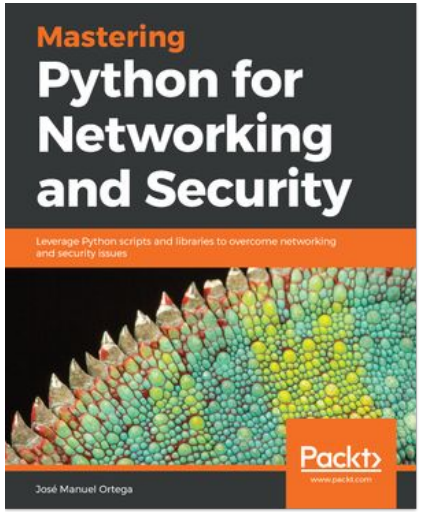
Python Memory Management 101

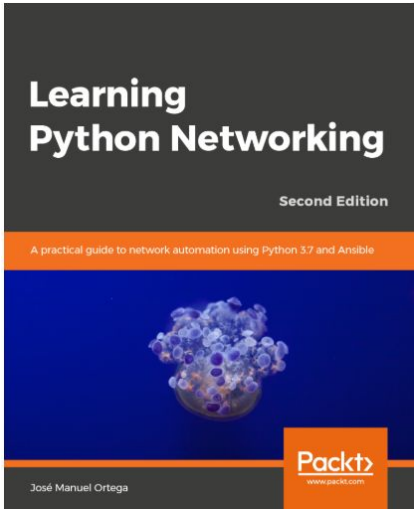
Deeping in Garbage collector

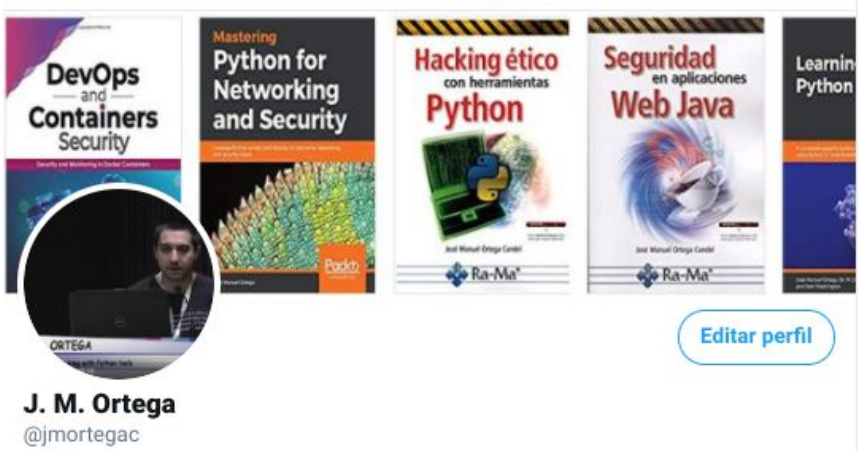
José Manuel Ortega
@jmortegac

About me

- @jmortegac
- http://jmortega.github.io
- https://www.linkedin.com/in/jmortega1/







