How to unwrap PL/SQL

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Introduction

- My name is Pete Finnigan
  - I specialise in researching and securing Oracle databases
- The PL/SQL wrapping process has particularly interested me for some years
- I wanted to investigate why the method chosen to secure intellectual property written in PL/SQL is weak
- I also felt it was intriguing that Oracle has made it “easy” for anyone to understand how to recover source code in 9i and lower
- I also find it interesting that Oracle has shipped API’s since the beginning of PL/SQL that can be used to unwrap

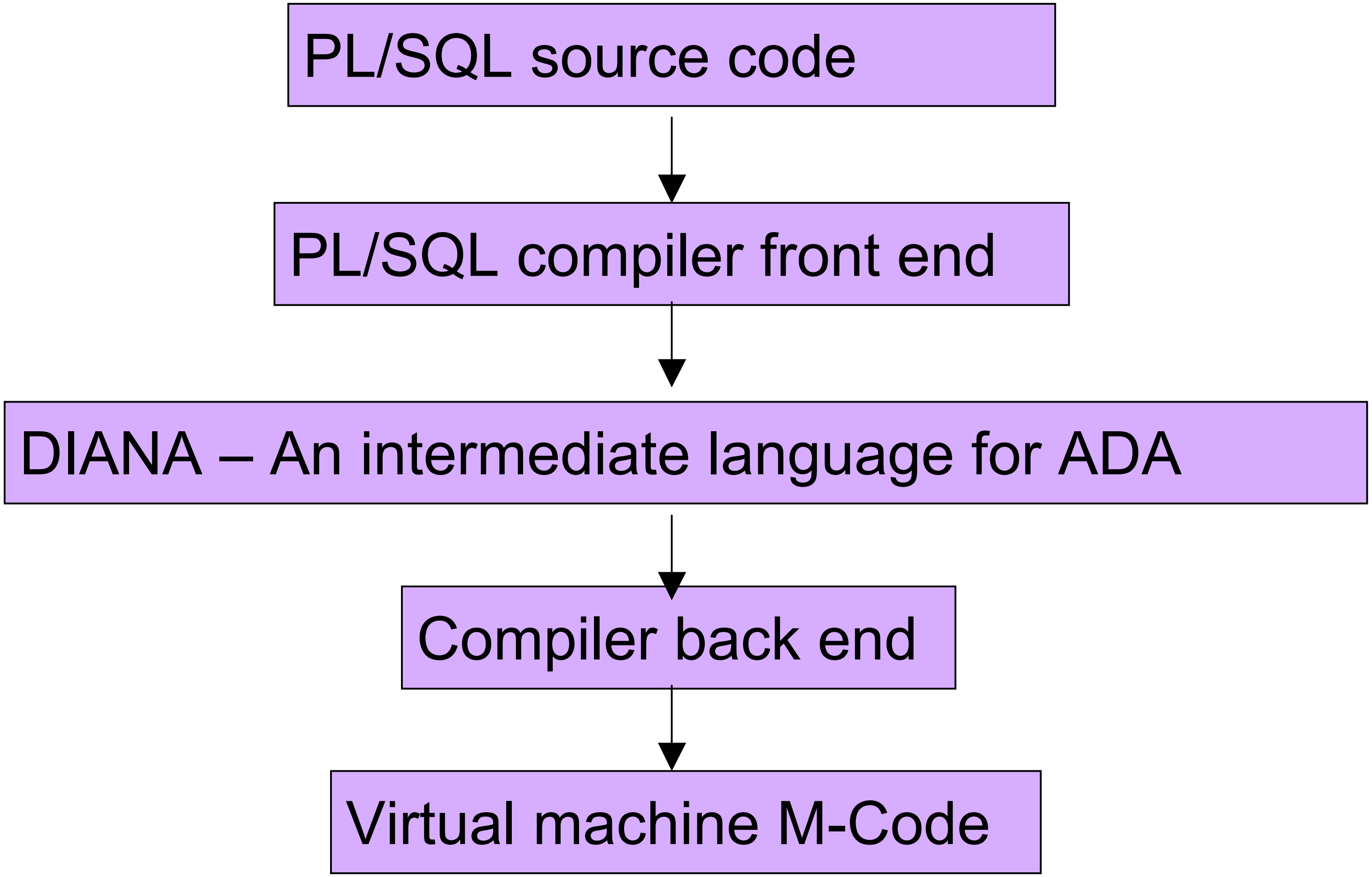
The agenda

- Oracle’s PL/SQL language – a sample procedure
- How PL/SQL is wrapped, the language internals, the database tables and files used, the events that can reveal information
- Why it is possible to read wrapped code – driven by history and design choice!
- How it is possible to read wrapped code – some sample code shipped by Oracle
- The built in API’s shipped by Oracle
- 10g, the changes
- What can be done to protect PL/SQL source code

Why is there a problem with wrapped PL/SQL

- Intellectual property can be revealed if PL/SQL is un-wrapped
- This can include
  - Your own application source code
  - Oracle shipped features hidden by the wrapper
- In 9i and lower wrapped PL/SQL revealed symbols
- Finding SQL injection bugs just became easier
- There are PL/SQL unwrapping tools available

PL/SQL language compilation structure



PL/SQL source code

PL/SQL compiler front end

DIANA – An intermediate language for ADA

Compiler back end

Virtual machine M-Code

DIANA is the key for 9i and lower

- PL/SQL is based on ADA
- DIANA – Descriptive intermediate language for ADA
  - DIANA is an abstract data type
  - DIANA is an intermediate form of PL/SQL programs
  - Intended to communicate between the front end and back ends of a PL/SQL compiler
  - Each defining DIANA entity represents a PL/SQL entity
  - Two trees –
    - Abstract syntax tree constructed prior to semantic analysis
    - Attributed tree (the DIANA structure)

IDL – Interface description language

- DIANA is written down as IDL
- What is IDL? – Interface description language – Also derived from ADA
- IDL is stored in the database in 4 dictionary tables
    - IDL_CHAR$, IDL_SB4$, IDL_UB1$ and IDL_UB2$
- Wrapped PL/SQL is simply DIANA written down as IDL
- Oracle say that wrapped PL/SQL is simply encoded
- Therefore the *wrap* program is the front end of a PL/SQL compiler.
- Is wrapped PL/SQL – DIANA – reversible?

A book about DIANA

DIANA – An Intermediate Language for ADA

Editors: G. Goos, W.A. Wulf

A. Evans, Jr and K.J. Butler

Springer-Verlag

ISBN : 0387126953

Revised Edition (December 1983)

Quote from page 165:

“Appendix III – Reconstructing the source”

“One of the basic principals of DIANA is that the structure of the original source program is to be retained in the DIANA representation…..”

