elements

```
SQL> Declare
  2    TYPE TYP_TAB is table of varchar2(100) ;
  3    tab  TYP_TAB ;
  4  Begin
  5    tab := TYP_TAB( 'One','Two','Three' ) ;
  6    dbms_output.put_line( 'Suppression of all elements' ) ;
  7    tab.DELETE ;
  8    dbms_output.put_line( 'tab.COUNT = ' || tab.COUNT) ;
  9  End;
 10  /
Suppression of all elements
tab.COUNT = 0

PL/SQL procedure successfully completed.
```

Suppression of the second element

```
SQL> Declare
  2    TYPE TYP_TAB is table of varchar2(100) ;
  3    tab  TYP_TAB ;
  4  Begin
  5    tab := TYP_TAB( 'One','Two','Three' ) ;
  6    dbms_output.put_line( 'Suppression of the 2nd element' ) ;
  7    tab.DELETE(2) ;
  8    dbms_output.put_line( 'tab.COUNT = ' || tab.COUNT) ;
  9    dbms_output.put_line( 'tab.LAST  = ' || tab.LAST) ;
 10    For i IN tab.FIRST .. tab.LAST Loop
 11      If tab.EXISTS(i) Then
 12         dbms_output.put_line( tab(i) ) ;
 13      End if ;
 14    End loop ;
 15  End;
 16  /
Suppression of the 2nd element
tab.COUNT = 2
tab.LAST  = 3
One
Three

PL/SQL procedure successfully completed.
```

Caution:
For Varrays, you can suppress only the last element.
If the element does not exists, no exception is raised.

6.9 Main collection exceptions

```
DECLARE
   TYPE NumList IS TABLE OF NUMBER;
   nums NumList;  -- atomically null
BEGIN
   /* Assume execution continues despite the raised exceptions. */
   nums(1) := 1;            -- raises COLLECTION_IS_NULL       (1)
   nums := NumList(1,2);    -- initialize table
   nums(NULL) := 3          -- raises VALUE_ERROR              (2)
   nums(0) := 3;            -- raises SUBSCRIPT_OUTSIDE_LIMIT  (3)
   nums(3) := 3;            -- raises SUBSCRIPT_BEYOND_COUNT   (4)
   nums.DELETE(1);          -- delete element 1
   IF nums(1) = 1 THEN ...  -- raises NO_DATA_FOUND            (5)
```

7. Multi-level Collections

A collection is a one-dimension table.
You can have multi-dimension tables by creating collection of collection.

```
SQL> Declare
  2    TYPE TYP_TAB is table of NUMBER index by PLS_INTEGER ;
  3    TYPE TYP_TAB_TAB is table of TYP_TAB index by PLS_INTEGER ;
  4    tab1 TYP_TAB_TAB ;
  5  Begin
  6    For i IN 1 .. 3 Loop
  7       For j IN 1 .. 2 Loop
  8         tab1(i)(j) := i + j ;
  9         dbms_output.put_line( 'tab1('   || ltrim(to_char(i))
 10                               || ')('   || ltrim(to_char(j))
 11                               || ') = ' || tab1(i)(j) ) ;
 12       End loop ;
 13    End loop ;
 14  End;
 15  /
tab1(1)(1) = 2
tab1(1)(2) = 3
tab1(2)(1) = 3
tab1(2)(2) = 4
tab1(3)(1) = 4
tab1(3)(2) = 5

PL/SQL procedure successfully completed.
```

Collections of records

```
SQL> Declare
  2    TYPE TYP_TAB is table of DEPT%ROWTYPE index by PLS_INTEGER ;
  3    tb_dept TYP_TAB ;
  4    rec     DEPT%ROWTYPE ;
  5    Cursor  CDEPT IS Select * From DEPT ;
  6  Begin
  7    Open CDEPT ;
  8    Loop
  9       Fetch CDEPT Into rec ;
 10       Exit  When CDEPT%NOTFOUND ;
 11       tb_dept(CDEPT%ROWCOUNT) := rec ;
 12    End loop ;
 13    For i IN tb_dept.FIRST .. tb_dept.LAST Loop
 14      dbms_output.put_line( tb_dept(i).DNAME || ' - ' ||tb_dept(i).LOC ) ;
 15    End loop ;
 16  End;
 17  /
ACCOUNTING - NEW YORK
RESEARCH - DALLAS
SALES - CHICAGO
OPERATIONS - BOSTON

PL/SQL procedure successfully completed.
```

8. Collections and database tables

Nested tables and Varrays can be stored in a database column of relational or object table.

To manipulate collection from SQL, you have to create the types in the database with the CREATE TYPE statement.

Nested tables

```
CREATE [OR REPLACE] TYPE [schema. .] type_name
{ IS | AS } TABLE OF datatype;
```

Varrays

```
CREATE [OR REPLACE] TYPE [schema. .] type_name
{ IS | AS } { VARRAY | VARYING ARRAY } ( limit ) OF datatype;
```

One or several collections can be stored in a database column.

Let’s see an example with a relational table.

You want to make a table that store the invoices and the currents invoice lines of the company.

You need to define the invoice line type as following:

```
-- type of invoice line --
CREATE TYPE TYP_LIG_ENV AS OBJECT (
  lig_num    Integer,
  lig_code   Varchar2(20),
  lig_Pht    Number(6,2),
  lig_Tva    Number(3,1),
  ligQty     Integer
);

-- nested table of invoice lines --
CREATE TYPE TYP_TAB_LIG_ENV AS TABLE OF TYP_LIG_ENV ;
```

Then create the invoice table as following:

```
-- table of invoices --
CREATE TABLE INVOICE (
  inv_num     Number(9),
  inv_numcli  Number(6),
  inv_date    Date,
  inv_line    TYP_TAB_LIG_ENV ) -- lines collection
  NESTED TABLE inv_line STORE AS inv_line_table ;
```

You can query the **USER_TYPES** view to get information on the types created in the database.

```
-- show all types --
SQL> select type_name, typecode, attributes from user_types
  2  /

TYPE_NAME                      TYPECODE                       ATTRIBUTES
------------------------------ ------------------------------ ----------
TYP_LIG_ENV                    OBJECT                                  5
TYP_TAB_LIG_ENV                COLLECTION                              0

SQL>
```

You can query the **USER_COLL_TYPES** view to get information on the collections created in the database.

```
-- show collections --
SQL> select type_name, coll_type, elem_type_owner, elem_type_name from user_coll_types
  2  /

TYPE_NAME                 COLL_TYPE              ELEM_TYPE_OWNER          ELEM_TYPE_NAME
------------------------- ---------------------- ------------------------ -------
TYP_TAB_LIG_ENV           TABLE                  TEST                     TYP_LIG_ENV
```