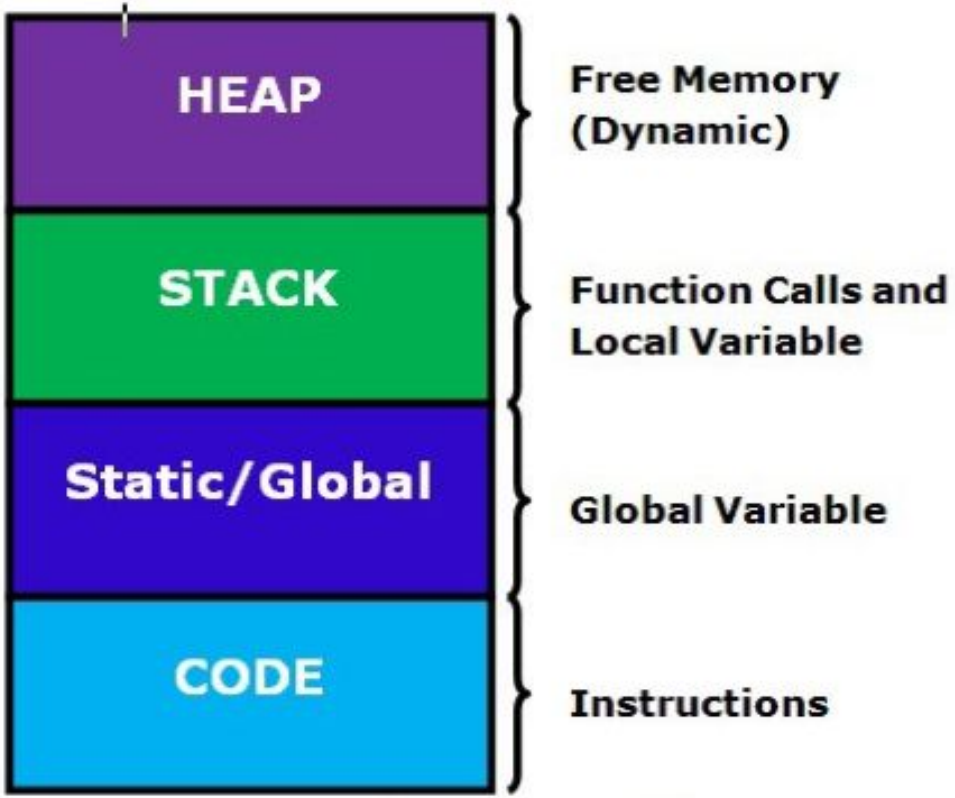
Agenda

- Introduction to memory management
- Garbage collector and reference counting with python
- Review the gc module for configuring the python garbage collector
- Best practices for memory managment

