Track memory leaks in Python

Pycon 2014, Montréal

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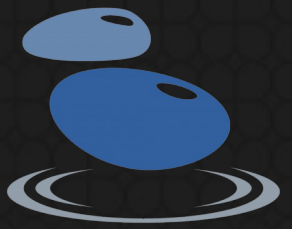

- Python core developer since 2010
- `github.com/haypo/`
- `bitbucket.org/haypo/`
- Working for eNovance

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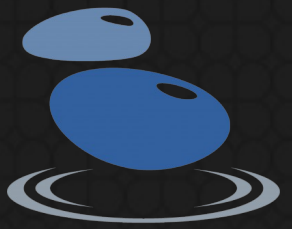
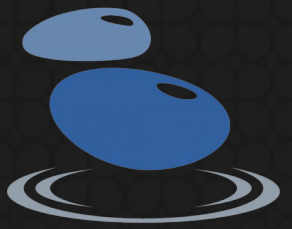
Reference cycle



```
a.b = b
b.a = a
# a → b → a
a = None
b = None
# a and b are not deleted
```

Reference cycle



```
a.b = b
b.a = weakref.ref(a)
# b.a() is a
a = None    # delete a
# b.a() is None
```

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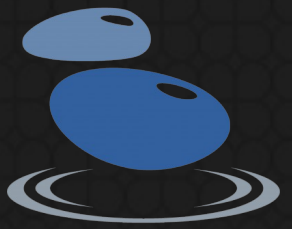
View the references



```
>>> import gc
>>> data = {'abc': 123}
>>> gc.get_referents(data)
['abc', 123]
```

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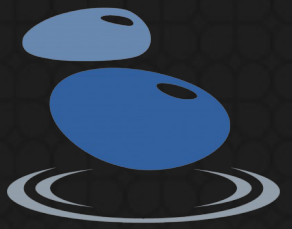
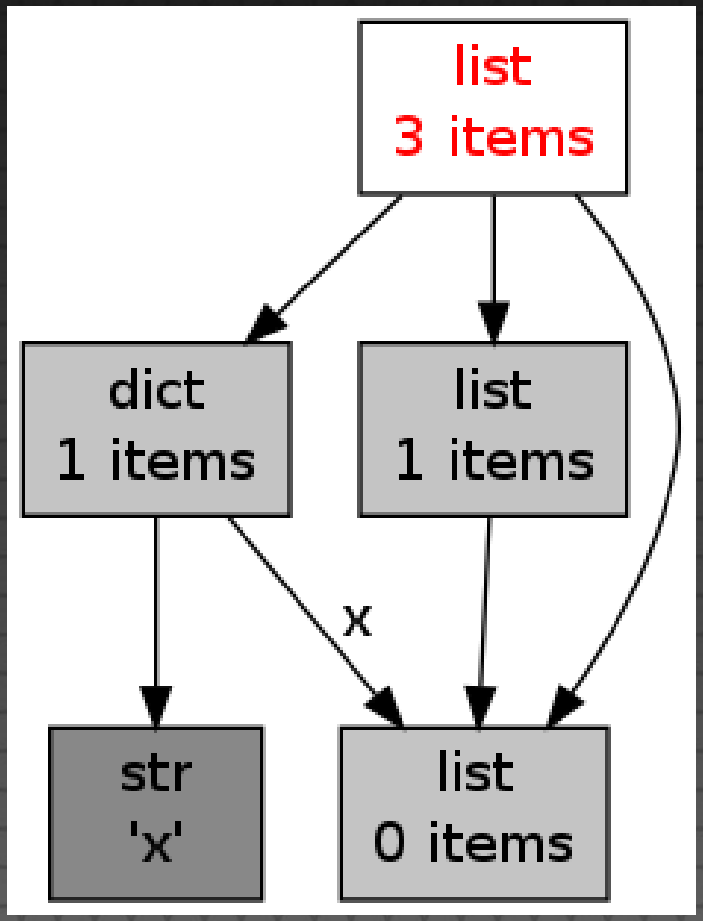
View the references



objgraph project



http://mg.pov.lt/objgraph/

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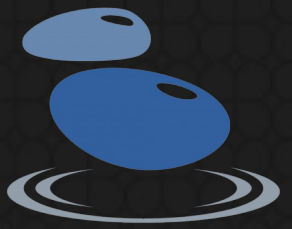
RSS memory