You can query the **USER_TYPE_ATTRS** view to get information on the collection attributes.

```
-- show collection attributes --
SQL> select type_name, attr_name, attr_type_name, length, precision, scale, attr_no
  2  from user_type_attrs
  3  /
TYPE_NAME       ATTR_NAME       ATTR_TYPE_     LENGTH  PRECISION      SCALE    ATTR_NO
--------------- --------------- ---------- ---------- ---------- ---------- ----------
TYP_LIG_ENV     LIG_NUM         INTEGER                                              1
TYP_LIG_ENV     LIG_CODE        VARCHAR2           20                                2
TYP_LIG_ENV     LIG_PHT         NUMBER                         6          2          3
TYP_LIG_ENV     LIG_TVA         NUMBER                         3          1          4
TYP_LIG_ENV     LIGQTY          INTEGER                                              5
```

Constraints on the collection attributes

You can enforce constraints on each attribute of a collection

```
-- constraints on collection attributes --
alter table inv_line_table
add constraint lignum_notnull CHECK( lig_num IS NOT NULL ) ;

alter table inv_line_table
add constraint ligcode_unique UNIQUE( lig_code ) ;

alter table inv_line_table
add constraint ligtva_check CHECK( lig_tva IN( 5.0,19.6 ) ) ;
```

Constraints on the whole collection

```
-- constraints on the whole collection --
alter table invoice
add constraint invoice_notnull CHECK( inv_line IS NOT NULL )
```

Check the constraints

```
SQL> select constraint_name, constraint_type, table_name
  2  from   user_constraints
  3  where  table_name IN ('INVOICE','INV_LINE_TABLE')
  4  order  by table_name
  5  /

CONSTRAINT_NAME                C TABLE_NAME
------------------------------ - ------------------------------
LIGNUM_NOTNULL                 C INV_LINE_TABLE
LIGCODE_UNIQUE                 U INV_LINE_TABLE
LIGTVA_CHECK                   C INV_LINE_TABLE
SYS_C0011658                   U INVOICE
INVOICE_NOTNULL                C INVOICE


SQL> select constraint_name, column_name, table_name
  2  from   user_cons_columns
  3  where  table_name IN ('INVOICE','INV_LINE_TABLE')
  4  order  by table_name
  5  /

CONSTRAINT_NAME                COLUMN_NAME          TABLE_NAME
------------------------------ -------------------- ------------------
LIGNUM_NOTNULL                 LIG_NUM              INV_LINE_TABLE
LIGCODE_UNIQUE                 LIG_CODE             INV_LINE_TABLE
LIGTVA_CHECK                   LIG_TVA              INV_LINE_TABLE
SYS_C0011658                   SYS_NC0000400005$    INVOICE
INVOICE_NOTNULL                SYS_NC0000400005$    INVOICE
INVOICE_NOTNULL                INV_LINE             INVOICE

6 rows selected.
```

8.1 Insertion

Add a line in the INVOICE table

Use the INSERT statement with all the constructors needed for the collection

```
SQL> INSERT INTO INVOICE
  2  VALUES
  3  (
  4     1
  5    ,1000
  6    ,SYSDATE
  7    , TYP_TAB_LIG_ENV  -- Table of objects constructor
  8      (
  9         TYP_LIG_ENV( 1 ,'COD_01', 1000, 5.0, 1 ) -- object constructor
 10      )
 11  )
 12  /

1 row created.
```

Add a line to the collection

Use the INSERT INTO TABLE statement

```
INSERT INTO TABLE
  ( SELECT the_collection FROM the_table WHERE ... )
```

The sub query must return a single collection row.

```
SQL> INSERT INTO TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1)
  2  VALUES( TYP_LIG_ENV( 2 ,'COD_02', 50, 5.0, 10 ) )
  3  /

1 row created.
```

Multiple inserts

You can add more than one element in a collection by using the SELECT statement instead of the VALUES keyword.

```
INSERT INTO TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1)
SELECT nt.* FROM TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
/
```

8.2 Update

8.2.1 Nested table

Use the UPDATE TABLE statement

```
UPDATE TABLE
  ( SELECT the_collection FROM the_table WHERE ... ) alias
SET
  Alias.col_name = ...
WHERE ...
```

The sub query must return a single collection row.

Update a single row of the collection

```
SQL> UPDATE TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  2  SET    nt.ligqty = 10
  3  WHERE  nt.lig_num = 1
  4  /

1 row updated.
```

Update all the rows of the collection

```
SQL> UPDATE TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  2  SET    nt.lig_pht = nt.lig_pht * .1
  3  /

2 rows updated.
```

8.2.2 Varray

It is not possible to update one element of a VARRAY collection with SQL.
You cannot use the TABLE keyword for this purpose (because Varrays are not stored in particular table like Nested tables).
So, a single VARRAY element of a collection must be updated within a PL/SQL block:

```
-- varray of invoice lines --
CREATE TYPE TYP_VAR_LIG_ENV AS VARRAY(5) OF TYP_LIG_ENV ;

-- table of invoices with varray --
CREATE TABLE INVOICE_V (
  inv_num     Number(9),
  inv_numcli  Number(6),
  inv_date    Date,
  inv_line    TYP_VAR_LIG_ENV ) ;

-- insert a row --
Insert into INVOICE_V
Values
(
  1, 1000, SYSDATE,
  TYP_VAR_LIG_ENV
  (
     TYP_LIG_ENV( 1, 'COD_01', 1000, 5, 1 ),
     TYP_LIG_ENV( 2, 'COD_02',  500, 5, 10 ),
     TYP_LIG_ENV( 3, 'COD_03',   10, 5, 100 )
  )
) ;

SQL> -- Query the varray collection --
SQL> Declare
  2     v_table   TYP_VAR_LIG_ENV ;
  3     LC$Head   Varchar2(200) ;
  4     LC$Lig    Varchar2(200) ;
  5  Begin
  6     LC$Head := 'Num Code       Pht        Tva        Qty' ;
  7     Select inv_line Into v_table From INVOICE_V Where inv_num = 1 For Update of inv_line ;
  8     dbms_output.put_line ( LC$Head ) ;
  9     For i IN v_table.FIRST .. v_table.LAST Loop
 10       LC$Lig := Rpad(To_char( v_table(i).lig_num ),3) || ' '
 11           || Rpad(v_table(i).lig_code, 10) || ' '
 12           || Rpad(v_table(i).lig_pht,10) || ' '
 13           || Rpad(v_table(i).lig_tva,10) || ' '
 14           || v_table(i).ligqty ;
 15       dbms_output.put_line( LC$Lig ) ;
 16     End loop ;
 17  End ;
 18  /
Num Code       Pht        Tva        Qty
1   COD_01     1000       5          1
2   COD_02     500        5          10
3   COD_03     10         5          100

PL/SQL procedure successfully completed..
```