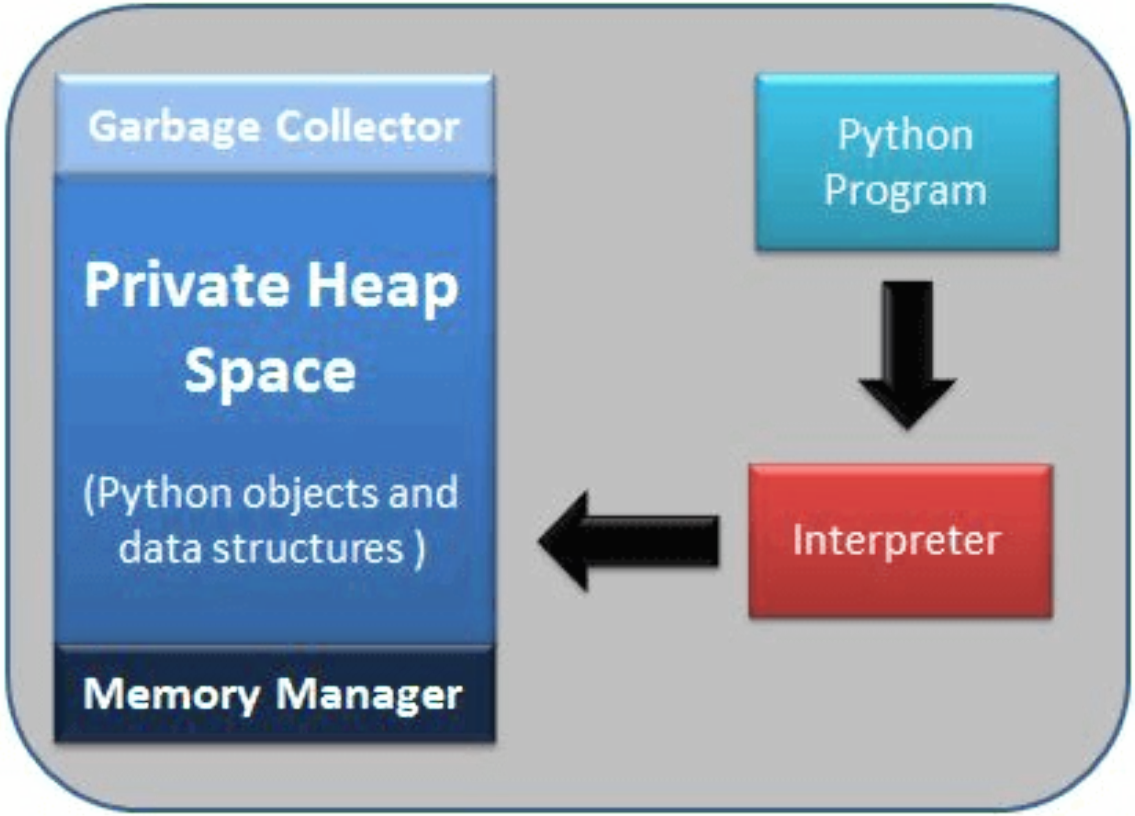
Introduction to memory management

- Memory management is the process of efficiently allocating, de-allocating, and coordinating memory so that all the different processes run smoothly and can optimally access different system resources.