“There is a close correspondence between ADA’s syntax and DIANA’s structural attributes… It is this correspondence that permits source code reconstruction.”

From Oracle’s own documentation

PL/SQL User's Guide and Reference
10*g* Release 1 (10.1)
Part Number B10807-01

“PL/SQL is based on ADA, as a result PL/SQL uses a variant of DIANA, a tree structured language….”

“It is defined using a meta notation called IDL (Interface Definition Language)…”

“DIANA is used internally by compilers and other tools…..”

“At compile time PL/SQL is translated into M-Code. Both DIANA and M-Code are stored in the database….”

A Sample PL/SQL procedure – 9i

```
SQL> connect sys/change_on_install as sysdba
Connected.
SQL> create or replace procedure AA as
  2  begin
  3     null;
  4  end;
  5  /
Procedure created.
SQL>
```

Connect in SQL*Plus and create a simple PL/SQL procedure

Save the PL/SQL and wrap the code

Wrapping is simple. Save the PL/SQL to a file and run the *wrap* utility.

```
SQL> save aa.sql
Created file aa.sql
SQL> exit
{output snipped}
G:\code>wrap iname=aa.sql oname=aa.pls

PL/SQL Wrapper: Release 9.2.0.1.0- Production on Mon Jun 19 18:05:57 2006

Copyright (c) Oracle Corporation 1993, 2001.  All Rights Reserved.
Processing aa.sql to aa.pls

G:\code>
```

The wrapped output

```
create or replace procedure
  AA wrapped
0
abcd
{snipped 15 identical lines}
3
7
9200000
1
4
0
1
2 :e:
1AA:
0
```

```
0
0
f
2
0 9a b4 55 6a 4f b7 a4
b1 11 68 4f 1d 17 b5
f
2
0 3 17 18 1c 20 22 24
28 2a 36 3a 3c 3d 46
{file contents snipped}
```

What is the meaning of this encoded file? –
Note the highlights – we will see them again

9i and below wrapped PL/SQL weaknesses

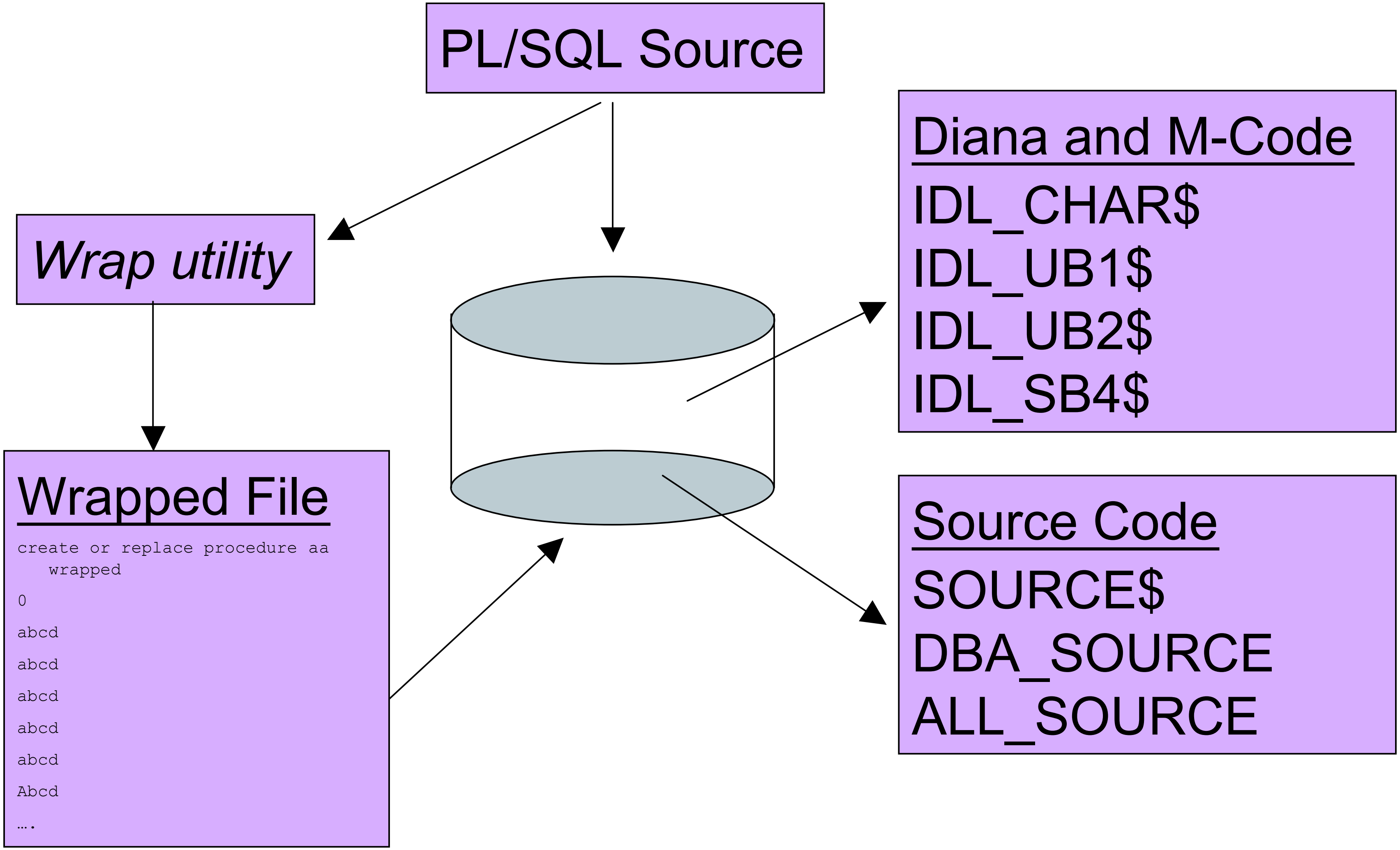
```
SQL> create or replace procedure encode (credit_card in varchar2,
  str out varchar2) is
  2   key varchar2(16):='01234567890ABCDEF';
  3   begin
  4   null;
  5   end;
  6   /

Procedure created.

SQL> save encode.sql
{snipped}

G:\code>wrap iname=encode.sql oname=encode.plb

PL/SQL Wrapper: Release 9.2.0.1.0- Production on Fri Jun 23 15:43:47
  2006

Copyright (c) Oracle Corporation 1993, 2001.  All Rights Reserved.

Processing encode.sql to encode.plb
```

```
2 :e:
1ENCODE:
1CREDIT_CARD:
1VARCHAR2:
1STR:
1OUT:
1KEY:
116:
101234567890ABCDEF:
```