Update the second line of the varray to change the quantity

```
SQL> Declare
  2     v_table   TYP_VAR_LIG_ENV ;
  3  Begin
  4     Select inv_line
  5     Into   v_table
  6     From   INVOICE_V
  7     Where  inv_num = 1
  8     For Update of inv_line ;
  9     v_table(2).ligqty := 2 ; -- update the second element
 10     Update INVOICE_V Set inv_line = v_table Where inv_num = 1 ;
 11  End ;
 12  /

PL/SQL procedure successfully completed.
```

Display the new varray:

```
SQL> -- Query the varray collection --
SQL> Declare
  2     v_table   TYP_VAR_LIG_ENV ;
  3     LC$Head   Varchar2(200) ;
  4     LC$Lig    Varchar2(200) ;
  5  Begin
  6     LC$Head := 'Num Code       Pht        Tva        Qty' ;
  7     Select inv_line Into v_table From INVOICE_V Where inv_num = 1 For Update of inv_line ;
  8     dbms_output.put_line ( LC$Head ) ;
  9     For i IN v_table.FIRST .. v_table.LAST Loop
 10       LC$Lig := Rpad(To_char( v_table(i).lig_num ),3) || ' '
 11           || Rpad(v_table(i).lig_code, 10) || ' '
 12           || Rpad(v_table(i).lig_pht,10) || ' '
 13           || Rpad(v_table(i).lig_tva,10) || ' '
 14           || v_table(i).ligqty ;
 15       dbms_output.put_line( LC$Lig ) ;
 16     End loop ;
 17  End ;
 18  /
Num Code       Pht        Tva        Qty
1   COD_01     1000       5          1
2   COD_02     500        5          2
3   COD_03     10         5          100

PL/SQL procedure successfully completed.
```

8.3 Delete

8.3.1 Nested table

Use the DELETE FROM TABLE statement

Delete a single collection row

```
DELETE FROM TABLE
  ( SELECT the_collection FROM the_table WHERE ... ) alias
WHERE alias.col_name = ...

SQL> DELETE FROM TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  2  WHERE nt.lig_num = 2
  3  /

1 row deleted.
```

Delete all the collection rows

```
SQL> DELETE FROM TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  2  /

1 row deleted.
```

Use of a PL/SQL record to handle the whole structure

```
SQL> Declare
  2    TYPE TYP_REC IS RECORD
  3    (
  4      inv_num     INVOICE.inv_num%Type,
  5      inv_numcli  INVOICE.inv_numcli%Type,
  6      inv_date    INVOICE.inv_date%Type,
  7      inv_line    INVOICE.inv_line%Type   -- collection line
  8    );
  9    rec_inv  TYP_REC ;
 10    Cursor C_INV IS Select * From INVOICE ;
 11  Begin
 12     Open C_INV ;
 13     Loop
 14       Fetch C_INV into rec_inv ;
 15       Exit when C_INV%NOTFOUND ;
 16       For i IN 1 .. rec_inv.inv_line.LAST Loop   -- loop through the collection lines
 17         dbms_output.put_line( 'Numcli/Date ' || rec_inv.inv_numcli || '/' || rec_inv.inv_date
 18           || ' Line ' || rec_inv.inv_line(i).lig_num
 19           || ' code ' || rec_inv.inv_line(i).lig_code || ' Qty '
 20           || To_char(rec_inv.inv_line(i).ligqty) ) ;
 21       End loop ;
 22     End loop ;
 23  End ;
 24  /
Numcli/Date 1000/11/11/05 Line 1 code COD_01 Qty 1
Numcli/Date 1000/11/11/05 Line 2 code COD_02 Qty 10

PL/SQL procedure successfully completed.
```

8.3.2 Varray

Varrays are more complicated to handle.
It is not possible to delete a single element in a Varray collection.
To do the job, you need a PL/SQL block and a temporary Varray that keep only the lines that are not deleted.

```
SQL> Declare
  2     v_table   TYP_VAR_LIG_ENV ;
  3     v_tmp     v_table%Type := TYP_VAR_LIG_ENV() ;
  4     ind       pls_integer  := 1 ;
  5  Begin
  6     -- select the collection --
  7     Select inv_line
  8     Into   v_table
  9     From   INVOICE_V
 10     Where  inv_num = 1
 11     For Update of inv_line ;
 12     -- Extend the temporary varray --
 13     v_tmp.EXTEND(v_table.LIMIT) ;
 14     For i IN v_table.FIRST .. v_table.LAST Loop
 15        If v_table(i).lig_num <> 2 Then
 16           v_tmp(ind) := v_table(i) ; ind := ind + 1 ;
 17        End if ;
 18     End loop ;
 19
 20     Update INVOICE_V Set inv_line = v_tmp Where inv_num = 1 ;
 21  End ;
 22  /

PL/SQL procedure successfully completed.
```

Display the new collection:

```
SQL> Declare
  2     v_table   TYP_VAR_LIG_ENV ;
```

```
   LC$Head   Varchar2(200) ;
   LC$Lig    Varchar2(200) ;
Begin
   LC$Head := 'Num Code       Pht        Tva        Qty' ;
   Select inv_line Into v_table From INVOICE_V Where inv_num = 1 For Update of inv_line ;
   dbms_output.put_line ( LC$Head ) ;
   For i IN v_table.FIRST .. v_table.LAST Loop
     LC$Lig := Rpad(To_char( v_table(i).lig_num ),3) || ' '
         || Rpad(v_table(i).lig_code, 10) || ' '
         || Rpad(v_table(i).lig_pht,10) || ' '
         || Rpad(v_table(i).lig_tva,10) || ' '
         || v_table(i).ligqty ;
     dbms_output.put_line( LC$Lig ) ;
   End loop ;
End ;
/
Num Code       Pht        Tva        Qty
1   COD_01     1000       5          1
3   COD_03     10         5          100

PL/SQL procedure successfully completed.
```

The second line of the Varray has been deleted.