- Representative for the system
- Coarse measurement
- Heap fragmentation
- Difficult to exploit

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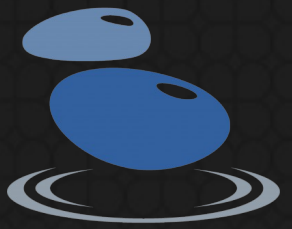
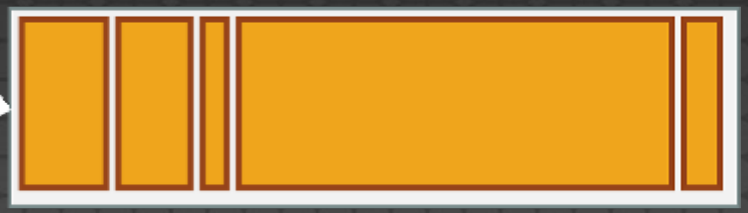
Heap fragmentation



Used 2 MB / RSS 2 MB

Allocate 8 MB



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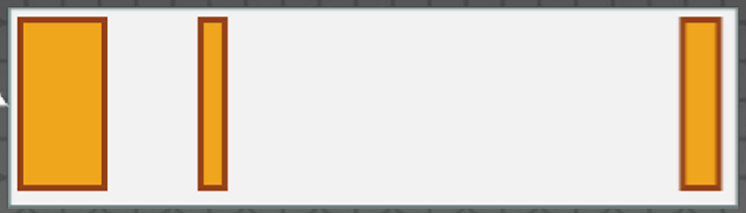

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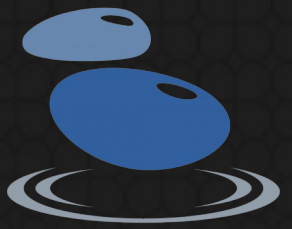
memory_profiler



```
Mem usage    Increment  Line Contents
================================================
                        @profile
  5.97 MB    0.00 MB   def my_func():
 13.61 MB    7.64 MB       a = [1] * (10 ** 6)
166.20 MB  152.59 MB       b = [2] * (10 ** 8)
 13.61 MB -152.59 MB       del b
 13.61 MB    0.00 MB       return a
```

http://pypi.python.org/pypi/memory_profiler

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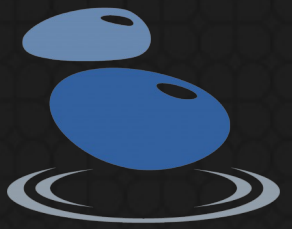
Manual computation



```
>>> data = {None: b'x' * 10000}
>>> sys.getsizeof(data)
296
>>> sum(sys.getsizeof(ref)
...         for ref in gc.get_referents(data))
10049
```

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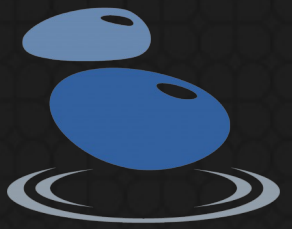
Heapy, Pympler, Melia



- List all Python objects:
  `gc.get_objects()`
- Compute the objects size
- Group objects by type

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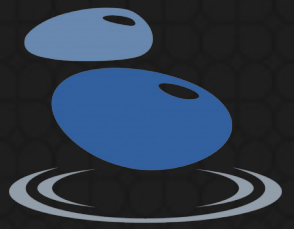

```
Total 17916 objects, 96 types,
Total size = 1.5MiB

Count      Size  Kind
  701   546,460  dict
7,138   414,639  str
  208    94,016  type
1,371    93,228  code
...
```