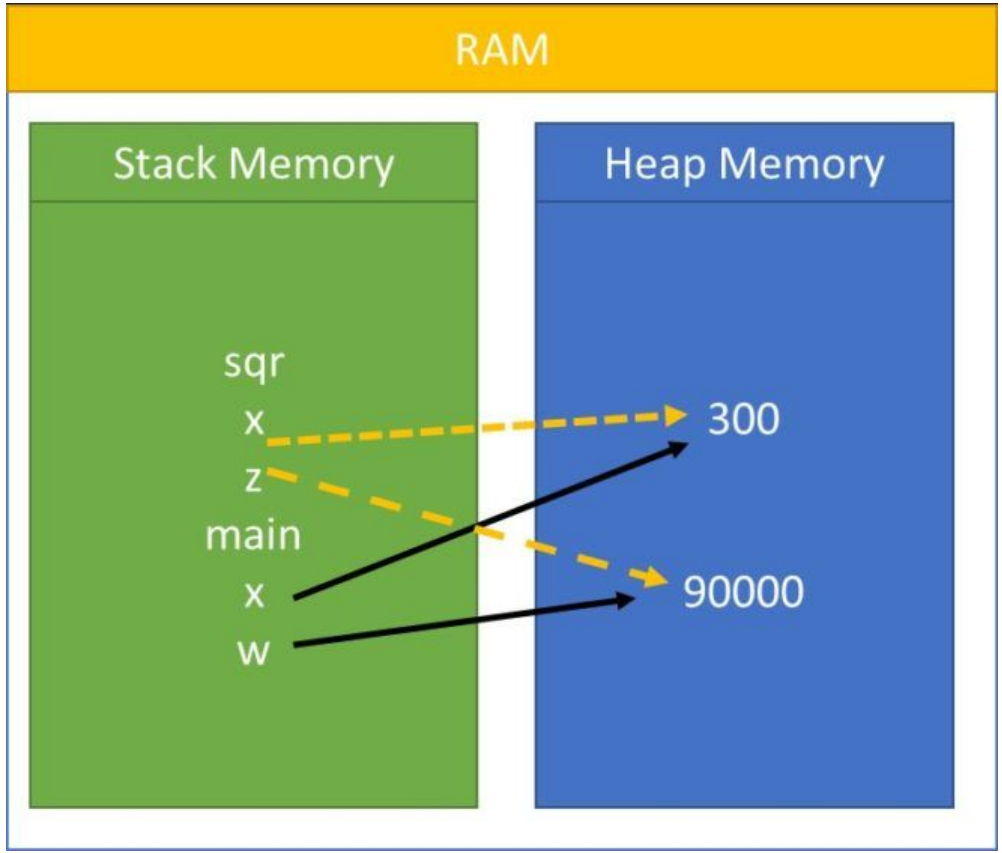
Python Objects in Memory



Python Memory Manager

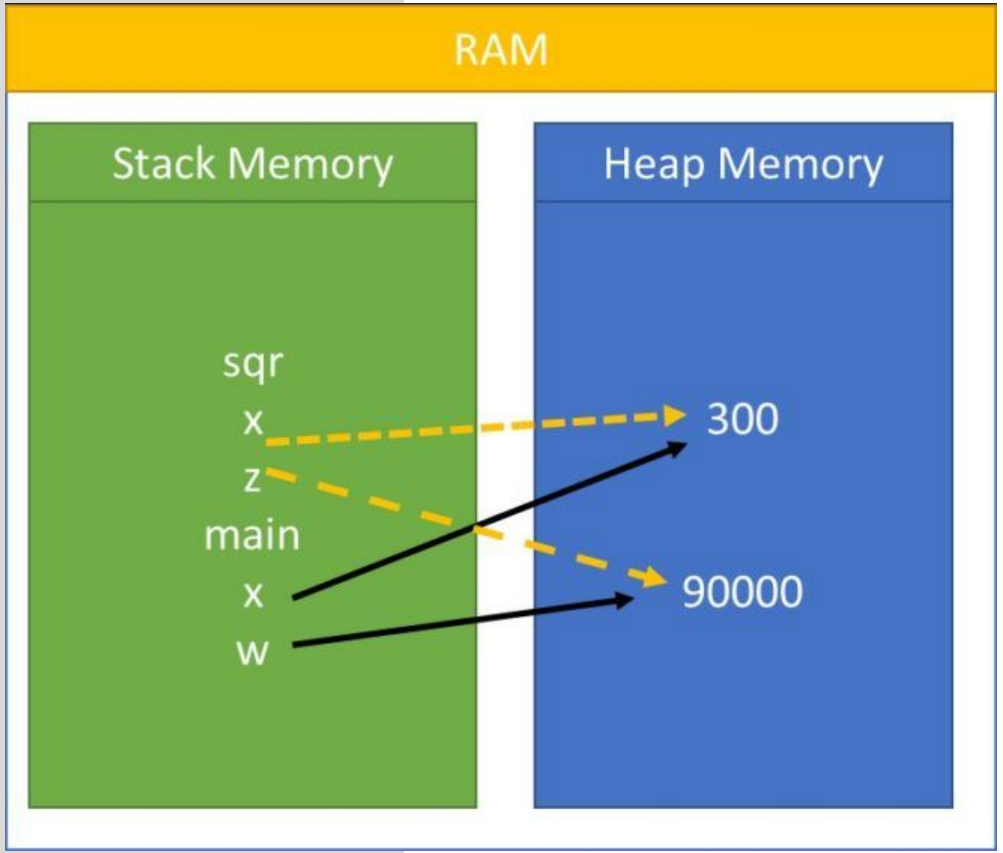


Heap allocation



Heap allocation

```
def main():
    x=300
    print(id(x))
    w=fun(x)
    print(id(w))

def sqr(x):
    print (id(x))
    z=x*x
    print(id(z))
    return z

if __name__ == "__main__":
    main()
```



Python Objects in Memory

- Each variable in Python acts as an object
- Python is a dynamically typed language which means that we do not need to declare types for variables.

Python Objects in Memory

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> x=5
> print(x)
5
> del(x)
> print(x)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'x' is not defined
>
```

Python Objects in Memory

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> x=50
> y=x
> x+=1
> print("x,y:",x,y)
x,y: 51 50
>
```