Here is a Procedure that do the job with any Varray collection

```
CREATE OR REPLACE PROCEDURE DEL_ELEM_VARRAY
(
  PC$Table in Varchar2, -- Main table name
  PC$Pk    in Varchar2, -- PK to identify the main table row
  PC$Type  in Varchar2, -- Varray TYPE
  PC$Coll  in Varchar2, -- Varray column name
  PC$Index in Varchar2, -- value of PK
  PC$Col   in Varchar2, -- Varray column
  PC$Value in Varchar2  -- Varray column value to delete
)
IS
  LC$Req Varchar2(2000);
Begin
LC$Req := 'Declare'
||  ' v_table ' || PC$Type || ';'
||  ' v_tmp v_table%Type := ' || PC$Type || '() ;'
||  ' ind  pls_integer := 1 ;'
||  'Begin'
||  ' Select ' || PC$Coll
||  ' Into  v_table'
||  ' From  ' || PC$Table
||  ' Where ' || PC$Pk || '=''' || PC$Index || ''''
||  ' For Update of ' || PC$Coll || ';'
||  ' v_tmp.EXTEND(v_table.LIMIT) ;'
||  ' For i IN v_table.FIRST .. v_table.LAST Loop'
||     ' If v_table(i).' || PC$Col|| '<>''' || PC$Value || ''' Then'
||     '   v_tmp(ind) := v_table(i) ; ind := ind + 1 ;'
||     ' End if ;'
||  ' End loop ;'
||  ' Update ' || PC$Table || ' Set ' || PC$Coll || ' = v_tmp Where ' || PC$Pk || '=''' || PC$Index ||
''';'
||  ' End;' ;

  Execute immediate LC$Req ;

End ;
/
```

Let’s delete the third element of the Varray:

```
SQL> Begin
  DEL_ELEM_VARRAY
  (
    'INVOICE_V',
    'inv_num',
    'TYP_VAR_LIG_ENV',
    'inv_line',
    '1',
    'lig_num',
    '3'
  );
End ;
/
```

```
PL/SQL procedure successfully completed.
```

8.4 Query

Query the whole table

```
SQL> select * from INVOICE
  2  /

   INV_NUM INV_NUMCLI INV_DATE
---------- ---------- --------
INV_LINE(LIG_NUM, LIG_CODE, LIG_PHT, LIG_TVA, LIGQTY)
------------------------------------------------------------------------------------------
         3       1001 11/11/05
TYP_TAB_LIG_ENV()

         2       1002 12/11/05
TYP_TAB_LIG_ENV(TYP_LIG_ENV(1, 'COD_03', 1000, 5, 1))

         1       1000 11/11/05
TYP_TAB_LIG_ENV(TYP_LIG_ENV(1, 'COD_01', 1000, 5, 1), TYP_LIG_ENV(2, 'COD_02', 50, 5, 10))
```

Not easy to read !
Let's try another syntax:

```
SQL> SELECT t1.inv_num, t1.inv_numcli, t1.inv_date, t2.* FROM invoice t1, TABLE(t1.inv_line) t2
  2  ORDER BY t1.inv_num, t2.lig_num desc
  3  /

   INV_NUM INV_NUMCLI INV_DATE    LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- ---------- -------- ---------- -------------------- ---------- ---------- ----------
         1       1000 11/11/05          2 COD_02                       50          5         10
         1       1000 11/11/05          1 COD_01                     1000          5          1
         2       1002 12/11/05          1 COD_03                     1000          5          1
```

We can see that the collection is treated as a table with the TABLE keyword.
The collection could be sorted on any column.

Query a particular row of the main table and the corresponding collection's rows

```
SQL> SELECT   t1.inv_num, t1.inv_numcli, t1.inv_date, t2.* FROM invoice t1, TABLE(t1.inv_line) t2
  2  WHERE    t1.inv_num = 1
  3  ORDER BY t1.inv_num, t2.lig_num desc
  4  /

   INV_NUM INV_NUMCLI INV_DATE    LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- ---------- -------- ---------- -------------------- ---------- ---------- ----------
         1       1000 11/11/05          2 COD_02                       50          5         10
         1       1000 11/11/05          1 COD_01                     1000          5          1
```

Query one main table row with a particular collection row

```
SQL> SELECT   t1.inv_num, t1.inv_numcli, t1.inv_date, t2.* FROM invoice t1, TABLE(t1.inv_line) t2
  2  WHERE    t1.inv_num  = 1
  3  AND      t2.lig_code = 'COD_01'
  4  /

   INV_NUM INV_NUMCLI INV_DATE    LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- ---------- -------- ---------- -------------------- ---------- ---------- ----------
         1       1000 11/11/05          1 COD_01                     1000          5          1
```

Query only the collection lines

```
SQL> select t2.* from invoice t1,TABLE(t1.inv_line) t2
  2  /

   LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- -------------------- ---------- ---------- ----------
         1 COD_03                     1000          5          1
         1 COD_01                     1000          5          1
         2 COD_02                       50          5         10
```

Query the collection for a particular parent row

Use the SELECT FROM TABLE statement

SQL

```
SELECT FROM TABLE
  ( SELECT the_collection FROM the_table WHERE ... )

SQL>  select * from TABLE(SELECT inv_line FROM INVOICE WHERE inv_num = 1)
  2  /

   LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- -------------------- ---------- ---------- ----------
         1 COD_01                     1000          5          1
         2 COD_02                       50          5         10
```

Another syntax:

```
SQL> Select t2.* from invoice t1,TABLE(t1.inv_line) t2
  2  Where  t1.inv_numcli = 1000
  3  /

   LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- -------------------- ---------- ---------- ----------
         1 COD_01                     1000          5          1
         2 COD_02                       50          5         10
```

