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Python and Oracle Database On the Table

TIP4076

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Data Access Development
Oracle Database
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About Me

Anthony Tuininga

- Creator and maintainer of cx_Oracle

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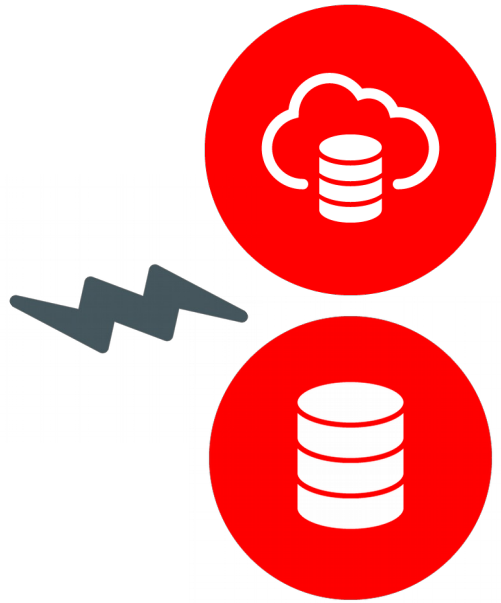
Oracle Database for the Developer

LANGUAGE	API
C	OCI, ODBC, ODPI-C
C++	OCCI
Java	JDBC
.NET	ODP.NET
Node.js	node-oracledb
Python	cx_Oracle
PHP	OCI8, PDO_OCI
R	ROracle
Erlang	erloci
Perl	DBD::Oracle
Ruby	ruby-oci8, ruby-odpi
Rust	mimir, rust-oracle
Go	goracle, rana, mattn

- Oracle Proprietary Drivers
- Oracle Open Source Drivers
- Third Party Open Source Drivers



… and Pro*C, OLE DB, Pro*COBOL, Pro*Fortran, SQLJ, OLE DB

Program Agenda

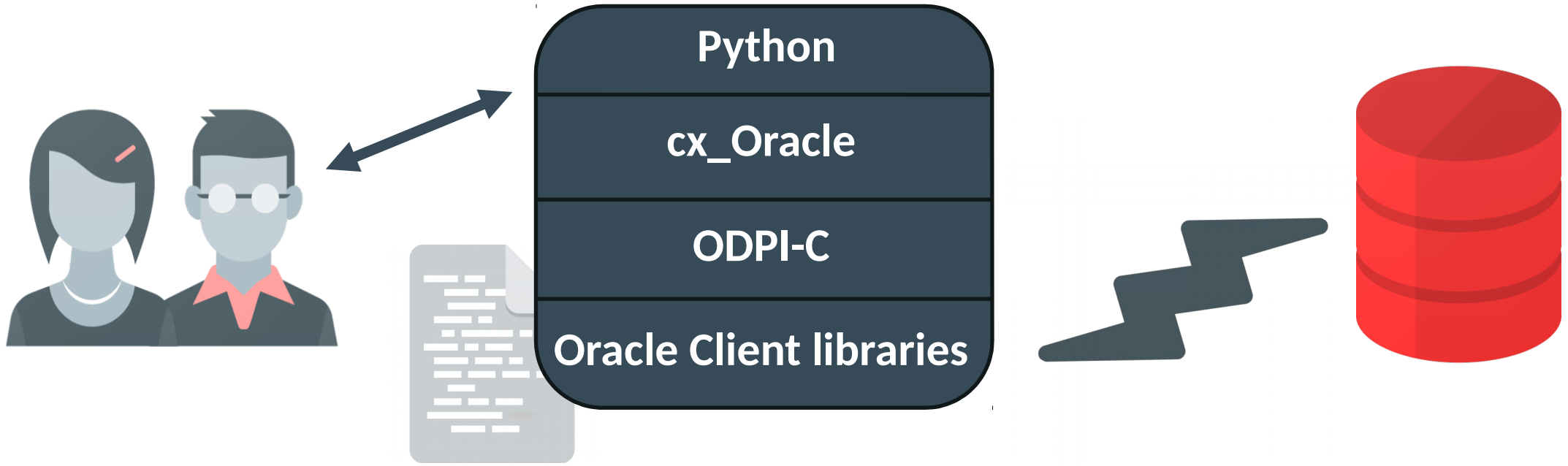
1. About cx_Oracle
2. SODA
3. Batch Execution
4. Named Object Types
5. Tips & Tricks

