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# **Pympler Documentation**

*Release 0.2.1*

**Jean Brouwers, Ludwig Haehne, Robert Schuppenies**

November 11, 2015



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Pympler is a development tool to measure, monitor and analyze the memory behavior of Python objects in a running Python application.

By pympling a Python application, detailed insight in the size and the lifetime of Python objects can be obtained. Undesirable or unexpected runtime behavior like memory bloat and other “pymples” can easily be identified.

Pympler integrates three previously separate modules into a single, comprehensive profiling tool. The *asizeof* module provides basic size information for one or several Python objects, module *muppy* is used for on-line monitoring of a Python application and module *Class Tracker* provides off-line analysis of the lifetime of selected Python objects.

A web profiling frontend exposes process statistics, garbage visualisation and class tracker statistics.



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# Requirements

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Pympler is written entirely in Python, with no dependencies to external libraries. It integrates [Bottle](#) and [Highcharts](#). Pympler has been tested with Python 2.4, 2.5, 2.6, 2.7, 3.1 and 3.2. However, the Pympler web frontend does not work with Python 2.4.

Pympler is platform independent and has been tested on various Linux distributions (32bit and 64bit), Windows XP, Windows 7 and MacOS X.





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### Download

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If you have *SetupTools* installed, the easiest way to get Pympler is to use *easy\_install*:

```
easy_install pympler
```

Alternately, download Pympler releases from the [Python Package Index](#) or [check out the latest development revision](#) with svn. Please see the README file for installation instructions.



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## Target Audience

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Every Python developer interested in analyzing the memory consumption of his or her Python program should find a suitable, readily usable facility in Pympler.



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## Usage Examples

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Aaron is curious how much memory certain Python objects consume. He uses one of the *asizeof* functions to get the size of these objects and all associated referents:

```
>>> from pympler.asizeof import asizeof
>>> obj = [1, 2, (3, 4), 'text']
>>> asizeof(obj)
176
```

Peter is trying to compare different implementations of a new parser module. For each implementation, he uses the *asizeof* module to print simple statistics like size and number of objects summarized by type.

Graham has been notified that his Python script leaks memory. Looking at the garbage collector debug output does not reveal where the leaks come from. Thus he decides to use the *muppy* module to see which actions result in an increased memory usage. Graham discovers that whenever his script iterates over the input set, a new dict object is created. With the help of the *muppy* module he can identify where these new dicts are referenced and eliminates the leak.

Helen maintains a complex application that is taking up a large amount of memory. She would like to reduce the memory footprint of her program by optimizing or restructuring her code. She has a number of optimization candidates and she would like to know if optimizing one of them would likely reduce the total memory footprint. Helen uses the *Class Tracker* to track and profile her candidate classes. The results tell her which class instances take up the largest shares of memory and are therefore best suited for optimization attempts. After trying to optimize her code she runs the program again and compares the profiling results to quantify the improvements.



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**History**

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Pympler was founded in August 2008 by Jean Brouwers, Ludwig Haehne, and Robert Schuppenies with the goal of providing a complete and stand-alone memory profiling solution for Python.





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**Quick Links**

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**Download pympler:** <http://pypi.python.org/pypi/Pympler>

**File a bug report:** <http://code.google.com/p/pympler/issues/>

**Check out repository:** <http://code.google.com/p/pympler/source/checkout>



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## Table of Content

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- *Sizing individual objects* - A description of the *asizeof* module.
- *Tracking class instances* - A description of the *ClassTracker* facility.
- *Identifying memory leaks* - A description of the *muppy* modules.
- *Library* - The library reference guide.
- *Pympler Tutorials* - Pympler tutorials and usage examples.
- *Related Work* - Other projects which deal which memory profiling in Python are mentioned in the this section.
- *Glossary* - A few basic terms used throughout the documentation.
- *Changes in pympler* - Changes in Pympler.
- *Copyright* - Last but not least ..