Python Objects in Memory

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> x = [1,2,3]
> y = x
> x[2] = 4
> print("x,y:",x,y)
x,y: [1, 2, 4] [1, 2, 4]
>
```

Python Objects in Memory

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> x = ['foo', [1, 2, 3], 10.4]
> y = x
> print(x,y)
['foo', [1, 2, 3], 10.4] ['foo', [1, 2, 3], 10.4]
> y[1][0] = 4
> print(x,y)
['foo', [4, 2, 3], 10.4] ['foo', [4, 2, 3], 10.4]
> x[1][0] = 5
> print(x,y)
['foo', [5, 2, 3], 10.4] ['foo', [5, 2, 3], 10.4]
>
```

id() method

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> list = [1,2,3]
> id(list)
140352728911232
> list2 = [1,2,3]
> id(list2)
140352725718848
> list2 = list
> id(list2)
140352728911232
> id(list)
140352728911232
>
```

id() method

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> x=10
> y=10
> print(id(x))
139786009870880
> print(id(y))
139786009870880
> print(x is y)
True
> print(y is x)
True
> z=x
> print(id(z))
139786009870880
>
```

id() method

```
> w='string'
> z=w
> print(id(w))
139785921940720
> print(id(z))
139785921940720
> print(x is z)
False
> print(z is x)
False
```

is Operator

```
> x = 1234
> y = x
> id(x)
140395389327632
> id(y)
140395389327632
> x is y
True
> y is x
True
>
```

```
> x = 1234
> y = 1234
> x is y
False
> y is x
False
>
```

Reference counting

- Python manages objects by using reference counting
- Reference counting works by counting the number of times an object is referenced by other objects in the application.
- When references to an object are removed, the reference count for an object is decremented.

Reference counting

- A reference is a container object pointing at another object.

- Reference counting is a simple technique in which objects are allocated when there is reference to them in a program

Reference counting

- when reference count increases?
  - x=1
  - def(x):
  - list.append(x)

Reference counting

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> import sys
> list = [1,2,3,4]
> sys.getrefcount(list)
2
> list2 = list
> sys.getrefcount(list)
3
```

Reference counting

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> l1 = [1,2,3,4]
> l2 = l1
> import sys
> sys.getrefcount(l1)
3
> l2 = None
> sys.getrefcount(l1)
2
> sys.getrefl1 = None
> l1 = None
> sys.getrefcount(l1)
4268
>
```

Reference counting

```
> import sys
> def print_value(value):
...     print("Value is",value)
...     print("RefCount is ",sys.getrefcount(value))
...
> value=7
> sys.getrefcount(value)
20
> print_value(value)
Value is 7
RefCount is  22
> sys.getrefcount(value)
20
```

Reference counting

- Easy to implement
- Objects are immediately deleted when reference counter is 0

✗ Not thread-safe
✗ Doesn't detect cyclic references
✗ space overhead - reference count is stored for every object