Hacking wrapped PL/SQL – pre-9i

- The symbol table is visible
- For the previous example it is possible to
  - Deduce the purpose of the procedure
  - Find out the encryption algorithm used using DBA_DEPENDENCIES unless it is implemented internally to the procedure
  - Decrypt Credit Cards – in this case
- Trojans can be planted
- Wrapped source can be modified without un-wrapping
  - Example: Fixed DBMS_OUTPUT limits problem
- SQL injection identification is possible / DDL can be altered

The relationships in 9i



PL/SQL Source

Wrap utility

<u>Wrapped File</u>

```
create or replace procedure aa
   wrapped
0
abcd
abcd
abcd
abcd
abcd
Abcd
….
```

<u>Diana and M-Code</u>

IDL_CHAR$

IDL_UB1$

IDL_UB2$

IDL_SB4$

<u>Source Code</u>

SOURCE$

DBA_SOURCE

ALL_SOURCE

The dictionary tables and views

- SYS.IDL_CHAR$
- SYS.IDL_UB1$ →
- SYS.IDL_UB2$
- SYS.IDL_SB4$
- SYS.SOURCE$

```
SQL> desc idl_ub1$
 Name                Null?     Type
 ------------- -------- ----------


 OBJ#              NOT NULL NUMBER
 PART              NOT NULL NUMBER
 VERSION                    NUMBER
 PIECE#            NOT NULL NUMBER
 LENGTH            NOT NULL NUMBER
 PIECE             NOT NULL LONG RAW
```

```
SQL> desc source$
 Name                      Null?    Type
 --------------- -------- ----------
  -------


 OBJ#                      NOT NULL NUMBER
 LINE                      NOT NULL NUMBER
 SOURCE                    VARCHAR2(4000)
```

From $OH/rdbms/admin/sql.bsq

```
/* part: 0 = diana, 1 = portable
  pcode, 2 = machine-dependent pcode
  */
```

Recursive SQL

- What is recursive SQL? – background supporting SQL needed to execute the submitted statement
- When compiling PL/SQL there are other background SQL statements that need to run as SYS
  - Check for user’s privileges and roles
  - Triggers
  - Retrieving the PL/SQL code to run
  - Indexes
- How can we see the complete picture?
- Using traces, dumps and events

Trace the compilation of PL/SQL

```
SQL> alter session set events '10046 trace name context forever, level
  12';

Session altered.

SQL> create or replace procedure aa is
  2  begin
  3  null;
  4  end;
  5  /

Procedure created.

SQL> alter session set events '10046 trace name context off';

Session altered.

SQL>
```

Locate the trace file and check the contents

```
PARSING IN CURSOR #2 len=106 dep=1 uid=0 oct=6 lid=0 tim=465432930704 hv=1545875908
   ad='66f37b44'
update idl_ub2$ set piece#=:1 ,length=:2 , piece=:3 where obj#=:4 and part=:5 and
   piece#=:6 and version=:7
END OF STMT
PARSE #2:c=0,e=42,p=0,cr=0,cu=0,mis=0,r=0,dep=1,og=4,tim=465432930696
BINDS #2:
 bind 0: dty=2 mxl=22(22) mal=00 scl=00 pre=00 oacflg=08 oacfl2=1 size=24 offset=0
   bfp=04822394 bln=24 avl=02 flg=05
   value=4
 bind 1: dty=2 mxl=22(22) mal=00 scl=00 pre=00 oacflg=08 oacfl2=1 size=24 offset=0
   bfp=04822364 bln=24 avl=03 flg=05
   value=123
 bind 2: dty=25 mxl=4000(4000) mal=00 scl=00 pre=00 oacflg=12 oacfl2=1 size=4000 offset=0
   bfp=04c67ff4 bln=4000 avl=246 flg=09
   value=
Dump of memory from 0x04C67FF4 to 0x04C680EA
4C67FF0          00030000 000D000C 00250011      [..........%.]
4C68000 002A0029 0038002C 003E003A 00000040  [).*.,.8.:.>.@...]
4C68010 001D0017 009A0068 00B40055 001100B5  [....h...U.......]
4C68020 00A400B1 004F00B7 00010000 00010001  [......O.........]
4C68030 00010001 00010001 00010001 00010001  [................]
4C68040 00000001 00010001 000B0001 00010001  [................]
```

Those numbers look familiar!

DIANA for package bodies is not stored (idl.sql)

```
SQL> select count(*),'CHAR$',part,object_type
  2  from idl_char$,dba_objects
  3  where obj#=object_id
  4  and part=0
  5  group by part,object_type
  6  union
  7  select count(*),'UB1$',part,object_type
  8  from idl_ub1$,dba_objects
  9  where obj#=object_id
 10  and part=0
 11  group by part,object_type
 12  union
 13  select count(*),'UB2$',part,object_type
 14  from idl_ub2$,dba_objects
 15  where obj#=object_id
 16  and part=0
 17  group by part,object_type
 18  union
 19  select count(*),'SB4$',part,object_type
 20  from idl_sb4$,dba_objects
 21  where obj#=object_id
 22  and part=0
 23  group by part,object_type
 24  order by 2
SQL> /
```

```
SQL> /

  COUNT(*) 'CHAR       PART OBJECT_TYPE
---------- ----- ---------- -----------
   -------
        28 CHAR$          0 OPERATOR
        44 CHAR$          0 PROCEDURE
        50 CHAR$          0 TYPE BODY
        72 CHAR$          0 SEQUENCE
        91 CHAR$          0 LIBRARY
       101 CHAR$          0 FUNCTION
       329 CHAR$          0 VIEW
       481 CHAR$          0 TABLE
       559 CHAR$          0 PACKAGE
       728 CHAR$          0 SYNONYM
       778 CHAR$          0 TYPE

  COUNT(*) 'CHAR       PART OBJECT_TYPE
---------- ----- ---------- -----------
   -------
        56 SB4$           0 OPERATOR
        88 SB4$           0 PROCEDURE
{output snipped}
```