About cx_Oracle

cx_Oracle Background

- Open Source package giving Python access to Oracle Database
- Covers all of Python Database API specification
  - many additions to support advanced Oracle features
- Begun by Anthony Tuininga in 1998 using Oracle 8i and Python 1.5
  - 30+ releases covering Oracle 8i through 18c
- Latest release is cx_Oracle 7.0 (September 2018)

cx_Oracle Architecture



SODA

Simple Oracle Document Access (SODA)

- NoSQL-style APIs to create and access documents
  - Documents are often JSON
  - SODA calls are mapped to managed tables, indexes and sequences
  - Query-by-example makes data operations easy
  - Preview in cx_Oracle 7 with Oracle Database 18.3
- Recommend use of autocommit
  - But like with SQL, avoid autocommit when inserting lots of documents
  - DDL-like operations occur in autonomous transactions
- SODA APIs also exist in Node.js, C and Java

Creating/Populating SODA Collections


```
SQL> grant SODA_APP to pythondemo;
```

```
 1 conn = cx_Oracle.connect("pythondemo/welcome@localhost/orclpdb")
 2 conn.autocommit = True
 3 soda = conn.getSodaDatabase()
 4 coll = soda.createCollection("mycollection")
 5
 6 content = {'name': 'Matilda', 'address': {'city': 'Melbourne'}}
 7 coll.insertOne(content)
 8
 9 content = {'name': 'Sally', 'address': {'city': 'Singapore'}}
10 doc = coll.insertOneAndGet(content)
11 keyForSally = doc.key
12 print("Key is", keyForSally)
13
14 content = {'name': 'Mary', 'address': {'city': 'Madrid'}}
15 coll.insertOne(content)
```

Querying Collections


```
 1 doc = coll.find().key(keyForSally).getOne()
 2 print("Document content:", doc.getContent())
 3 print()
 4
 5 docs = coll.find().filter({'name': {'$like': 'Ma%'}}).getDocuments()
 6 names = [d.getContent()["name"] for d in docs]
 7 print("Names matching 'Ma%':", names)
 8 print()
 9
10 count = coll.find().count()
11 print('Collection has', count, 'documents')
```

```
Document content: {'name': 'Sally', 'address': {'city': 'Singapore'}}

Names matching 'Ma%': ['Matilda', 'Mary']

Collection has 3 documents
```

Updating Collections


```
1 content = {'name': 'Sally', 'address': {'city': 'Sydney'}}
2 coll.find().key(keyForSally).replaceOne(content)
3
4 count = coll.find().filter({'address.city': {'$regex': '.*o.*'}}).remove()
5 print("Removed", count, "documents")
6 print()
7
8 count = coll.find().count()
9 print('Collection has', count, 'documents')
```

```
Removed 1 documents

Collection has 2 documents
```

Batch Execution

Batch Execution

Execute one DML or PL/SQL statement with many data values

```
 1 rows = [ (1, "First" ),
 2          (2, "Second" ),
 3          (3, "Third" ),
 4          (4, "Fourth" ),
 5          (5, "Fifth" ),
 6          (6, "Sixth" ),
 7          (7, "Seventh" ) ]
 8
 9 cursor = connection.cursor()
10 cursor.executemany("insert into mytab(id, data) values (:1, :2)", rows)
```

Saves “round-trips” between Python and Oracle Database

Array DML Row Counts

- Enables application to get a count of the number of rows affected when executing a DML statement multiple times using `cursor.executemany()`
- Enabled using `cursor.executemany(..., arraydmlrowcounts = True)`
- Row counts are returned using `cursor.getarraydmlrowcounts()`
- Available when both Oracle client and database are 12.1 or higher
- Added in cx_Oracle 5.2

Array DML Row Counts Example


```
 1 create table ParentTable (
 2     ParentId number(9) not null,
 3     Description varchar2(60) not null,
 4     constraint ParentTable_pk primary key (ParentId)
 5 );
 6
 7 create table ChildTable (
 8     ChildId number(9) not null,
 9     ParentId number(9) not null,
10     Description varchar2(60) not null,
11     constraint ChildTable_pk primary key (ChildId),
12     constraint ChildTable_fk foreign key (ParentId) references ParentTable
13 );
14 . . .
```