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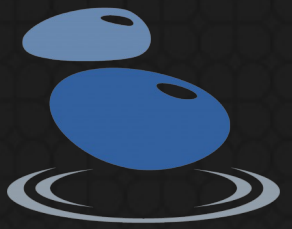

- Don't trace all the memory (ex: zlib)
- Don't provide the origin of objects
- Difficult to exploit

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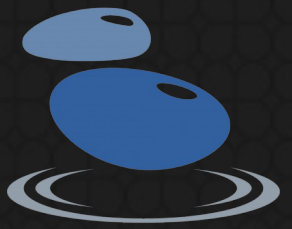
PEP 445: API malloc()



- `PyMem_GetAllocator()`
- `PyMem_SetAllocator()`
- Replace memory allocators
- Set up a hook on allocators
- Implemented in Python 3.4

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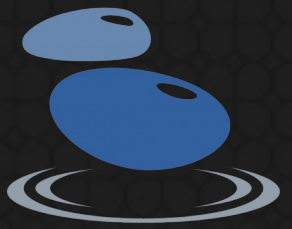
PEP 454: tracemalloc



```
traces = {}

def trace_malloc(size):
    ptr = malloc(size)
    if ptr:
        tb = traceback.extract_stack()
        traces[ptr] = (size, tb)
    return ptr
```

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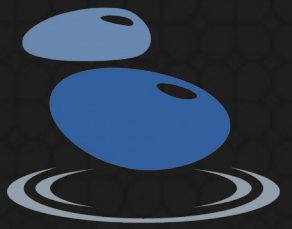
PEP 454: tracemalloc



```
def trace_free(ptr):
    if ptr in traces:
        del traces[ptr]
    free(ptr)
```

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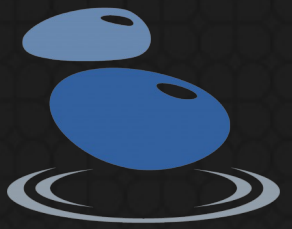
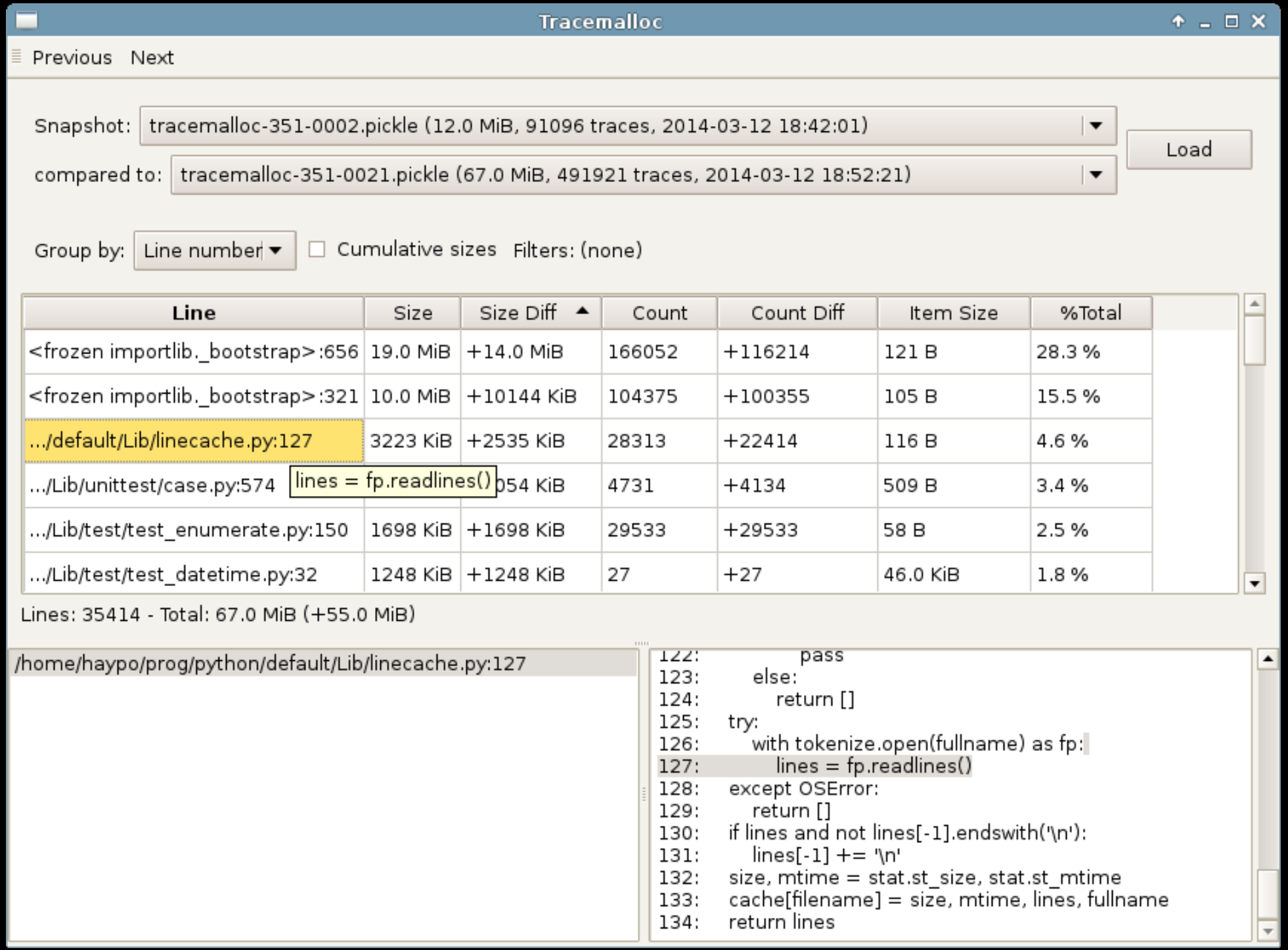
Tracemalloc features