What IDL was created for procedure ‘AA’?

```
SQL> select dbms_rowid.rowid_block_number(rowid) blk,
  2  dbms_rowid.rowid_relative_fno(rowid) fno,
  3  dbms_rowid.rowid_row_number(rowid) rnum,
  4  'CHAR$',part,version,piece#,length
  5  from idl_char$
  6  where obj#=(select obj# from obj$ where name = 'AA')
  7  union
  8  select dbms_rowid.rowid_block_number(rowid) blk,
  9  dbms_rowid.rowid_relative_fno(rowid) fno,
 10  dbms_rowid.rowid_row_number(rowid) rnum,
 11  'UB2$',part,version,piece#,length
 12  from idl_ub2$
 13  where obj#=(select obj# from obj$ where name = 'AA')
 14  union
 15  select dbms_rowid.rowid_block_number(rowid) blk,
 16  dbms_rowid.rowid_relative_fno(rowid) fno,
 17  dbms_rowid.rowid_row_number(rowid) rnum,
 18  'ub1$',part,version,piece#,length
 19  from idl_ub1$
 20  where obj#=(select obj# from obj$ where name = 'AA')
 21  union
 22  select dbms_rowid.rowid_block_number(rowid) blk,
 23  dbms_rowid.rowid_relative_fno(rowid) fno,
 24  dbms_rowid.rowid_row_number(rowid) rnum,
 25  'sb4$',part,version,piece#,length
 26  from idl_sb4$
 27  where obj#=(select obj# from obj$ where name = 'AA')
 28  order by part,piece#
SQL> save rowid.sql
```

```
SQL> @rowid

   BLK FNO RNUM 'CHAR       PART    VERSION     PIECE#     LENGTH
------ --- ---- ----- ---------- ---------- ---------- ----------
 49951   1   24 sb4$           0  153092096          0         14
 49951   1   48 sb4$           0  153092096          1          2
 42671   1   21 ub1$           0  153092096          2          3
 35792   1   36 CHAR$          0  153092096          3          5
 50581   1    8 UB2$           0  153092096          4        123
 50581   1    9 UB2$           0  153092096          5         10
 49951   1   50 sb4$           2  153092096          0         18
 42671   1   10 ub1$           2  153092096          1        112
 42671   1   13 ub1$           2  153092096          2          1
`
9 rows selected.
```

Dump the datablocks to find the DIANA

- Why do we need to dump datablocks for the IDL$ tables?

```
SQL> select piece
  2  from sys.idl_ub2$
  3  where obj#=(select obj# from obj$ where name='AA')
  4  and part=0
  5  and piece#=4;
ERROR:
ORA-00932: inconsistent datatypes: expected %s got %s

no rows selected

SQL> alter system dump datafile 1 block 50581;

System altered.
```

The contents of the IDL$ tables cannot be selected

Instead the data must be dumped from the datafile

The contents of the block dump for IDL_UB2$

```
tab 0, row 8, @0x11b1
tl: 271 fb: --H-FL-- lb: 0x1  cc: 6
col  0: [ 4]  c3 04 05 0a
col  1: [ 1]  80
col  2: [ 6]  c5 02 36 0a 15 61
col  3: [ 2]  c1 05
col  4: [ 3]  c2 02 18
col  5: [246]
 00 00 03 00 0c 00 0d 00 11 00 25 00 29 00 2a 00 2c 00 38 00 3a 00 3e 00 40
 00 00 00 17 00 1d 00 68 00 9a 00 55 00 b4 00 b5 00 11 00 b1 00 a4 00 b7 00
 4f 00 00 00 01 00 01 00 01 00 01 00 01 00 01 00 01 00 01 00 01 00 01 00 01
 00 01 00 00 00 01 00 01 00 01 00 0b 00 01 00 01 00 01 00 01 00 01 00 01 00
 00 00 01 00 00 00 00 00 00 00 02 00 03 00 07 00 00 00 00 00 00 00 00 00 00
 00 00 00 00 00 04 00 05 00 08 00 01 00 01 00 05 00 08 00 00 00 00 00 04 00
 00 00 00 00 ff 00 01 00 00 00 03 00 01 00 20 00 00 00 00 00 00 00 00 00 00
 00 01 00 06 00 00 00 00 00 03 00 00 00 00 00 00 00 09 00 0b 00 0a 00 00 00
 00 00 00 00 00 00 00 00 04 00 03 00 00 00 00 00 00 00 08 00 00 00 08 00 00
 00 08 00 03 00 08 00 00 00 0b 00 00 00 00 00 00 00 01 00 0c 00
```

Those values look familiar but in a different order

IDL dependencies – (a detour)

```
SQL> select distinct owner,name,type
  2  from dba_dependencies
  3  where referenced_name like 'IDL_%'
SQL> /

OWNE NAME                 TYPE
---- -------------------- ------------
SYS  ALL_PROBE_OBJECTS    VIEW
SYS  CODE_PIECES          VIEW
SYS  INITJVMAUX           PACKAGE BODY
SYS  ORA_KGLR7_IDL_CHAR   VIEW
SYS  ORA_KGLR7_IDL_SB4    VIEW
SYS  ORA_KGLR7_IDL_UB1    VIEW
SYS  ORA_KGLR7_IDL_UB2    VIEW
SYS  PARSED_PIECES        VIEW
SYS  RMJVM                PACKAGE BODY
```

How are IDL tables used?

```
SQL> desc code_pieces
 Name           Null?    Type
 -------------- -------- ------


 OBJ#                    NUMBER
 BYTES                   NUMBER

SQL> set long 1000000
SQL> select text from dba_views
  2  where view_name='CODE_PIECES'
```

```
SQL> /

TEXT
--------------------------------

select i.obj#, i.length
  from sys.idl_ub1$ i
  where i.part in (1,2)
union all
  select i.obj#, i.length
  from sys.idl_ub2$ i
  where i.part in (1,2)
union all
  select i.obj#, i.length
  from sys.idl_sb4$ i
  where i.part in (1,2)
union all
  select i.obj#, i.length
  from sys.idl_char$ i
  where i.part in (1,2)
```

The DIANA and IDL API packages

```
SQL> select text from dba_source
  2  where name='PIDL';

package     PIDL is
  ----------------------------------------------------------------------------
  -- Persistent IDL datatypes
  ----------------------------------------------------------------------------
  subtype ptnod     is binary_integer; -- generic IDL node type
  TRENULL CONSTANT ptnod := 0;         -- a NULL node
  subtype ub4       is binary_integer; -- Oracle C type, unsigned byte 4
  subtype ub2       is binary_integer; -- Oracle C type, unsigned byte 2
{Output snipped to 550 lines}
SQL> select text from dba_source
  2  where name='DIANA';

package     diana is
  D_ABORT    constant pidl.ptnty := 1;
  D_ACCEPT   constant pidl.ptnty := 2;
  D_ACCESS   constant pidl.ptnty := 3;
  D_ADDRES   constant pidl.ptnty := 4;
{output snipped to 1596 lines}
```