Also available are

- [genindex](#)
- [modindex](#)
- [search](#)

### 7.1 Sitemap

Below you can find a complete overview of all pages of this documentation.

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By pympling a Python application, detailed insight in the size and the lifetime of Python objects can be obtained. Undesirable or unexpected runtime behavior like memory bloat and other “pymples” can easily be identified.

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## 7.1.6 Sizing individual objects

### Introduction

This module exposes 9 functions and 2 classes to obtain lengths and sizes of Python objects (for Python 2.2 or later <sup>1</sup>).

### Public Functions <sup>2</sup>

Function **sizeof** calculates the combined (approximate) size of one or several Python objects in bytes. Function **sizesof** returns a tuple containing the (approximate) size in bytes for each given Python object separately. Function **sized** returns for each object an instance of class **Asized** containing all the size information of the object and a tuple with the referents.

Functions **basicsize** and **itemsize** return the basic resp. item size of the given object.

Function **flatsize** returns the flat size of a Python object in bytes defined as the basic size plus the item size times the length of the given object.

Function **leng** returns the length of an object, like standard `len` but extended for several types, e.g. the **leng** of a multi-precision int (or long) is the number of `digits` <sup>3</sup>. The length of most mutable sequence objects includes an estimate of the over-allocation and therefore, the **leng** value may differ from the standard `len` result.

Function **refs** returns (a generator for) the referents of the given object, i.e. the objects referenced by the given object.

Certain classes are known to be sub-classes of or to behave as dict objects. Function **adict** can be used to install other class objects to be treated like dict.

### Public Classes <sup>1</sup>

An instance of class **Asized** is returned for each object sized with the **sized** function or method.

Class **Asizer** may be used to accumulate the results of several **sizeof** or **sizesof** calls. After creating an **Asizer** instance, use methods **sizeof** and **sizesof** as needed to size any number of additional objects.

Call methods **exclude\_refs** and/or **exclude\_types** to exclude references to resp. instances or types of certain objects. Use one of the **print... methods** to report the statistics.

### Duplicate Objects

Any duplicate, given objects are sized only once and the size is included in the combined total only once. But functions **sizesof** and **sized** do return a size value resp. an **Asized** instance for each given object, including duplicates.

### Definitions <sup>4</sup>

The size of an object is defined as the sum of the flat size of the object plus the sizes of any referents. Referents are visited recursively up to a given limit. However, the size of objects referenced multiple times is included only once.

The flat size of an object is defined as the basic size of the object plus the item size times the number of allocated items. The flat size does include the size for the items (references to the referents), but not the referents themselves.

<sup>1</sup> Tested with Python 2.2.3, 2.3.7, 2.4.5, 2.5.1, 2.5.2, 2.6 or 3.0 on CentOS 4.6, SuSE 9.3, MacOS X 10.4.11 Tiger (Intel) and Panther 10.3.9 (PPC), Solaris 10 and Windows XP all 32-bit Python and on RHEL 3u7 and Solaris 10 both 64-bit Python.

<sup>2</sup> The functions and classes in this module are not thread-safe.

<sup>3</sup> See Python source file `../Include/longinterp.h` for the C typedef of `digit` used in multi-precision int (or long) objects. The C `sizeof(digit)` in bytes can be obtained in Python from the int (or long) `__itemsize__` attribute. Function **leng** determines the number of `digits` of an int (or long) value.

<sup>4</sup> These definitions and other assumptions are rather arbitrary and may need corrections or adjustments.

The flat size returned by function **flatsize** equals the result of the **asizeof** function with options *code=True*, *ignored=False*, *limit=0* and option *align* set to the same value.

The accurate flat size for an object is obtained from function `sys.getsizeof()` where available. Otherwise, the length and size of sequence objects as dicts, lists, sets, etc. is based on an estimate for the number of allocated items. As a result, the reported length and size may substantially differ from the actual length and size.