- No overhead when disabled
- Get the traceback where an object was allocated
- Compute statistics per filename, line number or traceback
- Compute differences between two snapshots


Tracemalloc
Previous
Next
Snapshot: tracemalloc-351-0002.pickle (12.0 MiB, 91096 traces, 2014-03-12 18:42:01)
compared to: tracemalloc-351-0021.pickle (67.0 MiB, 491921 traces, 2014-03-12 18:52:21)
Load
Group by: Line number
Cumulative sizes
Filters: (none)
Line | Size | Size Diff | Count | Count Diff | Item Size | %Total
<frozen importlib._bootstrap>:656 | 19.0 MiB | +14.0 MiB | 166052 | +116214 | 121 B | 28.3 %
<frozen importlib._bootstrap>:321 | 10.0 MiB | +10144 KiB | 104375 | +100355 | 105 B | 15.5 %
.../default/Lib/linecache.py:127 | 3223 KiB | +2535 KiB | 28313 | +22414 | 116 B | 4.6 %
.../Lib/unittest/case.py:574 | lines = fp.readlines() | 054 KiB | 4731 | +4134 | 509 B | 3.4 %
.../Lib/test/test_enumerate.py:150 | 1698 KiB | +1698 KiB | 29533 | +29533 | 58 B | 2.5 %
.../Lib/test/test_datetime.py:32 | 1248 KiB | +1248 KiB | 27 | +27 | 46.0 KiB | 1.8 %
Lines: 35414 - Total: 67.0 MiB (+55.0 MiB)
/home/haypo/prog/python/default/Lib/linecache.py:127
122: pass
123: else:
124: return []
125: try:
126: with tokenize.open(fullname) as fp:
127: lines = fp.readlines()
128: except OSError:
129: return []
130: if lines and not lines[-1].endswith('\n'):
131: lines[-1] += '\n'
132: size, mtime = stat.st_size, stat.st_mtime
133: cache[filename] = size, mtime, lines, fullname
134: return lines

