Python References

Summary: in this tutorial, you'll have a good understanding of Python references and referencing counting.

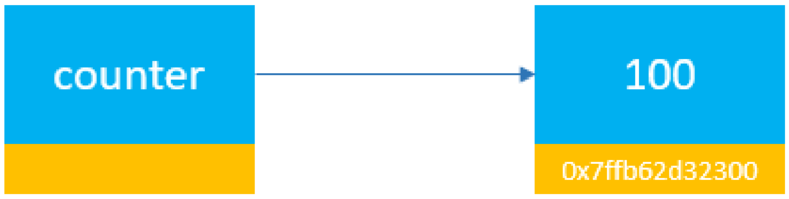
Introduction to Python references

In Python, a variable (https://www.pythontutorial.net/python-basics/python-variables/) is not a label of a value like you may think. Instead, A variable references an object that holds a value. In other words, variables are references.

The following example assigns a number with the value of `100` to a variable:

```
counter = 100
```

Behind the scene, Python creates a new integer object (`int`) in the memory and binds the `counter` variable to that memory address:



When you access the `counter` variable, Python looks up the object referenced by the `counter` and returns the value of that object:

```
print(counter) # 100
```

So variables are references that point to the objects in the memory.

To find the memory address of an object referenced by a variable, you pass the variable to the built-in `id()` function.

For example, the following returns the memory address of the integer object referenced by the `counter` variable:

```
counter = 100
print(id(counter))
```

Output:

```
140717671523072
```

The `id()` function returns the memory address of an object referenced by a variable as a base-10 number.

To convert this memory address to a hexadecimal, you use the `hex()` function:

```
counter = 100

print(id(counter))
print(hex(id(counter)))
```

Output:

```
140717671523072
0x7ffb62d32300
```

Reference counting

An object in the memory address can have one or more references. For example:

```
counter = 100
```

The integer object with the value of 100 has one reference which is the `counter` variable. If you assign the `counter` to another variable e.g., `max` :

```
counter = 100
max = counter
```

Now, both `counter` and `max` variables reference the same integer object. The integer object with value 100 has two references:

If you assign a different value to the `max` variable:

```
max = 999
```

…the integer object with value 100 has one reference, which is the `counter` variable:

And the number of references of the integer object with a value of 100 will be zero if you assign a different value to the `counter` variable:

```python
counter = 1
```

Once an object doesn't have any reference, Python Memory Manager will destroy that object and reclaim the memory.

Counting references

To get the number of references of an object, you use the `from_address()` method of the `ctypes` module.

```
ctypes.c_long.from_address(address).value
```

To use this method, you need to pass the memory address of the object that you want to count the references. Also, the address needs to be an integer number.

The following defines a function called `ref_count()` that uses the `from_address()` method:

```
import ctypes


def ref_count(address):
    return ctypes.c_long.from_address(address).value
```

Now, you can use a shorter `ref_count()` function instead of using the long syntax like above.

This example defines a list of three integers:

```
numbers = [1, 2, 3]
```

To get the memory address of the `numbers` list, you use the `id()` function as follows:

```
numbers_id = id(numbers)
```

The following shows the number of references of the list referenced by the `numbers` variable:

```
print(ref_count(numbers_id))  # 1
```

It returns one because currently only the `numbers` variable references the list.

This assigns the `numbers` variable to a new variable:

```
ranks = numbers
```

The number of references of the list should be two now because it is referenced by both `numbers` and `ranks` variables:

```
print(ref_count(numbers_id)) # 2
```

If you assign `ranks` variable `None` , the reference count of the list will reduce to one:

```
ranks = None
print(ref_count(numbers_id))  # 1
```

And if you assign the `numbers` variable `None` , the number of references of the list will be zero:

```
numbers = None
print(ref_count(numbers_id))  # 0
```

Put it all together:

```
import ctypes


def ref_count(address):
    return ctypes.c_long.from_address(address).value


numbers = [1, 2, 3]
numbers_id = id(numbers)

print(ref_count(numbers_id))  # 1

ranks = numbers
```

```
print(ref_count(numbers_id))  # 2

ranks = None
print(ref_count(numbers_id))  # 1

numbers = None
print(ref_count(numbers_id))  # 0
```

Summary

- Python variables are references to objects located in the memory
- Use the `id()` function to get the memory address of the object referenced by a variable.