Array DML Row Counts Example


```
1 parentIdsToDelete = [20, 30, 50]
2
3 cur.executemany("delete from ChildTable where ParentId = :1",
4                 [(i,) for i in parentIdsToDelete],
5                 arraydmlrowcounts = True)
6
7 rowCounts = cur.getarraydmlrowcounts()
8 for parentId, count in zip(parentIdsToDelete, rowCounts):
9     print("Parent ID:", parentId, "deleted", count, "rows.")
```

```
Parent ID: 20 deleted 3 rows.
Parent ID: 30 deleted 2 rows.
Parent ID: 50 deleted 4 rows.
```

Array DML Returning

- Enables application to use batch execution and return data in one call
- Added in cx_Oracle 7
  - With cx_Oracle 6.3 can set cx_Oracle.__future__.dml_ret_array_val = True

Array DML Returning Example


```
 1 parentIdsToDelete = [20, 30, 50]
 2
 3 var = cur.var(int, arraysize = len(parentIdsToDelete))
 4 cur.setinputsizes(None, var)
 5
 6 cur.executemany("delete from ChildTable where ParentId = :1 returning ChildId into :2",
 7                 [(i,) for i in parentIdsToDelete])
 8
 9 for parentId, childIds in zip(parentIdsToDelete, var.values):
10     print("Parent ID:", parentId, "deleted children with ids", childIds)
```

```
Parent ID: 20 deleted children with ids [1002, 1003, 1004]
Parent ID: 30 deleted children with ids [1005, 1006]
Parent ID: 50 deleted children with ids [1012, 1013, 1014, 1015]
```

Batch Errors

- Enables application to determine which rows resulted in an error when calling `executemany()` without causing the entire batch to fail
- Enabled using `cursor.executemany(..., batcherrors = True)`
- Batch errors are returned using `cursor.getbatcherrors()`
  - Each element of the list is an error object
- Can be combined with Array DML Row Counts feature
- Available when both Oracle client and database are 12.1 or higher
- Added in cx_Oracle 5.2

Batch Errors Example


```
 1 dataToInsert = [
 2     (1016, 10, 'Red'),
 3     (1018, 20, 'Blue'),
 4     (1018, 30, 'Green’),  # duplicate key
 5     (1022, 40, 'Yellow'),
 6     (1021, 75, 'Orange'), # parent does not exist
 7 ]
 8
 9 cur.executemany("insert into ChildTable values (:1, :2, :3)", dataToInsert,
10         batcherrors = True)
11 for error in cur.getbatcherrors():
12     print("Error", error.message, "at row offset", error.offset)
```

```
Error ORA-00001: unique constraint (PYTHONDEMO.CHILDTABLE_PK) violated at row offset 2
Error ORA-02291: integrity constraint (PYTHONDEMO.CHILDTABLE_FK) violated - parent key not
found at row offset 4
```

Named Object Types

Binding Named Object Types

- Support added for binding named object types such as SDO (Spatial Data Objects) in cx_Oracle 5.3
  - cx_Oracle 4.3 had the ability to *query* named object types
- Object types can be looked up using **`connection.gettype()`**
- Objects are created by calling **`newobject()`** on the object type or calling the object type directly
- Attributes can be read and written directly
- Elements can be added to a collection using **`append()`** or **`extend()`**

Binding Named Object Types Example


```
 1 create table TestGeometry (
 2     IntCol number(9) not null,
 3     Geometry SDO_GEOMETRY not null
 4 );
 5
 6 describe SDO_GEOMETRY
 7 Name                                      Null?    Type
 8  ----------------------------------------- -------- ----------------------------
 9  SDO_GTYPE                                           NUMBER
10  . . .
11  SDO_ELEM_INFO                                       MDSYS.SDO_ELEM_INFO_ARRAY
12  SDO_ORDINATES                                       MDSYS.SDO_ORDINATE_ARRAY
13  . . .
```

Binding Named Object Types Example


```
 1 typeObj = conn.gettype("SDO_GEOMETRY")
 2 elementInfoTypeObj = conn.gettype("SDO_ELEM_INFO_ARRAY")
 3 ordinateTypeObj = conn.gettype("SDO_ORDINATE_ARRAY")
 4
 5 obj = typeObj.newobject()   # or typeObj()
 6 obj.SDO_GTYPE = 2003
 7 obj.SDO_ELEM_INFO = elementInfoTypeObj.newobject()
 8 obj.SDO_ELEM_INFO.extend([1, 1003, 3])
 9 obj.SDO_ORDINATES = ordinateTypeObj.newobject()
10 obj.SDO_ORDINATES.extend([1, 1, 5, 7])
11
12 cur = conn.cursor()
13 cur.execute("insert into TestGeometry values (1, :objbv)", objbv = obj)
```