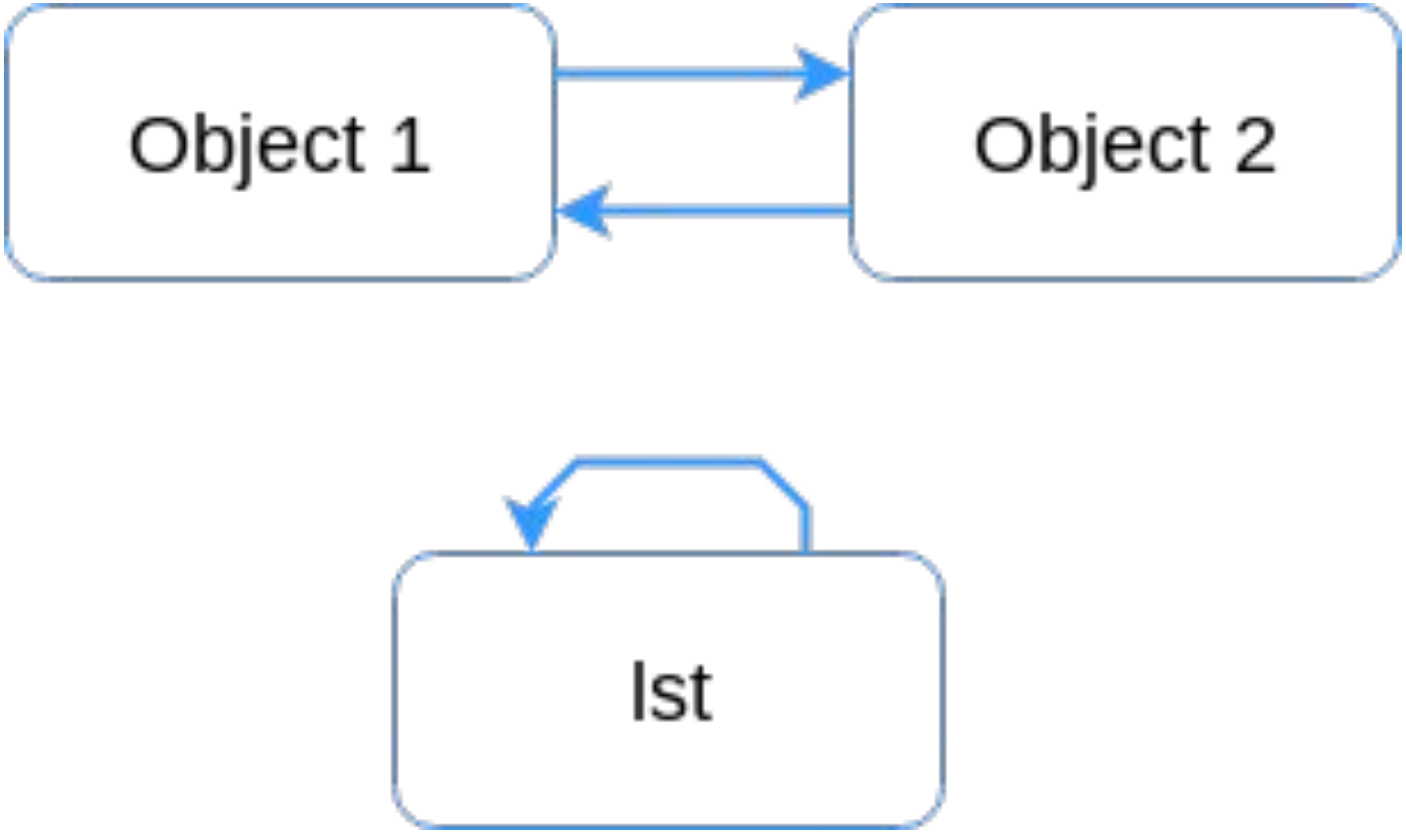
Garbage collector(GC) module

```
Python 3.8.1 (default, Feb  2 2020, 08:37:37)
> list = [1,2,3,4]
> list2 = [list,[5,6,7,8]]
> dict = {'key':list2,'key2':'value'}
> import gc
> gc.get_referents(dict)
[[[1, 2, 3, 4], [5, 6, 7, 8]], 'value']
>
```

Python Garbage collector

- Reference Counting + Generational GC
- RefCount reaches zero, immediate deletion
- Deleted objects with cyclic references are deleted with Tracing GC

Garbage collector(GC) reference cycle



Garbage collector(GC) reference cycle

```
>>> def ref_cycle():
...     list = [1, 2, 3, 4]
...     list.append(list)
...     return list
```

Garbage collector(GC) reference cycle

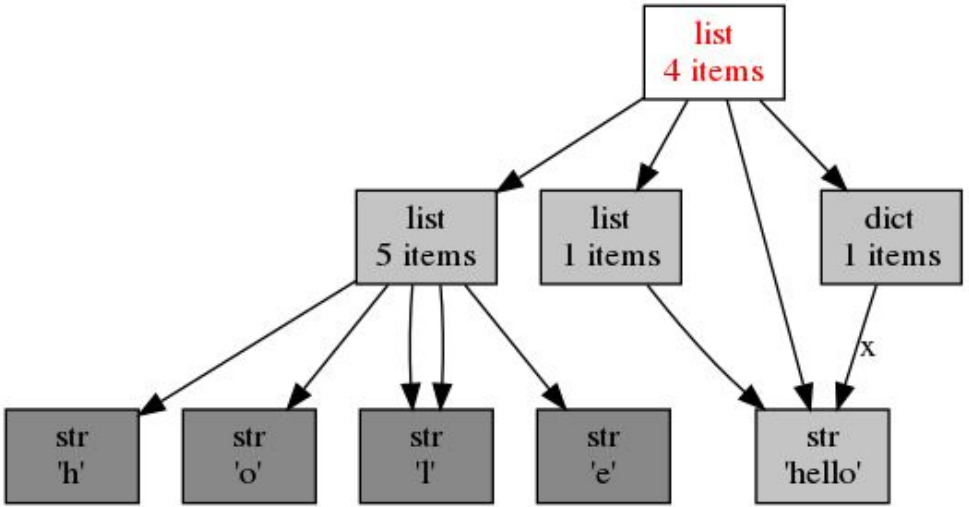
```
import gc
for i in range(8):
        ref_cycle()

n = gc.collect()

print("Number of unreachable objects collected by GC:", n)
print("Uncollectable garbage:", gc.garbage)
print("Number of unreachable objects collected by GC:",
gc.collect())
```