Source code available in $ORACLE_HOME/rdbms/admin/pipidl.sql and pidian.sql

DIANA Utilities - $OH/rdbms/admin/diutil.sql

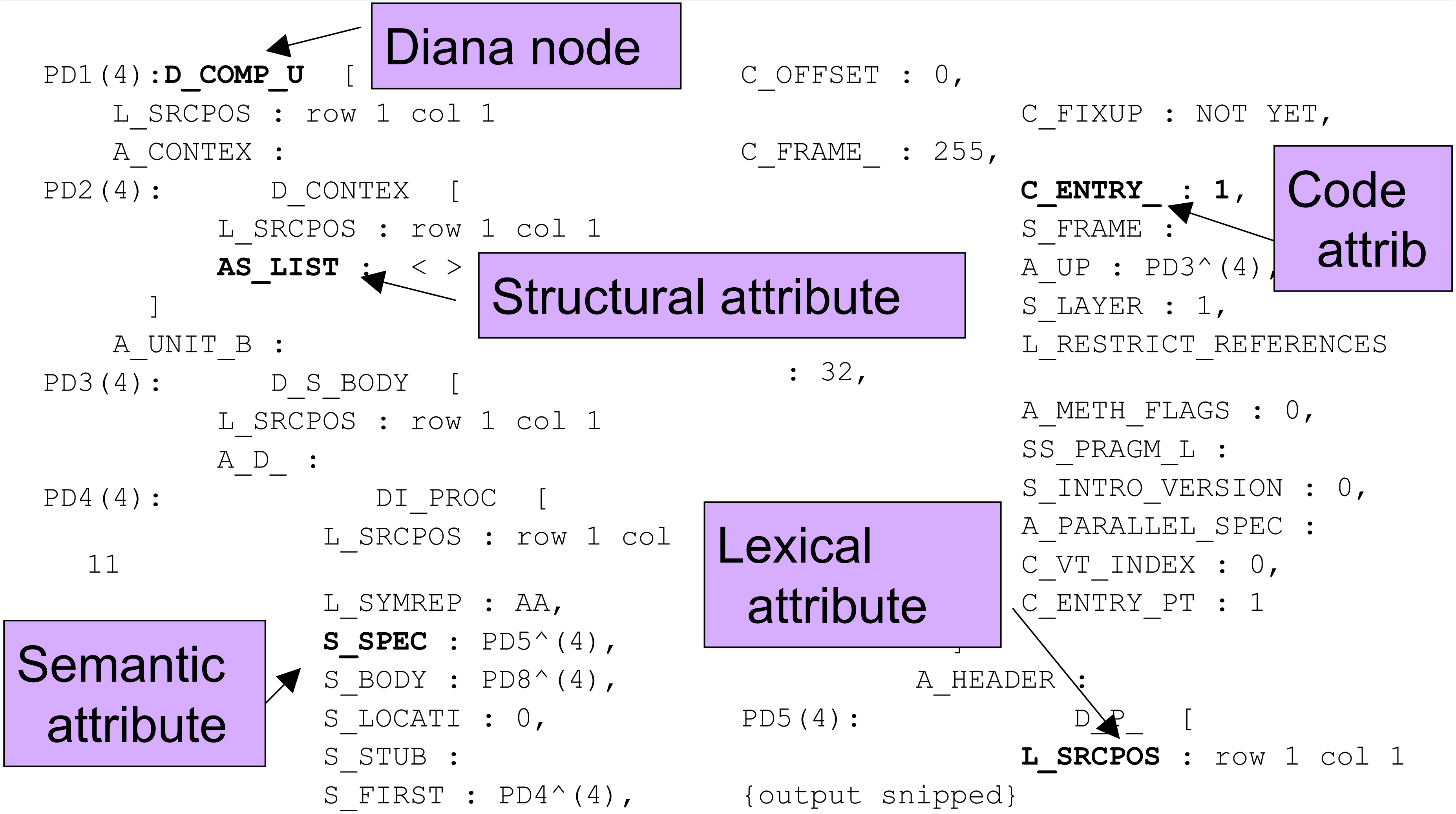
```
SQL> desc diutil
PROCEDURE ATTRIBUTE_USE_STATISTICS
 Argument Name           Type                    In/Out Default?
 ----------------------- ----------------------- ------ --------
 LIBUNIT_NODE            BINARY_INTEGER          IN
 ATTRIBUTE_COUNT         BINARY_INTEGER          OUT
 ATTRIBUTE_LIMIT         BINARY_INTEGER          OUT
PROCEDURE GET_D
 Argument Name           Type                    In/Out Default?
 ----------------------- ----------------------- ------ --------
 NAME                    VARCHAR2                IN
 USR                     VARCHAR2                IN
 DBNAME                  VARCHAR2                IN
 DBOWNER                 VARCHAR2                IN
 STATUS                  BINARY_INTEGER          IN/OUT
 NOD                     BINARY_INTEGER          OUT
 LIBUNIT_TYPE            NUMBER                  IN     DEFAULT
 LOAD_SOURCE             NUMBER                  IN     DEFAULT
{snipped}
```

Dumpdiana – a script to dump the DIANA

- $ORACLE_HOME/rdbms/admin/dumpdian.sql
- Not installed by default
- Run the script as SYS
- There are two bugs to fix – remove the lines REM ----
- Ensure DIANA, PIDL and DIUTIL PL/SQL packages are installed as well
- Run for sample ‘AA’ procedure as SYS – (output to trace) :-

```
SQL> exec sys.dumpdiana.dump(aname => 'AA');

PL/SQL procedure successfully completed.

SQL>
```

A DIANA tree dump – (Goos/Wulf - pages 137 – 144)



```
PD1(4):D_COMP_U   [                     C_OFFSET : 0,
    L_SRCPOS : row 1 col 1                              C_FIXUP : NOT YET,
    A_CONTEX :                          C_FRAME_ : 255,
PD2(4):      D_CONTEX   [                               C_ENTRY_ : 1,
          L_SRCPOS : row 1 col 1                        S_FRAME :
          AS_LIST :  < >                                A_UP : PD3^(4),
      ]                                                 S_LAYER : 1,
    A_UNIT_B :                                          L_RESTRICT_REFERENCES
                                          : 32,
PD3(4):      D_S_BODY   [
                                                        A_METH_FLAGS : 0,
          L_SRCPOS : row 1 col 1
                                                        SS_PRAGM_L :
          A_D_ :
                                                        S_INTRO_VERSION : 0,
PD4(4):            DI_PROC   [
                                                        A_PARALLEL_SPEC :
                L_SRCPOS : row 1 col
                                                        C_VT_INDEX : 0,
  11
                L_SYMREP : AA,                          C_ENTRY_PT : 1
                S_SPEC : PD5^(4),                     ]
                S_BODY : PD8^(4),                 A_HEADER :
                S_LOCATI : 0,           PD5(4):         D_P_   [
                S_STUB :                                L_SRCPOS : row 1 col 1
                S_FIRST : PD4^(4),      {output snipped}
```