PL/SQL

```
SQL> Declare
  2    TYPE TYP_REC IS RECORD
  3    (
  4      num   INV_LINE_TABLE.LIG_NUM%Type,
  5      code  INV_LINE_TABLE.LIG_CODE%Type,
  6      pht   INV_LINE_TABLE.LIG_PHT%Type,
  7      tva   INV_LINE_TABLE.LIG_TVA%Type,
  8      qty   INV_LINE_TABLE.LIGQTY%Type
  9    );
 10    -- Table of records --
 11    TYPE TAB_REC IS TABLE OF TYP_REC ;
 12    t_rec  TAB_REC ;
 13  Begin
 14    -- Store the lines into the table of records --
 15    Select *
 16    BULK COLLECT
 17    Into   t_rec
 18    from   TABLE(SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt ;
 19    -- Print the record attributes of each line--
 20    For i IN t_rec.FIRST .. t_rec.LAST Loop
 21      dbms_output.put_line( '** Line   = ' || t_rec(i).num || ' **' ) ;
 22      dbms_output.put_line( 'Code     = ' || t_rec(i).code ) ;
 23      dbms_output.put_line( 'Price    = ' || t_rec(i).pht ) ;
 24      dbms_output.put_line( 'Tax rate = ' || t_rec(i).tva ) ;
 25      dbms_output.put_line( 'Quantity = ' || t_rec(i).qty ) ;
 26    End loop ;
 27  End ;
 28  /
** Line   = 1 **
Code     = COD_01
Price    = 1000
Tax rate = 5
Quantity = 1
** Line   = 2 **
Code     = COD_02
Price    = 50
Tax rate = 5
Quantity = 10

PL/SQL procedure successfully completed.
```

Query a particular column of the collection

SQL

```
SQL> SELECT nt.lig_code, nt.lig_pht
  2  FROM   TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  3  WHERE  nt.lig_num = 1
  4  /

LIG_CODE                LIG_PHT
-------------------- ----------
COD_01                     1000
```

Another syntax:

```
SQL> Select t2.* from invoice t1,TABLE(t1.inv_line) t2
  2  Where  t1.inv_numcli = 1000
  3  And    t2.lig_num = 1
  4  /

   LIG_NUM LIG_CODE                LIG_PHT    LIG_TVA     LIGQTY
---------- -------------------- ---------- ---------- ----------
         1 COD_01                     1000          5          1
```

PL/SQL

```
SQL> Declare
  2    TYPE t_rec IS RECORD
  3    (
  4      num   INV_LINE_TABLE.LIG_NUM%Type,
  5      code  INV_LINE_TABLE.LIG_CODE%Type,
  6      pht   INV_LINE_TABLE.LIG_PHT%Type,
  7      tva   INV_LINE_TABLE.LIG_TVA%Type,
  8      qty   INV_LINE_TABLE.LIGQTY%Type
  9    );
 10    rec t_rec ;
 11  Begin
 12    -- Store the line into the record --
 13    Select *
 14    Into   rec
 15    from   TABLE(SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
 16    Where  nt.lig_num = 1 ;
 17    -- Print the record attributes --
 18    dbms_output.put_line( 'Code     = ' || rec.code ) ;
 19    dbms_output.put_line( 'Price    = ' || rec.pht ) ;
 20    dbms_output.put_line( 'Tax rate = ' || rec.tva ) ;
 21    dbms_output.put_line( 'Quantity = ' || rec.qty ) ;
 22  End ;
 23  /
Code     = COD_01
Price    = 1000
Tax rate = 5
Quantity = 1

PL/SQL procedure successfully completed.
```

Query both table and collection

All the collection's rows

SQL

```
SQL> SELECT v.inv_numcli, v.inv_date, nt.lig_code, nt.lig_pht
  2  FROM   INVOICE v,
  3         TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  4  WHERE  v.inv_num = 1
  5  /

INV_NUMCLI INV_DATE LIG_CODE                LIG_PHT
---------- -------- -------------------- ----------
      1000 11/11/05 COD_01                     1000
      1000 11/11/05 COD_02                       50
```

A particular collection's row

```
SQL> SELECT v.inv_numcli, v.inv_date, nt.lig_code, nt.lig_pht
  2  FROM   INVOICE v,
  3         TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  4  WHERE  v.inv_num = 1
  5  AND    nt.lig_num = 1
  6  /

INV_NUMCLI INV_DATE LIG_CODE                 LIG_PHT
---------- -------- -------------------- ----------
      1000 11/11/05 COD_01                     1000
```

PL/SQL

```
SQL> Declare
  2    invoice_rec  INVOICE%ROWTYPE ;
  3    LC$Print  Varchar2(512) ;
  4  Begin
  5    -- Select the INVOICE line --
  6    Select *
  7    Into   invoice_rec
  8    From   INVOICE
  9    Where  inv_numcli = 1000 ;
 10    -- Print the parent and collection attributes--
 11    For i IN invoice_rec.inv_line.FIRST .. invoice_rec.inv_line.LAST Loop
 12      LC$Print := invoice_rec.inv_numcli
 13   || ' - ' || To_Char(invoice_rec.inv_date,'DD/MM/YYYY')
 14   || ' - ' || invoice_rec.inv_line(i).lig_num
 15   || ' - ' || invoice_rec.inv_line(i).lig_code
 16   || ' - ' || invoice_rec.inv_line(i).lig_pht
 17   || ' - ' || invoice_rec.inv_line(i).lig_tva
 18   || ' - ' || invoice_rec.inv_line(i).ligqty ;
 19      dbms_output.put_line( LC$Print ) ;
 20    End loop ;
 21  End ;
 22  /
1000 - 11/11/2005 - 1 - COD_01 - 1000 - 5 - 1
1000 - 11/11/2005 - 2 - COD_02 - 50 - 5 - 10

PL/SQL procedure successfully completed.
```

What happens when the collection is empty ?

Let's insert a row with an empty collection:

```
SQL> INSERT INTO INVOICE
  2   VALUES
  3   (
  4      3
  5     ,1001
  6     ,SYSDATE
  7     , TYP_TAB_LIG_ENV()  -- Empty collection
  8   )
  9   /

1 row created.

SQL> SELECT v.inv_numcli, v.inv_date, nt.lig_code, nt.lig_pht
  2  FROM   INVOICE v,
  3         TABLE (SELECT inv_line FROM INVOICE WHERE inv_num = 1) nt
  4  WHERE  v.inv_num = 1
  5  /

INV_NUMCLI INV_DATE LIG_CODE                 LIG_PHT
---------- -------- -------------------- ----------
      1000 11/11/05 COD_01                     1000
      1000 11/11/05 COD_02                       50
```

The client 1001 does not appears in the query

You can use NESTED CURSOR to get information on rows where collection is NULL or EMPTY

```
SQL> SELECT
  2     v.inv_numcli,
  3     v.inv_date,
  4     CURSOR( SELECT nt.lig_code, nt.lig_pht FROM TABLE (inv_line) nt)
  5  FROM   INVOICE v
  6  /

INV_NUMCLI INV_DATE CURSOR(SELECTNT.LIG_
---------- -------- --------------------
```

```
      1001 11/11/05 CURSOR STATEMENT : 3

CURSOR STATEMENT : 3

no rows selected


INV_NUMCLI INV_DATE CURSOR(SELECTNT.LIG_
---------- -------- --------------------
      1000 11/11/05 CURSOR STATEMENT : 3

CURSOR STATEMENT : 3

LIG_CODE                LIG_PHT
-------------------- ----------
COD_01                     1000
COD_02                       50

      1001 11/11/05 CURSOR STATEMENT : 3

CURSOR STATEMENT : 3

no rows selected
```