Binding PL/SQL Collections and Records

- Prior to cx_Oracle 5.3 only able to bind contiguously populated PL/SQL index-by tables (also known as PL/SQL arrays)
- In cx_Oracle 5.3 now able to bind (both IN and OUT) sparsely populated PL/SQL index-by tables as well as records
- PL/SQL types (index-by tables and records) defined in packages can be looked up using `connection.gettype()`
- Available when both client and database are 12.1 or higher

Binding PL/SQL Collections Example


```
 1 create or replace package pkg_Demo as
 2
 3    type udt_StringList is table of varchar2(100) index by binary_integer;
 4    . . .
 5
 6 create or replace package body pkg_Demo as
 7
 8   procedure DemoCollectionOut (
 9         a_Value out nocopy udt_StringList
10     ) is
11     begin
12         a_Value(-1048576) := 'First element';
13         a_Value(-576)     := 'Second element';
14         a_Value(284)      := 'Third element';
15         a_Value(8388608)  := 'Fourth element';
16     end;
17     . . .
```

Binding PL/SQL Collections Example


```
 1 typeObj = con.gettype("PKG_DEMO.UDT_STRINGLIST")
 2 obj = typeObj.newobject()
 3 cur.callproc("pkg_Demo.DemoCollectionOut", (obj,))
 4
 5 ix = obj.first()
 6 while ix is not None:
 7    print(ix, "->", obj.getelement(ix))
 8    ix = obj.next(ix)
 9
10 print(obj.aslist())
11 print(obj.asdict())
```

```
-1048576 -> First element
-576 -> Second element
284 -> Third element
8388608 -> Fourth element
```

```
['First element', 'Second element', 'Third element', 'Fourth element']
```

```
{-1048576: 'First element', -576: 'Second element',
284: 'Third element', 8388608: 'Fourth element'}
```

Binding PL/SQL Records Example


```
 1 create or replace package pkg_Demo as
 2     type udt_DemoRecord is record (
 3         NumberValue          number,
 4         StringValue          varchar2(30),
 5         DateValue            date,
 6         BooleanValue         boolean
 7     );
 8    . . .
 9
10 create or replace package body pkg_Demo as
11     procedure DemoRecordsInOut (
12         a_Value in out nocopy udt_DemoRecord
13     ) is
14     begin
15         a_Value.NumberValue := a_Value.NumberValue * 2;
16         a_Value.StringValue := a_Value.StringValue || ' (Modified)';
17         a_Value.DateValue := a_Value.DateValue + 5;
18         a_Value.BooleanValue := not a_Value.BooleanValue;
19     end;
```

Binding PL/SQL Records Example


```
 1 typeObj = con.gettype("PKG_DEMO.UDT_DEMORECORD")
 2 obj = typeObj.newobject()
 3
 4 obj.NUMBERVALUE = 6
 5 obj.STRINGVALUE = "Test String"
 6 obj.DATEVALUE = datetime.datetime(2016, 5, 28)
 7 obj.BOOLEANVALUE = False
 8
 9 cur.callproc("pkg_Demo.DemoRecordsInOut", (obj,))
10 print("NUMBERVALUE ->", obj.NUMBERVALUE)
11 print("STRINGVALUE ->", obj.STRINGVALUE)
12 print("DATEVALUE ->", obj.DATEVALUE)
13 print("BOOLEANVALUE ->", obj.BOOLEANVALUE)
```

```
NUMBERVALUE -> 12.0
STRINGVALUE -> Test String (Modified)
DATEVALUE -> 2016-06-02 00:00:00
BOOLEANVALUE -> True
```

Tips and Tricks

General Tips

- For queries use cursor attribute "`arraysize`"
  - Increased size reduces network round trips but uses additional memory
- Use bind variables instead of literal values
  - Reduces overhead of parsing
  - Improves security (eliminates SQL injection)
- Use `executemany()` for Array DML
- Use Session Pooling (optionally with Database Resident Connection Pooling)
  - reduces overhead for establishing and tearing down connections