tracemallocqt

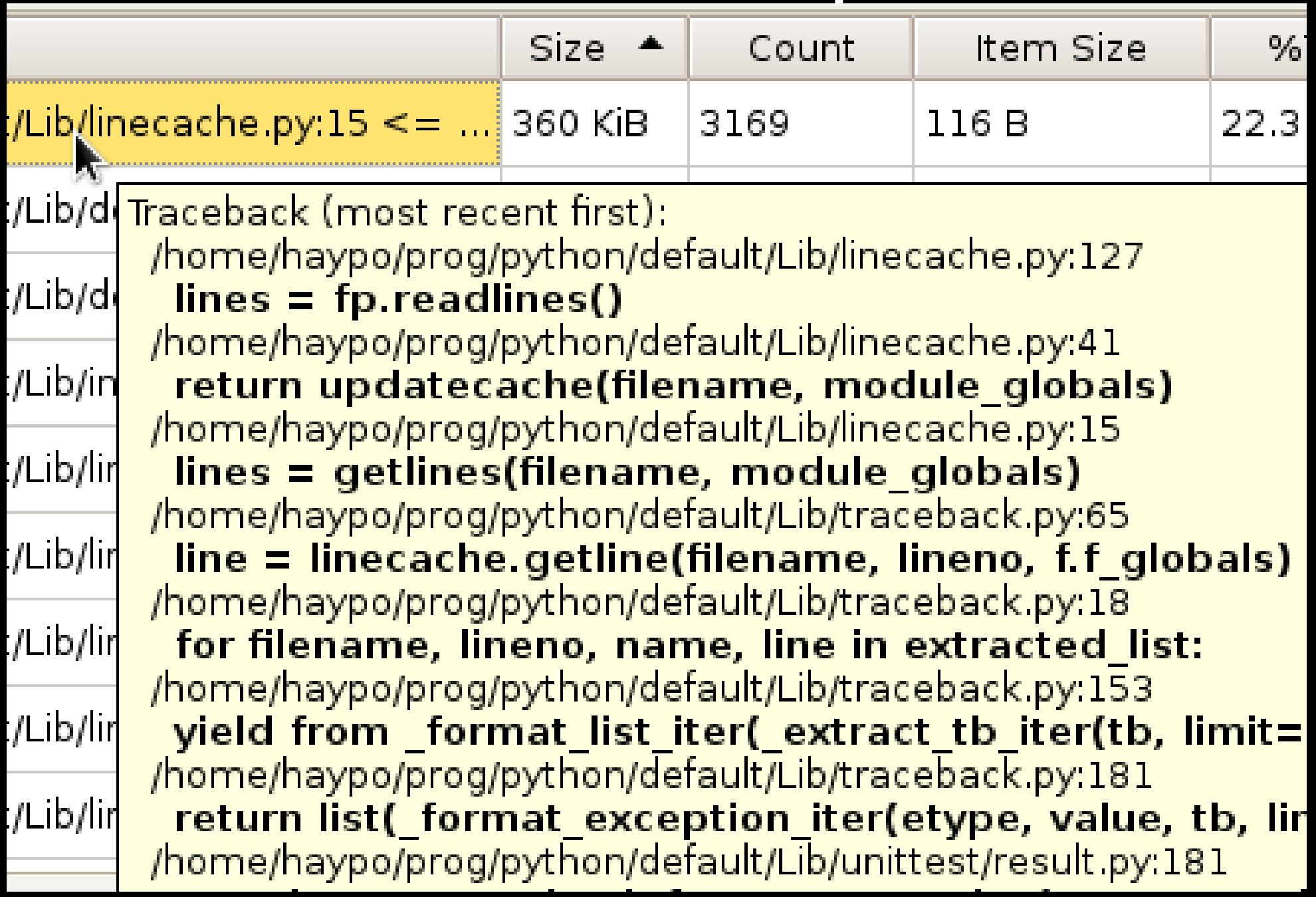
Line	Size	Size Diff ▲
<frozen importlib._bootstrap>:656	19.0 MiB	+14.0 MiB
<frozen importlib._bootstrap>:321	10.0 MiB	+10144 KiB
.../default/Lib/linecache.py:127	3223 KiB	+2535 KiB
.../Lib/unittest/case.py:574	lines = fp.readlines()	054 KiB
.../Lib/test/test_enumerate.py:150	1698 KiB	+1698 KiB
.../Lib/test/test_datetime.py:32	1248 KiB	+1248 KiB