Diana node

Structural attribute

Code attrib

Lexical attribute

Semantic attribute

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Attributed structured tree

```
 A_BLOCK_ :
PD8(4):            D_BLOCK   [
                L_SRCPOS : row 1 col 1
                AS_ITEM :
PD9(4):                  DS_ITEM   [
                      L_SRCPOS : row 1 col 1
                      AS_LIST :  < >
                      A_UP : PD8^(4)
                  ]
                AS_STM :
PDB(4):                  DS_STM   [
                      L_SRCPOS : row 1 col 0
                      AS_LIST :  <
PDC(4):                        D_NULL_S   [
                          L_SRCPOS : row 1 col 1
                          C_OFFSET : 0,
                          A_UP : PDB^(4)
                        ]
 >
                      A_UP : PD8^(4)
                  ]
```

```
 AS_ALTER :
PDA(4):                DS_ALTER   [
                L_SRCPOS : row 1 col 1
                AS_LIST :  < >
                S_BLOCK : PD8^(4),
                S_SCOPE :
                A_UP : PD8^(4)
           ]
```

- This is the Block section
- The PD?(?) syntax can also be seen on page 151 of Goos / Wulf book
- Each node has variable number of attributes dependant on node type
- Some of which are nodes
- L_SRCPOS is mandatory for all DIANA nodes – ADA included LX_COMMENT as well

Reconstructing PL/SQL source from DIANA - 1

- Block syntax for PL/SQL

```
Block_statement ::=
   [block_simple_name]
      [declare
               declarative part]
      begin
               sequence of statements
      [exception
              exception handler {exception handler}]
      end [block_simple_name] ;
```

- Diana Rules

```
block => as_item           : DS_ITEM,
         as_stm            : D_STM,
         as_alter          : DS_ALTER;
```

- See page 166 – Goos / Wulf et al

An alternate DIANA dump

```
{output snipped}
PD3(4) : D_S_BODY: [
  SRCPOS: row 1 col 1
  A_D_: PD4(4) : DI_PROC: [...]
  A_HEADER: PD5(4) : D_P_: [...]
  A_BLOCK_: PD8(4) : D_BLOCK: [...]
  A_UP: PD1(4) : <reference to D_COMP_U (262145)>
]
PD4(4) : DI_PROC: [
  SRCPOS: row 1 col 11
  L_SYMREP: text: 'AA'
{output snipped}
```

```
SQL> exec sys.dumpdiana.dump(aname =>
  'AA',print_format => 1);

PL/SQL procedure successfully completed.

SQL>
```

Reconstructing the PL/SQL source - 2

- Goos / Wulf et al page 167

```
Declare
        <DS_ITEM>
Begin
        <DS_STM>
Exception
        <DS_ALTER>
End;
```

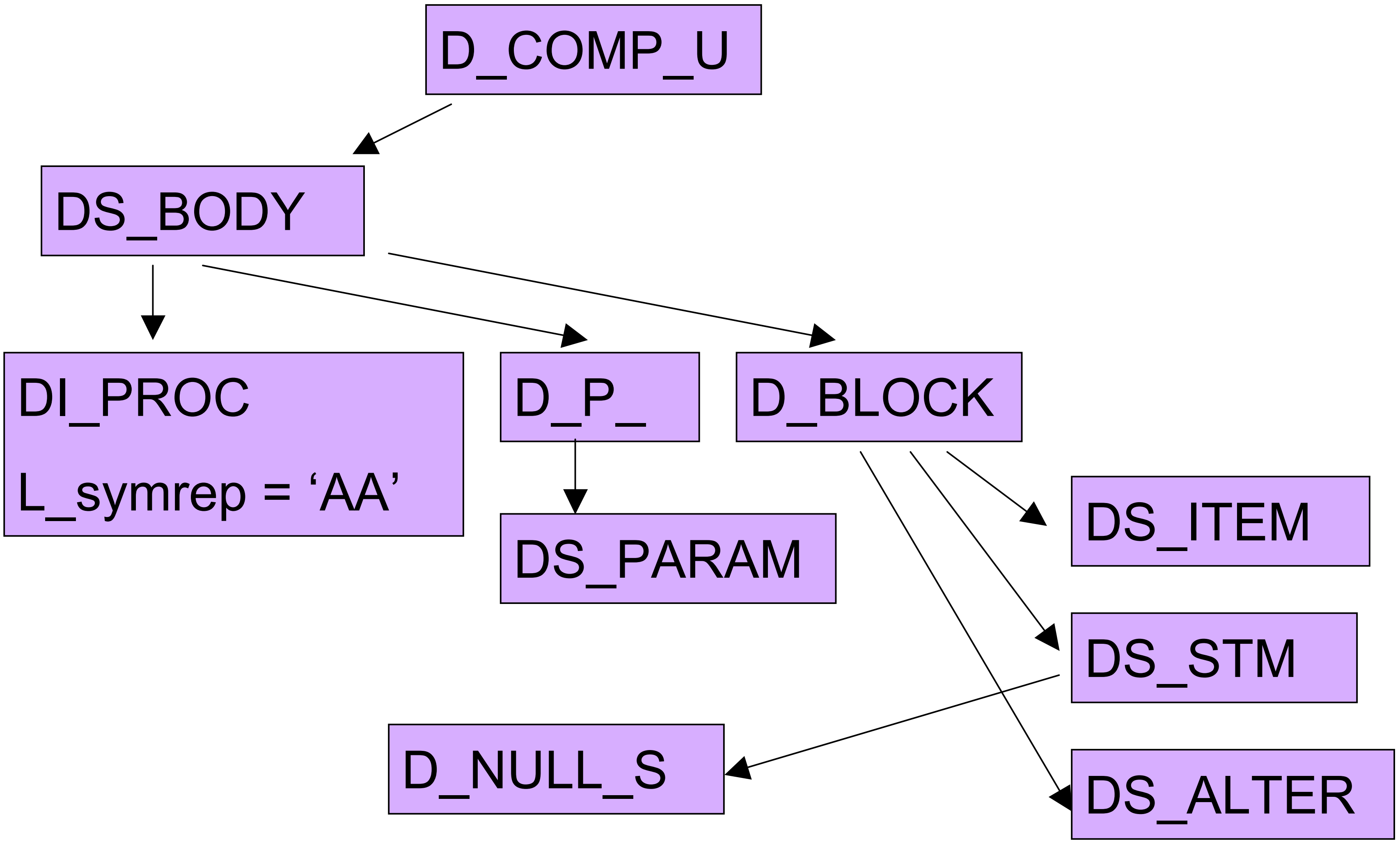
- It is easy to see the close relationship between PL/SQL and DIANA
- Then it is easy to see how PL/SQL can be reconstructed from DIANA

Mapping IDL to DIANA

Code	Dec	name
0	0	?
9a	154	DI_PROC
b4	180	DS_PARAM
55	85	D_P_
6a	106	D_S_DECL
4f	79	D_NULL_S
b7	183	DS_STM
a4	164	DS_ALTER
b1	177	DS_ITEM
11	17	D_BLOCK
68	104	D_S_BODY
4f	79	D_NULL_S
1d	29	D_CONTEX
17	23	D_COMP_U
b5	181	DS_PRAGM