Subclassing Connections and Cursors

- Enables application to “hook” connection/cursor creation and execution of statements
  - Logging of statement execution, connection creation/destruction
  - Changing the number of parameters to connection creation or statement execution
- Base classes are **`cx_Oracle.Connection`** and **`cx_Oracle.Cursor`**

Subclassing Connections and Cursors Example


```
 1 class Connection(cx_Oracle.Connection):
 2
 3   def __init__(self):
 4       print("CONNECT to a specific database")
 5       return super(Connection, self).__init__(dsn = "my_tns_entry")
 6
 7   def cursor(self):
 8       return Cursor(self)
 9
10 class Cursor(cx_Oracle.Cursor):
11
12   def execute(self, statement, args):
13       print("EXECUTE", statement)
14       print("ARGS:")
15       for argIndex, arg in enumerate(args):
16           print("   ", argIndex + 1, "=>", repr(arg))
17       return super(Cursor, self).execute(statement, args)
```

```
CONNECT to a specific database
EXECUTE select :1 from dual
ARGS:
    1 => 1234
```

Row Factory Functions

- Enables application to return an object other than a tuple when rows are returned from the various fetch routines
  - Can be used to provide names for the various columns
  - Can be used to return custom objects
- Enabled by setting cursor attribute "`rowfactory`" after the statement has been prepared or executed for the first time

Row Factory Functions Example


```
 1 import collections
 2
 3 cur.execute("select ParentId, Description from ParentTable")
 4 cur.rowfactory = collections.namedtuple("MyClass", ["newParentId", "newDescription"])
 5 for row in cursor:
 6    print(row.newParentId, "->", row.newDescription)
 7
 8 # Equivalent output from:
 9 # for i, d in cursor:
10 #    print(i, "->", d)
11 #
12 # for row in cursor:
13 #    print(row[0], "->", row[1])
```

```
1 -> Parent A
2 -> Parent B
. . .
```

Row Factory with Subclassing Example


```
 1 class Cursor(cx_Oracle.Cursor):
 2
 3     def execute(self, statement, args = None):
 4         prepareNeeded = (statement is not None and self.statement != statement)
 5         result = super(Cursor, self).execute(statement, args or [])
 6         if prepareNeeded and self.description:
 7             names = [d[0] for d in self.description]
 8             self.rowfactory = collections.namedtuple("GenericQuery", names)
 9         return result
10
11 for row in cur.execute("select ParentId, Description from ParentTable"):
12     print(row.PARENTID, "->", row.DESCRIPTION)
13
14 for row in cur.execute("""
15         select ParentId as "newParentId", Description as "newDescription"
16         from ParentTable"""):
17     print(row.newParentId, "->", row.newDescription)
```

```
1 -> Parent A
2 -> Parent B
. . .
```

Output Type Handlers

- Enables application to change how data is fetched from the database
  - Return numbers as strings or decimal objects
  - Return CLOB and NCLOB as strings or BLOB as bytes
  - In Python 2.x, return strings as Unicode objects
- Enabled by setting the attribute "`outputtypehandler`" on either the cursor or the connection
- Can be combined with variable converters to retrieve Python objects seamlessly

Output Type Handlers – Numbers as Strings


```
 1 for row in cur.execute("select * from ParentTable order by ParentId"):
 2     print(row)
 3
 4 def ReturnNumbersAsStrings(cursor, name, defaultType, size, precision, scale):
 5     if defaultType == cx_Oracle.NUMBER:
 6         return cursor.var(str, 9, cursor.arraysize)
 7
 8 cur.outputtypehandler = ReturnNumbersAsStrings
 9 for row in cur.execute("select * from ParentTable order by ParentId"):
10     print(row)
```

```
(1, 'Parent A')
(2, 'Parent B’)
. . .
```

```
('1', 'Parent A')
('2', 'Parent B’)
. . .
```

Output Type Handlers – Using a Decimal Converter


```
 1 for value, in cur.execute("select Data from DecimalTab"):
 2     print("Value:", value, "* 3 =", value * 3)
 3
 4 def ReturnNumbersAsDecimal(cursor, name, defaultType, size, precision, scale):
 5     if defaultType == cx_Oracle.NUMBER:
 6         return cursor.var(decimal.Decimal, arraysize = cursor.arraysize)
 7
 8 cur.outputtypehandler = ReturnNumbersAsDecimal
 9 for value, in cur.execute("select Data from DecimalTab"):
10     print("Value:", value, "* 3 =", value * 3)
```