Lines: 35414 - Total: 67.0 MiB (+55.0 MiB)

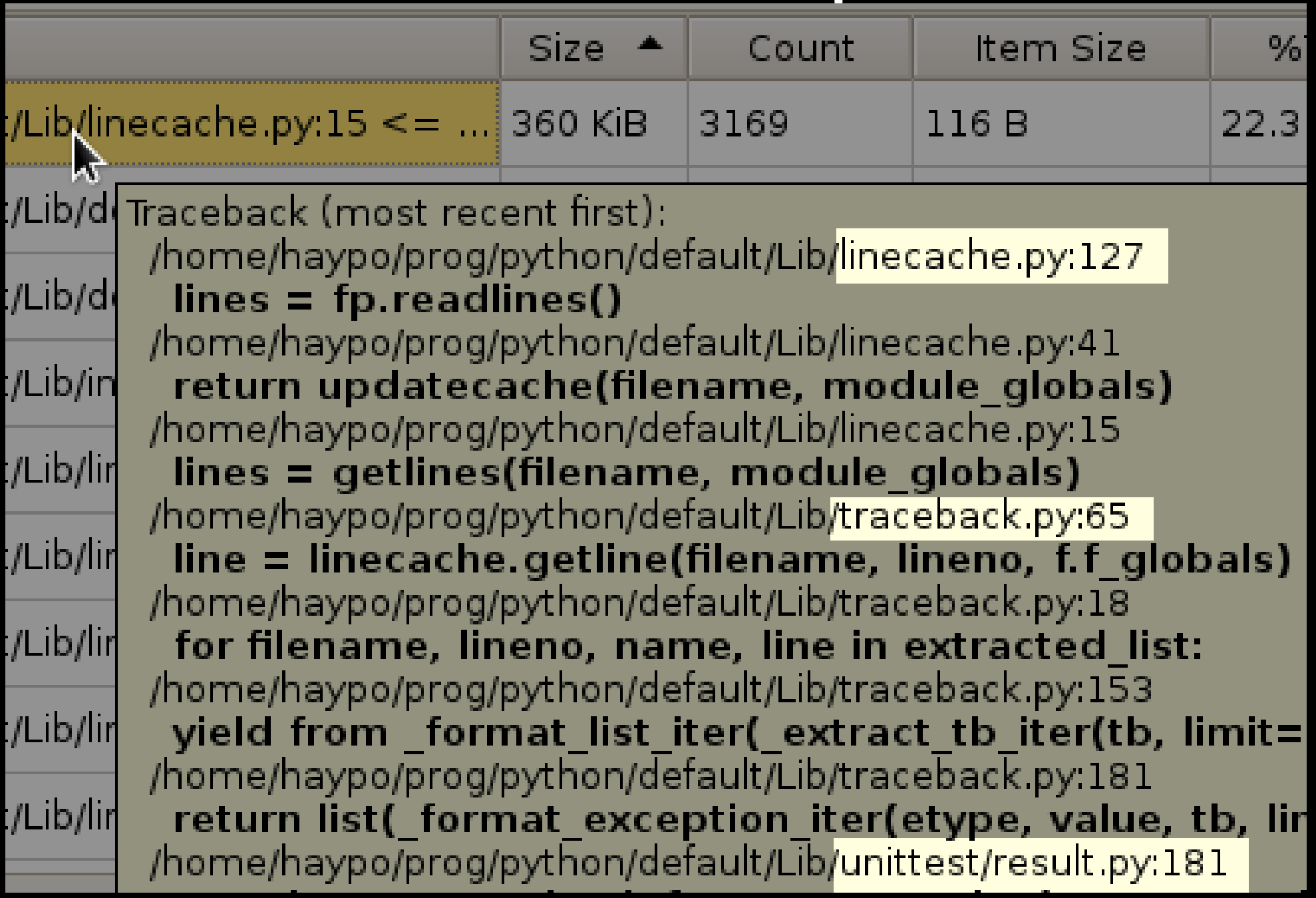
tracemallocqt

```
122:                pass
123:        else:
124:            return []
125:    try:
126:        with tokenize.open(fullname) as fp:
127:            lines = fp.readlines()
128:    except OSError:
129:        return []
130:    if lines and not lines[-1].endswith('\n'):
131:        lines[-1] += '\n'
132:    size, mtime = stat.st_size, stat.st_mtime
133:    cache[filename] = size, mtime, lines, fullname
134:    return lines
```