Garbage collector(GC) reference cycle

```
Creating garbage...
Collecting...
Number of unreachable objects collected by GC: 8
Uncollectable garbage: []
Number of unreachable objects collected by GC: 0
```

Python Object Graphs
https://mg.pov.lt/objgraph/

```
import objgraph
x = "hello"
y = [x, [x], list(x), dict(x=x)]
objgraph.show_refs([y],
filename='sample-graph.png'
```



Best practices for memory management

- Using gc.collect() carefully

```
print("Collecting...")
n = gc.collect()
print("Number of unreachable objects collected:", n)
print("Uncollectable garbage:", gc.garbage)
```

Garbage collector(GC) methods

gc — Garbage Collector interface

This module provides an interface to the optional garbage collector. It provides the ability to disable the collector, tune the collection frequency, and set debugging options. It also provides access to unreachable objects that the collector found but cannot free. Since the collector supplements the reference counting already used in Python, you can disable the collector if you are sure your program does not create reference cycles. Automatic collection can be disabled by calling `gc.disable()`. To debug a leaking program call `gc.set_debug(gc.DEBUG_LEAK)`. Notice that this includes `gc.DEBUG_SAVEALL`, causing garbage-collected objects to be saved in gc.garbage for inspection.

The `gc` module provides the following functions:

`gc.`**`enable`**()
Enable automatic garbage collection.

`gc.`**`disable`**()
Disable automatic garbage collection.

`gc.`**`isenabled`**()
Return `True` if automatic collection is enabled.

`gc.`**`collect`**(*`generation=2`*)
With no arguments, run a full collection. The optional argument *generation* may be an integer specifying which generation to collect (from 0 to 2). A `ValueError` is raised if the generation number is invalid. The number of unreachable objects found is returned.

Best practices for memory management

- Using with context manager for working with files

```
with open('data.txt', 'r') as file:
    data = ','.join(line.strip() for line in file)
```

Best practices for memory management

- Avoid List Slicing with [:]

```
list= [1,2,3,4]
list[1:3]


list[slice(1,3)]
```

Best practices for memory managment

- String Concatenation

```
string= “hello”
string+= “world”

wordList = ("hello", "world")
string = " ".join(wordList)
```

Best practices for memory management

- Use Iterators and Generators

```
def __iter__(self):
    """This function allows are set to be iterable. Elements can be
    looped over using 'for item in set'"""
    return self._generator()

def _generator(self):
    """This function is a helper for iterable. It stores the data we are
    currently on and gives the next item at each iteration of the loop."""
    for item in self.items():
        yield item
```

References

- https://stackabuse.com/basics-of-memory-management-in-python/
- https://realpython.com/python-memory-management
- https://rushter.com/blog/python-garbage-collector
- https://pythonchb.github.io/PythonTopics/weak_references.html

https://www.youtube.com/c/JoseManuelOrtegadev

J.M. Ortega

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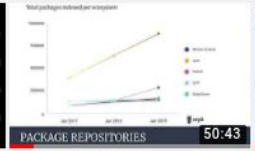

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