Default output:

```
Value: 0.1 * 3 = 0.30000000000000004
Value: 3.1 * 3 = 9.3
Value: 7.100000000000005 * 3 = 21.3
```

Output Type Handler output:

```
Value: 0.1 * 3 = 0.3
Value: 3.1 * 3 = 9.3
Value: 7.1 * 3 = 21.3
```

Output Type Handlers – LOBs as Strings/Bytes


```
 1 def OutputTypeHandler(cursor, name, defaultType, size, precision, scale):
 2     if defaultType == cx_Oracle.CLOB:
 3         return cursor.var(cx_Oracle.LONG_STRING, arraysize = cursor.arraysize)
 4     elif defaultType == cx_Oracle.BLOB:
 5         return cursor.var(cx_Oracle.LONG_BINARY, arraysize = cursor.arraysize)
 6
 7 cur.outputtypehandler = OutputTypeHandler
 8
 9 for value, in cur.execute("select myclob from mytable"):
10     print(value)
```

```
This is your CLOB data . . .
```

Output Type Handlers – Object


```
 1 def BuildingOutConverter(oracleObj):
 2     return Building(int(oracleObj.BUILDINGID), oracleObj.DESCRIPTION,
 3             int(oracleObj.NUMFLOORS), oracleObj.DATEBUILT)
 4
 5 def OutputTypeHandler(cursor, name, defaultType, size, precision, scale):
 6     if defaultType == cx_Oracle.OBJECT:
 7         return cursor.var(cx_Oracle.OBJECT, arraysize = cursor.arraysize,
 8                 outconverter = BuildingOutConverter, typename = "UDT_BUILDING")
 9
10 cur.outputtypehandler = OutputTypeHandler
11 for row in cur.execute("select * from Buildings order by BuildingId"):
12     print(row)
```

```
(1, <Building 1: The First Building>)
(2, <Building 2: The Second Building>)
(3, <Building 3: The Third Building>)
```

Input Type Handlers

- Enables application to change how data is bound to statements or to enable new types to be bound directly without having to be converted first
- Enabled by setting the attribute `inputtypehandler` on either the cursor or the connection
- Can be combined with variable converters to bind Python objects seamlessly

Input Type Handlers Example


```
 1 def BuildingInConverter(value):
 2     obj = objType.newobject()
 3     obj.BUILDINGID  = value.buildingId
 4     obj.DESCRIPTION = value.description
 5     obj.NUMFLOORS   = value.numFloors
 6     obj.DATEBUILT   = value.dateBuilt
 7     return obj
 8
 9 def InputTypeHandler(cursor, value, numElements):
10     if isinstance(value, Building):
11         return cursor.var(cx_Oracle.OBJECT, arraysize = numElements,
12                 inconverter = BuildingInConverter, typename = objType.name)
13
14 objType = con.gettype("UDT_BUILDING")
15 building = Building(1, ”Skyscraper 1", 5, datetime.date(2001, 5, 24))
16 cur.inputtypehandler = InputTypeHandler
17 cur.execute("insert into mytable values (:1, :2)", (1, building))
```

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Other Sessions: https://tinyurl.com/AppDevOOW18

- Python and Oracle Database 18c: Scripting for the Future [HOL6329]
  - Tuesday, Oct 23, 2:15 pm - 3:15 pm | Marriott Marquis (Yerba Buena Level) - Salon 3/4
- A Database Proxy for Transparent High Availability, Performance, Routing, and Security [TRN4070]
  - Wednesday, Oct 24, 11:15 am - 12:00 pm | Moscone West - Room 3009
- Meet the Experts: Node.js, Python, PHP, and Go with Oracle Database [MTE6765]
  - Wednesday, Oct 24, 3:00 pm - 3:50 pm | Moscone West - The Hub - Lounge B
- Node.js: Async Data In and Data Out with Oracle Database [TIP4080]
  - Thursday, Oct 25, 11:00 am - 11:45 am | Moscone West - Room 3009
- Performance and Scalability Techniques for Oracle Database Applications [TIP4075]
  - Thursday, Oct 25, 12:00 pm - 12:45 pm | Moscone West - Room 3009
- Demo Booth: APD-A03 Moscone South


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