8.5 Aggregate and ensemblist function

8.5.1 Aggregate funtions

```
SQL> -- count of number of elements in the collection --
SQL> Select COUNT(*) from TABLE( SELECT inv_line FROM INVOICE WHERE inv_num = 1 )
  2  /

  COUNT(*)
----------
         2

SQL> -- maximum quantity of all the collection rows --
SQL> Select MAX(ligqty) from TABLE( SELECT inv_line FROM INVOICE WHERE inv_num = 1 )
  2  /

MAX(LIGQTY)
-----------
         10


SQL> -- Number of collection lines for each invoice --
SQL> Select   i.inv_numcli, COUNT(nt.lig_num)
  2  From     invoice i, TABLE( i.inv_line) nt
  3  Group by i.inv_numcli
  4  /

INV_NUMCLI COUNT(NT.LIG_NUM)
---------- -----------------
      1000                 2
      1002                 1


SQL> -- Number of distinct product code for each invoice --
SQL> Select   i.inv_numcli, COUNT(DISTINCT(nt.lig_code))
  2  From     invoice i, TABLE( i.inv_line) nt
  3  Group by i.inv_numcli
  4  /

INV_NUMCLI COUNT(DISTINCT(NT.LIG_CODE))
---------- ----------------------------
      1000                            2
      1002                            1


SQL> -- total price for each invoice --
SQL> Select   i.inv_numcli, SUM(nt.lig_pht + (( nt.lig_pht * nt.lig_tva ) / 100.0))
  2  From     invoice i, TABLE( i.inv_line) nt
  3  Group by i.inv_numcli
  4  /

INV_NUMCLI SUM(NT.LIG_PHT+((NT.LIG_PHT*NT.LIG_TVA)/100.0))
---------- -----------------------------------------------
      1000                                          1102,5
      1002                                            1050
```

8.5.2 Ensemblist funtions

```
SQL> -- lines for customers 1000 and 10002 --
SQL> Select nt.lig_code, nt.ligqty
  2  From   invoice i, TABLE( i.inv_line ) nt
  3  Where  i.inv_numcli = 1000
  4  UNION
  5  Select nt.lig_code, nt.ligqty
  6  From   invoice i, TABLE( i.inv_line ) nt
  7  Where  i.inv_numcli = 1002
  8  /

LIG_CODE                 LIGQTY
-------------------- ----------
COD_01                        1
COD_02                       10
COD_03                        1
```

9. Collection and BULK COLLECT

9.1 BULK COLLECT

This keyword ask the SQL engine to return all the rows in one or several collections before returning to the PL/SQL engi
So, there is one single roundtrip for all the rows between SQL and PL/SQL engine.

BULK COLLECT cannot be use on the client-side

(Select)(Fetch)(execute immediate) … BULK COLLECT Into collection_name [,collection_name, …] [LIMIT max_l

LIMIT is used to limit the number of rows returned

```
SQL> set serveroutput on
SQL> Declare
  2    TYPE    TYP_TAB_EMP IS TABLE OF EMP.EMPNO%Type ;
  3    Temp_no TYP_TAB_EMP ; -- collection of EMP.EMPNO%Type
  4    Cursor  C_EMP is Select empno From EMP ;
  5    Pass    Pls_integer := 1 ;
  6  Begin
  7    Open C_EMP ;
  8    Loop
  9      -- Fetch the table 3 by 3 --
 10   Fetch C_EMP BULK COLLECT into Temp_no LIMIT 3 ;
 11      Exit When C_EMP%NOTFOUND ;
 12      For i In Temp_no.first..Temp_no.last Loop
 13        dbms_output.put_line( 'Pass ' || to_char(Pass) || ' Empno= ' || Temp_no(i) ) ;
 14      End loop ;
 15      Pass := Pass + 1 ;
 16    End Loop ;
 17  End ;
 18  /
Pass 1 Empno= 9999
Pass 1 Empno= 7369
Pass 1 Empno= 7499
Pass 2 Empno= 7521
Pass 2 Empno= 7566
Pass 2 Empno= 7654
Pass 3 Empno= 7698
Pass 3 Empno= 7782
Pass 3 Empno= 7788
Pass 4 Empno= 7839
Pass 4 Empno= 7844
Pass 4 Empno= 7876
Pass 5 Empno= 7900
Pass 5 Empno= 7902
Pass 5 Empno= 7934

PL/SQL procedure successfully completed.
```

You can use the LIMIT keyword to preserve your rollback segment:

```
Declare
  TYPE    TYP_TAB_EMP IS TABLE OF EMP.EMPNO%Type ;
  Temp_no TYP_TAB_EMP ;
  Cursor  C_EMP is Select empno From EMP ;
  max_lig Pls_Integer := 3 ;
Begin
  Open C_EMP ;
  Loop
    Fetch C_EMP BULK COLLECT into Temp_no LIMIT max_lig ;
    Forall i In Temp_no.first..Temp_no.last
        Update EMP set SAL = Round(SAL * 1.1) Where empno = Temp_no(i) ;
    Commit ; -- Commit every 3 rows
    Temp_no.DELETE ;
    Exit When C_EMP%NOTFOUND ;
  End Loop ;
End ;
```

BULK COLLECT can also be used to retrieve the result of a DML statement that uses the RETURNING INTO clause:

```
SQL> Declare
  2     TYPE    TYP_TAB_EMPNO IS TABLE OF EMP.EMPNO%Type ;
  3     TYPE    TYP_TAB_NOM   IS TABLE OF EMP.ENAME%Type ;
  4     Temp_no TYP_TAB_EMPNO ;
  5     Tnoms   TYP_TAB_NOM ;
  6  Begin
  7     -- Delete rows and return the result into the collection --
  8     Delete From EMP where sal > 3000
  9     RETURNING empno, ename BULK COLLECT INTO Temp_no, Tnoms ;
 10     For i in Temp_no.first..Temp_no.last Loop
 11        dbms_output.put_line( 'Fired employee : ' || To_char( Temp_no(i) ) || ' ' || Tnoms(i) ) ;
 12     End  loop ;
 13  End ;
 14  /
Fired employee : 7839 KING

PL/SQL procedure successfully completed.
```

9.2 FORALL

FORALL index IN min_index .. max_index [SAVE EXCEPTION] sql_order

This instruction allows to compute all the rows of a collection in a single pass.