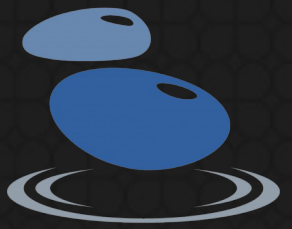
tracemallocqt



tracemallocqt



tracemalloc backport



- Available at PyPI
- Require to patch and recompile Python
- ... maybe also recompile Python extensions written in C
- Patches for Python 2.7 and 3.3
- Ubuntu packages

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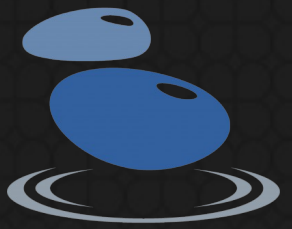
Questions ?

http://pytracemalloc.readthedocs.org/

Contact :
victor.stinner@gmail.com

Display top 10 lines



```
import tracemalloc
tracemalloc.start()
# or: python -X tracemalloc
# ... Run your application ...
snapshot = tracemalloc.take_snapshot()
top_stats = snapshot.statistics('lineno')
print("[Top 10]")
for stat in top_stats[:10]:
    print(stat)
```

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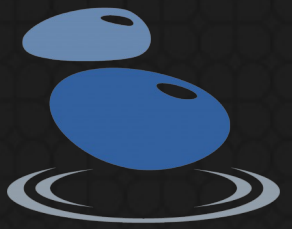
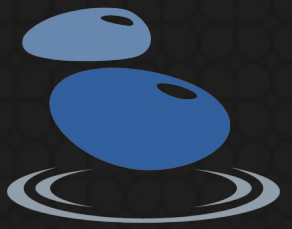
Get object traceback



```
import tracemalloc
tracemalloc.start(25)
# or: python -X tracemalloc=25
# ... Run your application ...
tb = tracemalloc.get_object_traceback(obj)
print("Object allocated at:")
for line in tb.format():
    print(line)
```

PEP 445 (API malloc)



- Ticket opened in 2008
- Patch proposed in march 2013
- Patch commited in june 2013
- Commit reverted => PEP 445
- Better API thanks to the PEP
- BDFL delegate: Antoine Pitrou

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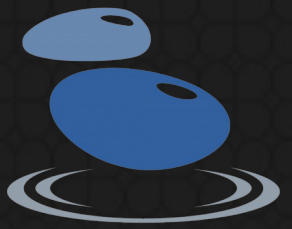
PEP 454 (tracemalloc)



- Store the traceback, not just 1 frame
- Code rewritten from scratch
- Much better API
- Exchanges with Kristján Valur Jónsson
- BDFL delegate: Charles-François Natali

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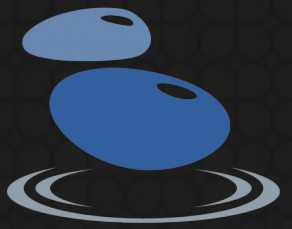
Python allocator



- "pymalloc": `PyObject_Malloc()`
- Allocate chunks of 256 KB
- Alignment on 8 bytes
- Used for size <= 512 bytes, or fallback to `malloc()`
- Python 3.4: use `mmap()` or `VirtualAlloc()`

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Thanks David Malcom for the LibreOffice model

http://dmalcolm.livejournal.com/