- Take the node names from the DIANA tree or line dump
- Use the DIANA package constants
- Convert dec numbers to Hex
- These hex numbers are familiar?
- Wrap file / idl / diana dumps are all the same
- Hence wrap format is DIANA

Simple tree structure



DIANA utilities - pstub

```
SQL> variable a varchar2(2000);
SQL> variable b varchar2(2000);
SQL> exec sys.pstub('AA',NULL,:a,:b);

PL/SQL procedure successfully completed.

SQL> print :b

B
--------------------------------------------------------------------
  ------------


procedure AA is begin stproc.init('begin AA; end;'); stproc.execute;
  end; procedure AA is begin stproc.init('begin AA; end;');
  stproc.execute; end; procedure AA is begin stproc.init('begin AA;
  end;'); stproc.execute; end;

SQL>
```

DIANA utilities - subptxt

```
SQL> variable a varchar2(2000);
SQL> exec sys.subptxt('AA',NULL,NULL,:a);

PL/SQL procedure successfully completed.

SQL> print :a

A
------------------------------------------------------


procedure AA;

SQL>
```

PSTUB and SUBPTXT

- PSTUB and SUBPTXT are demonstration programs that use the IDL and DIANA API’s
- PSTUB is used to allow the calling of V2 PL/SQL in the server from V1 PL/SQL client tools such as Forms
- SUBPTXT allows the describing of PL/SQL
- Both read DIANA and not PL/SQL source code
- Pistub.sql and the library diutil.sql are the only public example programs to use the DIANA and PIDL packages
- Diutil.exprtext (private function) is an excellent example of how to use DIANA and PIDL package calls

Writing a PL/SQL un-wrapper

- To create an unwrapping tool we need
  - To understand the relationship between DIANA and PL/SQL language constructs
  - A way to parse the DIANA in the correct order – API calls?
  - A way to read and understand the DIANA node types – API calls?
  - A way to read variable attributes for each node and to read their type and value – API calls
- Mapping PL/SQL to DIANA for some language constructs can be done using test programs and dumpdiana

Limitations of a PL/SQL API based un-wrapper

- A comprehensive PL/SQL un-wrapper can be written using the IDL and DIANA PL/SQL package API's
- The $OH/rdbms/admin/diutil.sql file indicates how
- PIDL API's do not emit the complete DIANA
- The DIANA for the body of procedures and functions is not available via the dumpdiana, PIDL, DIANA interfaces (see the next slide)
- The DIANA dump misses PL/SQL in the block section. Local variables are also not included
- It could be possible to write a complete un-wrapper in PL/SQL and read the DIANA from SYS.SOURCE$

PL/SQL API limitations

```
SQL> create or replace procedure ah (i in number, j out
  varchar2) is
  2  begin
  3  if i = 7 then
  4      j := 3;
  5  else
  6      j := 4;
  7  end if;
  8  end;
  9  /

Procedure created.
```

```
PD13(7) : DS_STM: [
  SRCPOS: row 1 col 0
  AS_LIST: PDa(7) : <sequence of 1 item:
 PD14(7)>
  A_UP: PD10(7) : <reference to D_BLOCK
  (458768)>
]
PD14(7) : D_NULL_S: [
  SRCPOS: row 1 col 1
  C_OFFSET: ub4: '0'
  A_UP: PD13(7) : <reference to DS_STM
  (458771)>
]
```

```
SQL> exec dumpdiana.dump(aname => 'AH',print_format => 1);

PL/SQL procedure successfully completed.
```

Enumerating DIANA nodes and attributes

```
SQL> exec attrib(23);
Node Type D_COMP_U
Num Attributes 9
0: 9:A_CONTEX:1: REF 1
1: 40:A_UNIT_B:1: REF 1
2: 62:AS_PRAGM:1: REF 1
3: 114:SS_SQL:30: REF 0
4: 113:SS_EXLST:30: REF 0
5: 111:SS_BINDS:30: REF 0
6: 41:A_UP:1: REF 0
7: 138:A_AUTHID:2: REF 0
8: 142:A_SCHEMA:2: REF 0

PL/SQL procedure successfully completed.

SQL>
```

- See attrib.sql - Also at http://www.petefinnigan.com/attrib.sql
- Uses PIDL to enumerate DIANA nodes and attributes

Creating a real PL/SQL un-wrapper

- Can a complete un-wrapper be written? – Of course, yes
  - There are at least 4 unwrapping tools that I know of
- The complete PL/SQL and SQL grammars are needed - http://www.antlr.org/grammar/1107752678378/PLSQLGrammar.g - Also see "PL/SQL user reference guide"
- It is necessary to understand all DIANA nodes and to map those to PL/SQL – this is not fully documented (partly it is documented as ADA / DIANA)
- It is necessary to understand the wrap file format and to extract the DIANA nodes and attributes from it
- It may be possible to disassemble M-Code back to PL/SQL
- The symbols are embedded in the M-Code

Keywords

```
SQL> desc v$reserved_words
 Name                    Null?    Type
 ------------------------ -------- -------------------


 KEYWORD                 VARCHAR2(64)
 LENGTH                  NUMBER

SQL> select count(*) from v$reserved_words;

  COUNT(*)
----------
       809

SQL>
```

Showing the PL/SQL M-Code as assembler

```
SQL> create or replace procedure ab as
  2  ae number:=1;
  3  begin
  4   ae:=ae+1;
  5  end;
  6  /

Procedure created.

SQL> alter session set events '10928 trace name context forever,
  level 1';

Session altered.

SQL> exec ab;

PL/SQL procedure successfully completed.

SQL> alter session set events '10928 trace name context off';

Session altered.

SQL>
```

The M-Code assembler

```
Entry #1
00001: ENTER      4, 0
<source not available>
00007: XCAL       1, 1
Entry #1
SYS.AB: 00001: ENTER      76, 0
SYS.AB: 00007: INFR       DS[0]+96
  Frame Desc Version = 2, Size = 22
    # of locals = 2
    TC_SSCALARi: FP+4, d=FP+12
    TC_SSCALARi: FP+8, d=FP+44
[Line 2] ae number:=1;
SYS.AB: 00012: CVTIN      HS+0 =1=, FP+4
[Line 4]  ae:=ae+1;
SYS.AB: 00017: CVTIN      HS+0 =1=, FP+8
SYS.AB: 00022: ADDN       FP+4, FP+8, FP+4
SYS.AB: 00029: RET
00012: RET
```

- PL/SQL source is shown
- When wrapped – *source not available* – is shown
- M-Code is mapped to PL/SQL line numbers
- This implies that the line and column details are held in the M-Code

