Pointers? In My Python?

It's more likely than you think!

Eli Holderness / @eliholderness
Developer Advocate at Anvil

what pointers are

what the `id` of a Python object is

how CPython can tell when you’re done with an object

What is a pointer?

```
void *a_pointer;

int *a_pointer_to_an_int;

char *a_pointer_to_a_char;
```

Pointer aliasing

… also known as ‘wait, I didn’t change that variable, did I?’

```
>>> a = [“my”, “cool”, “list”]
>>> a
[“my”, “cool”, “list”]
```

```
>>> b = a
>>> b[1] = “awesome”
>>> b
[“my”, “awesome”, “list”]

>>> a
[“my”, “awesome”, “list”]
```

```
>>> c = a.copy()
>>> c[1] = “amazing”
>>> c
[“my”, “amazing”, “list”]

>>> a
[“my”, “awesome”, “list”]
```

I heard you like pointers...

```
>>> a = [[“a”, “b”], [“A”, “B”]]
>>> a
[[“a”, “b”], [“A”, “B”]]
```

```
>>> b = a.copy()
>>> b[0].append(“c”)
>>> b[0]
[“a”, “b”, “c”]

>>> a[0]
[“a”, “b”, “c”]
```

What if it’s pointers all the way down?

```
>>> c = a.deepcopy()
>>> c[1].append(“C”)
>>> c[1]
[“A”, “B”, “C”]

>>> a[1]
[“A”, “B”]
```

= makes a new pointer to the same object

copy makes a new object, and copies the pointers contained in the original

deepcopy makes a new object and copies the values, all the way down

https://docs.python.org/3/library/copy.html

Tuples behaving badly

A tuple `a` is immutable

`a[0]` must point to the same object during the lifetime of `a`

So what if `a[0]` is mutable?

```
>>> a = ([1, 2, 3], [“x”, “y”])
>>> a[0]
[1, 2, 3]
```

```
>>> a[0].append(4)
>>> a[0]
[1, 2, 3, 4]
```

```
>>> a[1] += [“z”]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'tuple' object does not
support item assignment
```

```
>>> a[1]
[“x”, “y”, “z”]
```

```
>>> a[1] += [“z”]
```

+= mutates (+) then assigns (=)

Object IDs

`id(x)`

unique

constant

… for the lifetime of x

Many Python implementations use the object's address in memory as its `id`, but not all!

CPython uses the memory address

Skulpt generates and caches a random number

```
>>> a = [“a”, “list”]
>>> id(a)
140000359895536
```

```
>>> b = a
>>> id(a), id(b)
(140000359895536, 140000359895536)
```

```
>>> c = a.copy()
>>> id(a), id(c)
(140000359895536, 140000359764000)
```

When are two objects actually the same?

```
>>> a = [“a”, “list”]
>>> b = a
>>> c = a.copy()
```

```
>>> a == b
True
>>> a is b
True
```

```
>>> a == c
True
>>> a is c
False
```

`is` uses `id`

```
a is b
⇔
id(a) == id(b)
```

`==` uses `__eq__`

… so what is `__eq__`?

`__str__`

`__repr__`

`__init__`

The `__eq__` method defines the behaviour of `==` when applied to instances of its class.

```
class MyClass:
  def __eq__(self, other):
    return self is other
```

```
class MyNamedClass:
  def __init__(self, name):
    self.name = name

  def __eq__(self, other):
    return True
```

anvil

```
>>> a = MyNamedClass(“a”)
>>> b = MyNamedClass(“b”)
>>> a.name == b.name
False
>>> a == b
True
```

```python
class MyUniqueClass:
  def __eq__(self, other):
    return False
```

```
>>> a = MyUniqueClass()
>>> a == a
False
```

Object Lifetimes

`__del__`

called when an object is
about to be removed
from memory

```
class MyDelClass:
  def __init__(self, name):
    self.name = name

  def __del__(self):
    print(f“deleting {self.name}!”)
```

Python frees memory in two ways:

Reference Counting

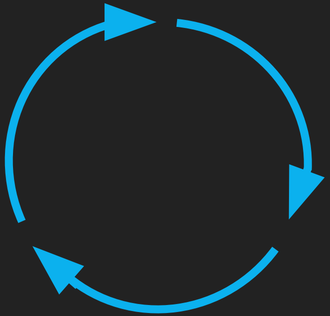
Garbage Collection

```
>>> dave = MyDelClass(“Dave”)
>>> del dave
Deleting Dave!
```

```
>>> alice = MyDelClass(“Alice”)
>>> also_alice = alice
>>> del alice

>>> del also_alice
Deleting Alice!
```

Cyclic references



```
>>> jane = MyDelClass(“Jane”)
>>> bob = MyDelClass(“Bob”)
>>> bob.friend = jane
>>> jane.friend = bob

>>> del jane
>>> del bob
```

Reference counting isn’t sufficient

CPython’s Garbage Collector

detects cyclic isolates

calls their finalizers (`__del__`)*

breaks the cyclic references

```
>>> import gc
```

```
>>> gc.is_tracked(“a string”)
False
```

```
>>> gc.is_tracked([“a”, “list”])
True
```

```
>>> jane = MyDelClass(“Jane”)
>>> gc.is_tracked(jane)
True
```

The GC uses an object's traversal method to access all its pointers

```
>>> my_list = [“a”, “list”]
>>> gc.get_referents(my_list)
[‘list’, ‘a’]
```

```
>>> jane = MyDelClass(“Jane”)
>>> bob = MyDelClass(“Bob”)
>>> bob.friend = jane
>>> jane.friend = bob
>>> del jane
>>> del bob
```

```
>>> import gc
>>> gc.collect()
Deleting Jane!
Deleting Bob!
4
```

Fun with finalizers

```python
class MyBadDelClass:
    def __init__(self, name):
        self.name = name

    def __del__(self):
        global person
        person = self
        print(f“deleting {self.name}!”)
```

```
>>> jane = MyBadDelClass(“Jane”)
>>> bob = MyBadDelClass(“Bob”)
>>> bob.friend = jane
>>> jane.friend = bob
>>> del jane
>>> del bob
```

```
>>> gc.collect()
Deleting Jane!
Deleting Bob!
0

>>> person
<__main__.MyBadDelClass object at
0x7ff8ce65dd30>
```

```
>>> person.name
‘Bob’
>>> person.friend.name
‘Jane’
```

```
>>> jane
NameError: name 'jane' is
not defined
```

```
>>> del person
>>> gc.collect()
4
```

Pointers? In My Python?

It’s more likely than you think!

Eli Holderness / @eliholderness
Developer Advocate at Anvil