FORALL cannot be use on the client-side and can proceed one and only one statement at a time.

```
SQL> Declare
  2    TYPE   TYP_TAB_TEST IS TABLE OF TEST%ROWTYPE ;
  3    tabrec TYP_TAB_TEST ;
  4    CURSOR C_test is select A, B From TEST ;
  5  Begin
  6     -- Load the collection from the table --
  7     Select A, B BULK COLLECT into tabrec From TEST ;
  8
  9     -- Insert into the table from the collection --
 10     Forall i in tabrec.first..tabrec.last
 11         Insert into TEST values tabrec(i) ;
 12
 13     -- Update the table from the collection --
 14     For i in tabrec.first..tabrec.last Loop
 15         tabrec(i).B := tabrec(i).B * 2 ;
 16     End loop ;
 17
 18     -- Use of cursor --
 19     Open  C_test ;
 20     Fetch C_test BULK COLLECT Into tabrec ;
 21     Close C_test ;
 22
 23  End ;
 24  /
```

Implementation restriction

It is not allowed to use the FORALL statement and an UPDATE order that use the SET ROW functionality

```
SQL> Declare
  2     TYPE    TAB_EMP is table of EMP%ROWTYPE ;
  3     emp_tab TAB_EMP ;
  4     Cursor  CEMP is Select * From EMP ;
  5  Begin
  6     Open  CEMP;
  7     Fetch CEMP BULK COLLECT Into emp_tab ;
  8     Close CEMP ;
  9
 10    Forall i in emp_tab.first..emp_tab.last
 11      Update EMP set row =  emp_tab(i) where EMPNO = emp_tab(i).EMPNO ; -- ILLEGAL
 12
 13  End ;
 14  /
    Update EMP set row =  emp_tab(i) where EMPNO = emp_tab(i).EMPNO ; -- ILLEGAL
                                                 *
ERROR at line 11:
ORA-06550: line 11, column 52:
PLS-00436: implementation restriction: cannot reference fields of BULK In-BIND
table of records
```

You have to use a standard FOR LOOP statement:

```
For i in emp_tab.first..emp_tab.last loop
   Update EMP set row =  emp_tab(i) where EMPNO = emp_tab(i).EMPNO ;
End loop ;
```

Or use simple collections:

```
Declare
   TYPE    TAB_EMPNO   is table of EMP.EMPNO%TYPE ;
   TYPE    TAB_EMPNAME is table of EMP.ENAME%TYPE ;
   no_tab  TAB_EMPNO ;
   na_tab  TAB_EMPNAME ;
   Cursor  CEMP is Select EMPNO, ENAME From EMP ;
Begin
   Open  CEMP;
   Fetch CEMP BULK COLLECT Into no_tab, na_tab ;
   Close CEMP ;

  Forall i in no_tab.first..no_tab.last
    Update EMP set ENAME = na_tab(i) where EMPNO = no_tab(i) ;

End ;
```

FORALL and exceptions

If an error is raised by the FORALL statement, all the rows processed are rolled back.

You can save the rows that raised an error (and do not abort the process) with the SAVE EXCEPTION keyword.

Every exception raised during execution is stored in the %BULK_EXCEPTIONS collection.
This is a collection of records composed by two attributes:

- **%BULK_EXCEPTIONS(n).ERROR_INDEX** which contains the index number
- **%BULK_EXCEPTIONS(n).ERROR_CODE** which contains the error code

The total amount of errors raised by the FORALL instruction is stored in the **SQL%BULK_EXCEPTIONS.COUNT** attribute.

```
SQL> Declare
  2    TYPE    TYP_TAB IS TABLE OF Number ;
  3    tab     TYP_TAB := TYP_TAB( 2, 0, 1, 3, 0, 4, 5 ) ;
  4    nb_err  Pls_integer ;
  5  Begin
  6     Forall i in tab.first..tab.last SAVE EXCEPTIONS
  7         Delete from EMP where SAL = 5 / tab(i) ;
  8  Exception
  9    When others then
 10       nb_err := SQL%BULK_EXCEPTIONS.COUNT ;
 11       dbms_output.put_line( to_char( nb_err ) || ' Errors ' ) ;
 12       For i in 1..nb_err Loop
 13          dbms_output.put_line( 'Index ' || to_char( SQL%BULK_EXCEPTIONS(i).ERROR_INDEX ) || ' Er
ror :  '
 14   || to_char( SQL%BULK_EXCEPTIONS(i).ERROR_CODE ) ) ;
 15       End loop ;
 16  End ;
 17  /
```

```
2 Errors
Index 2 Error :  1476
Index 5 Error :  1476

PL/SQL procedure successfully completed.
```

The %BULK_ROWCOUNT attribute.

This is an INDEX-BY table that contains for each SQL order the number of rows processed.
If no row is impacted, SQL%BULK_ROWCOUNT(n) equals 0.