Native compilation and initialisation parameters

- PL/SQL can be natively compiled
- There are a number of initialisation parameters – “*sho parameter*” in SQL*Plus
- It is possible in some versions to use the native compilation to hack Oracle
- It could be possible to inject PL/SQL code via native compilation
- The generated C Code is M-Code VM calls for each instruction

Some sample code – getting started

```
SQL> set serveroutput on size
  1000000
SQL> exec unwrap('AA');
Start up
Root Node :262145
Root code (hex) :23
Root Type :D_COMP_U
--
A_UNIT_B Node :262147
A_UNIT_B Type :D_S_BODY
A_UNIT_B code (hex) :104
--
A_D_ Node :262148
A_D_ Type :DI_PROC
A_D_ code (hex) :154
--
A_HEADER Node :262149
A_HEADER Type :D_P_
A_HEADER code (hex) :85
```

- See unwrap.sql (also on http://www.petefinnigan.com/unwrap.sql
- Test program to
  - Familiarise with the API's
  - Walk the DIANA nodes
  - Read attributes
- It works! Next, work out the PL/SQL that should be emitted for each node or node group

PL/SQL code generation

DS_BODY	“CREATE %{} END;\
DI_PROC = ‘AA’	l_symrep => PROCEDURE ‘AA’
D_P_ = params	{not implemented}
DS_PARAM	{not implemented}
D_BLOCK	“IS” “BEGIN” %{} “EXCEPTION” %{} “END;”
DS_ITEM – local variable	{not implemented}
DS_STM	No output
D_NULL_S	NULL;
DS_ALTER	{not implemented}

A proof of concept un-wrapper

```
SQL> set serveroutput on size 1000000
SQL> exec unwrap_r('AA');
Start up
CREATE OR REPLACE
PROCEDURE AA
IS
BEGIN
NULL;
END;
\

PL/SQL procedure successfu

SQL>
```

- Unwrap_r.sql – also available from http://www.petefinnigan.com/unwrap_r.sql
- Implements the code generation to create PL/SQL from DIANA for a simple procedure
- Uses a simple recursive descent parser

Unwrap_r.sql recursive function

```
create or replace procedure unwrap_r(aname varchar2)
is
        root sys.pidl.ptnod;
        status   sys.pidl.ub4;
  procedure recurse (n sys.pidl.ptnod) is
        seq sys.pidl.ptseqnd;
        len integer;
  begin
               if(pidl.ptkin(n) = diana.d_comp_u) then
                       recurse(diana.a_unit_b(n));
               elsif (pidl.ptkin(n) = diana.d_s_body) then
               dbms_output.put_line('CREATE OR REPLACE ');
               recurse(diana.a_d_(n));
               recurse(diana.a_header(n));
               recurse(diana.a_block_(n));
               dbms_output.put_line('END;');
               dbms_output.put_line('/');
{output snipped}
```

10g – Different but the same?

- **New**
- A new wrap mechanism has been provided
- The contents of symbol table are no longer visible
- The encryption involves base64
- 10gR2 provides the ability to wrap from within the database using DBMS_DDL
- There is a new optimizing compiler for PL/SQL
- **Old**
- The IDL$ tables still contain DIANA and M-Code
- The DIANA, PIDL, DIUTIL and DUMPDIANA packages are still available
- It is still possible to reverse simple procedures using the API’s

The 10g wrapped procedure

```
SQL> select text from dba_source where name='AA';

TEXT
------------------------------------------------------------------------
  --------
procedure aa wrapped
a000000
1
abcd
{identical output snipped}
abcd
7
21 55
tpZtVM0u7lC31uX+QfYfxhNmy+Awg5nnm7+fMr2ywFy49cOldIvAwDL+0oabmYEILYvAgcct
yaam9+Lntg==
```

- This is base64 character set
- Using base64 decode does not reveal the source
- The symbol table is not visible

Create procedure and check IDL use in 10g

- The same sample procedure
- Wrap with 10g *wrap*
- Roughly the same IDL is created in the database as 9i

```
SQL> create or replace procedure aa is
  2  begin
  3  null;
  4  end;
  5  /

Procedure created.

SQL> save aa.sql replace
Wrote file aa.sql
SQL> !wrap iname=aa.sql oname=aa.pls
SQL> @aa.pls
Procedure created.
SQL> @rowid

   BLK FNO RNUM 'CHAR        PART    VERSION     PIECE#     LENGTH
------ --- ---- ----- ---------- ---------- ---------- ----------
 49722   1   22 sb4$           0  167772160          0         14
 49722   1   23 sb4$           0  167772160          1          2
 24966   1    7 ub1$           0  167772160          2          3
 46407   1   14 CHAR$          0  167772160          3          5
 52973   1    6 UB2$           0  167772160          4        131
 52973   1    7 UB2$           0  167772160          5         10
 49722   1   24 sb4$           2  167772160          0         18
 15481   1    0 ub1$           2  167772160          1        174
 15481   1    1 ub1$           2  167772160          2          1

9 rows selected.
```

Simple unwrapping PL/SQL in 10g

```
SQL> exec dumpdiana.dump(aname => 'AA');
user: SYS
PL/SQL procedure successfully completed.
SQL> @unwrap_r
Procedure created.
SQL> exec unwrap_r('AA');
Start up
CREATE OR REPLACE
PROCEDURE AA
IS
BEGIN
NULL;
END;
/

PL/SQL procedure successfully completed.

SQL>
```

- Running dumpdiana creates the same DIANA tree dump trace file as 9i
- Running the proof of concept un-wrapper still works in 10g
- The wrap process in 10g is different though

Protecting PL/SQL based intellectual property

- Can you protect PL/SQL based intellectual property?
- Write PL/SQL as packages; DIANA is not stored in the database
- 9i and 10g wrap mechanisms have both been cracked and un-wrappers are available but not to most people
- Don’t ship source code to the server
- 10g affords better protection because the symbol tables are not visible and the DIANA cannot be read from SOURCE$ but the mechanism is not as strong as 10g
- Protect database structures such as IDL_CHAR$, IDL_UB1$, IDL_UB2$,IDL_SB4$, SOURCE$, ALL_SOURCE, DBA_SOURCE
- Use the scripts from http://www.petefinnigan.com/tools.htm to confirm who can access tables and views

Scripts used

- Rowid.sql – lists the contents of the IDL$ tables
- Idl.sql – lists the IDL contents for all parsed objects
- Unwrap.sql – test program to walk the DIANA nodes
- Unwrap_r.sql – Proof of concept PL/SQL unwrapper
- Ah.sql – test program
- Aa.sql – test program
- Attrib.sql – dumps DIANA types and attributes
- All scripts are available on http://www.petefinnigan.com – add the script name to the URL

Questions and Answers

- Any Questions, please ask
- Later?
  - Contact me via email peter.finnigan@siemens.com
  - Or via my website http://www.petefinnigan.com

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