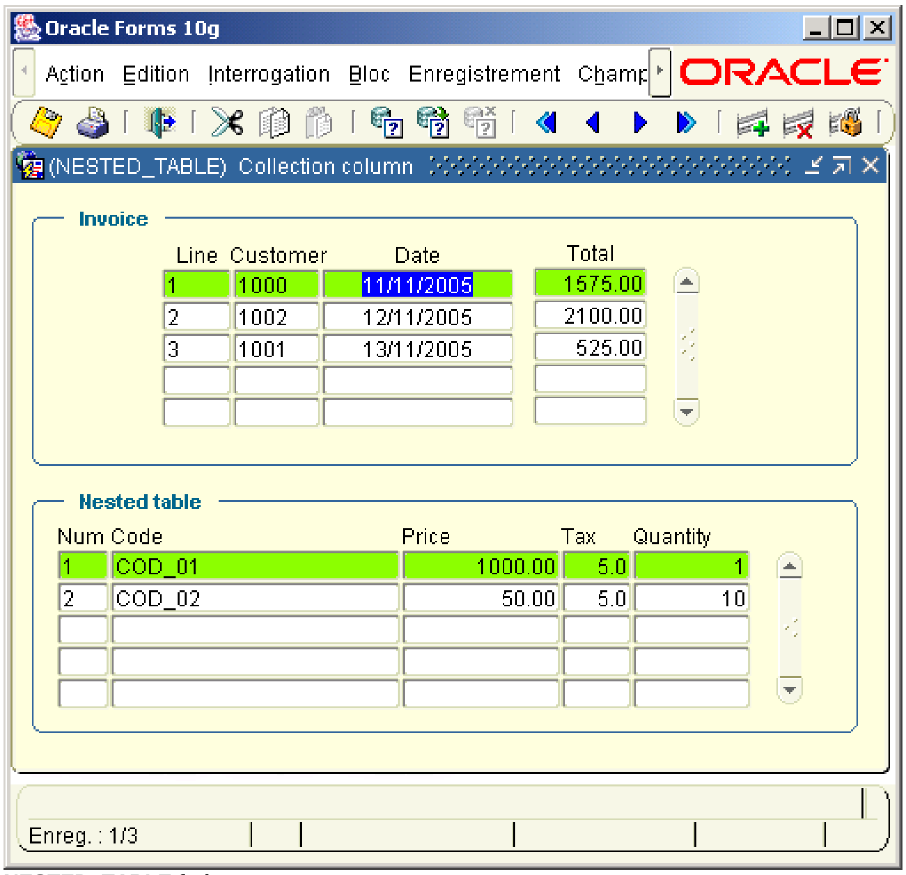
```
SQL> Declare
  2    TYPE   TYP_TAB_TEST IS TABLE OF TEST%ROWTYPE ;
  3    TYPE   TYP_TAB_A IS TABLE OF TEST.A%TYPE ;
  4    TYPE   TYP_TAB_B IS TABLE OF TEST.B%TYPE ;
  5    tabrec TYP_TAB_TEST ;
  6    taba   TYP_TAB_A ;
  7    tabb   TYP_TAB_B ;
  8    total  Pls_integer := 0 ;
  9    CURSOR C_test is select A, B From TEST ;
 10  begin
 11     -- Load the collection from the table --
 12     Select A, B BULK COLLECT into tabrec From TEST ;
 13
 14     -- Insert rows --
 15     Forall i in tabrec.first..tabrec.last
 16         insert into TEST values tabrec(i) ;
 17
 18     For i in tabrec.first..tabrec.last Loop
 19         total := total + SQL%BULK_ROWCOUNT(i) ;
 20     End loop ;
 21
 22     dbms_output.put_line('Total insert : ' || to_char( total) ) ;
 23
 24     total := 0 ;
 25     -- Upadate rows --
 26     For i in tabrec.first..tabrec.last loop
 27       update TEST set row =  tabrec(i) where A = tabrec(i).A ;
 28     End loop ;
 29
 30     For i in tabrec.first..tabrec.last Loop
 31         total := total + SQL%BULK_ROWCOUNT(i) ;
 32     End loop ;
 33
 34     dbms_output.put_line('Total upfdate : ' || to_char( total) ) ;
 35
 36  End ;
 37  /
Total insert : 20
Total upfdate : 20

PL/SQL procedure successfully completed.
```

10. Oracle Forms and collections

Oracle Forms, in its actual version (10.1.2) does not handle collections internally.

However, we can handle this kind of object with a few lines of code.


Oracle Forms 10g
Action Edition Interrogation Bloc Enregistrement Champ
ORACLE
(NESTED_TABLE) Collection column
Enreg. : 1/3

Invoice

Line	Customer	Date	Total
1	1000	11/11/2005	1575.00
2	1002	12/11/2005	2100.00
3	1001	13/11/2005	525.00

Nested table

Num	Code	Price	Tax	Quantity
1	COD_01	1000.00	5.0	1
2	COD_02	50.00	5.0	10

NESTED_TABLE.fmb

This is a MASTER/DETAIL module.

The first block (Invoice) is based on the INVOICE table

The second block (Nested table) is based on a FROM clause

At initialization, the dummy FROM clause is specified as:

```
Select 1,2,3,4,5 from Dual.
```

In the *When-New-Record-Instance* of the first block, we change dynamically this property:

```
Declare
  LC$Req  Varchar2(256) ;
Begin
  If :INVOICE.INV_NUM Is not null Then
     -- Dynamic query on nested table block --
     LC$Req := '(SELECT nt.lig_num, nt.lig_code, nt.lig_pht, nt.lig_tva, nt.ligqty FROM TABLE ( SELECT
inv_line FROM INVOICE WHERE inv_num = ' || :INVOICE.INV_NUM || ') nt)' ;
    Go_Block('NT' );
    Clear_Block ;
    Set_Block_Property( 'NT', QUERY_DATA_SOURCE_NAME, LC$Req ) ;
    :System.message_level := 25 ;
    Execute_Query ;
    :System.message_level := 0 ;
    Go_Block('INVOICE') ;
  Else
    Go_Block('NT' );
    Clear_Block ;
    Go_Block('INVOICE') ;
  End if ;
End ;
```

Handling the nested table of the detail block

All we have to do is to overload the standard Forms process for Insert, Update and Delete line of the collection.

This job is done in the ON-xxx triggers of the detail block.

Trigger ON-INSERT:

```
-- Insert a line into the collection --
INSERT INTO TABLE
 (
   SELECT
      inv_line
   FROM
      INVOICE
   WHERE
      inv_num = :INVOICE.inv_num
 )
 Values
 (
   TYP_LIG_ENV( :NT.lig_num, :NT.lig_code, :NT.lig_pht, :NT.lig_tva, :NT.ligqty )
 );
```

Trigger ON-UPDATE

```
-- Update the line in collection --
UPDATE TABLE
 (
   SELECT
      inv_line
   FROM
      INVOICE
   WHERE
      inv_num = :INVOICE.inv_num
 ) nt
 SET
   VALUE(nt) = TYP_LIG_ENV( :NT.lig_num, :NT.lig_code, :NT.lig_pht, :NT.lig_tva, :NT.ligqty )
 WHERE
   nt.lig_num = :NT.lig_num
 ;
```

Trigger ON-DELETE

```
-- Delete the line from the collection --
DELETE FROM TABLE
 (
   SELECT
      inv_line
   FROM
      INVOICE
   WHERE
      inv_num = :INVOICE.inv_num
 ) nt
 WHERE
   nt.lig_num = :NT.lig_num
 ;
```

Download the samples

You can download the collection.zip

Unzip the **collection.zip** file

Create the database objects with the ***/scripts/install.sql*** script

Open the **NESTED_TABLE.fmb** module (Oracle Forms 10.1.2)

Compile the module and run.