The basic and item sizes are obtained from the `__basicsize__` resp. `__itemsize__` attributes of the (type of the) object. Where necessary (e.g. sequence objects), a zero `__itemsize__` is replaced by the size of a corresponding C type. The basic size (of GC managed objects) objects includes the overhead for Python's garbage collector (GC) as well as the space needed for `refcounts` (used only in certain Python builds).

Optionally, size values can be aligned to any power of 2 multiple.

### Size of (byte)code

The (byte)code size of objects like classes, functions, methods, modules, etc. can be included by setting option *code=True*.

Iterators are handled similar to sequences: iterated object(s) are sized like referents, only if the recursion *limit* permits. Also, function `gc.get_referents()` must return the referent object of iterators.

Generators are sized as (byte)code only, but the generated objects are never sized.

### Old- and New-style Classes

All old- and new-style class, instance and type objects, are handled uniformly such that (a) instance objects are distinguished from class objects and (b) instances of different old-style classes can be dealt with separately.

Class and type objects are represented as `<class ...* def>` resp. `<type ... def>` where an `*` indicates an old-style class and the `def` suffix marks the definition object. Instances of old-style classes are shown as new-style ones but with an `*` at the end of the name, like `<class module.name*>`.

### Ignored Objects

To avoid excessive sizes, several object types are ignored<sup>3</sup> by default, e.g. built-in functions, built-in types and classes<sup>5</sup>, function globals and module referents. However, any instances thereof are sized and module objects will be sized when passed as given objects. Ignored object types are included if option *ignored* is set accordingly.

In addition, many `__...__` attributes of callable objects are ignored<sup>3</sup>, except crucial ones, e.g. class attributes `__dict__`, `__doc__`, `__name__` and `__slots__`. For more details, see the type-specific `__...__refs()` and `__len__...()` functions below.

### Asizer

**class** `pympler.asizeof.Asized` (*size, flat, refs=()*, *name=None*)

Store the results of an **asized** object in these 4 attributes:

*size* – total size of the object

*flat* – flat size of the object

*name* – name or `repr` of the object

*refs* – tuple containing an **Asized** instance for each referent

---

<sup>5</sup> Types and classes are considered built-in if the `__module__` of the type or class is listed in `__builtin_modules` below.

---

```

class pympler.sizeof.ASizer (**opts)
   Sizer state and options.

    asized (*objs, **opts)
        Size each object and return an Asized instance with size information and referents up to the given detail
        level (and with modified options, see method set).

        If only one object is given, the return value is the Asized instance for that object.

    asizeof (*objs, **opts)
        Return the combined size of the given objects (with modified options, see method set).

    asizesof (*objs, **opts)
        Return the individual sizes of the given objects (with modified options, see method set).

    exclude_refs (*objs)
        Exclude any references to the specified objects from sizing.

        While any references to the given objects are excluded, the objects will be sized if specified as positional
        arguments in subsequent calls to methods asizeof and asizesof.

    exclude_types (*objs)
        Exclude the specified object instances and types from sizing.

        All instances and types of the given objects are excluded, even objects specified as positional arguments in
        subsequent calls to methods asizeof and asizesof.

    print_profiles (w=0, cutoff=0, **print3opts)
        Print the profiles above cutoff percentage.

        w=0 – indentation for each line

        cutoff=0 – minimum percentage printed

        print3options – print options, ala Python 3.0

    print_stats (objs=(), opts={}, sized=(), sizes=(), stats=3.0, **print3opts)
        Print the statistics.

        w=0 – indentation for each line

        objs=() – optional, list of objects

        opts={} – optional, dict of options used

        sized=() – optional, tuple of Asized instances returned

        sizes=() – optional, tuple of sizes returned

        stats=0.0 – print stats, see function asizeof

        print3options – print options, as in Python 3.0

    print_summary (w=0, objs=(), **print3opts)
        Print the summary statistics.

        w=0 – indentation for each line

        objs=() – optional, list of objects

        print3options – print options, as in Python 3.0

    print_typedefs (w=0, **print3opts)
        Print the types and dict tables.

        w=0 – indentation for each line

```

*print3options* – print options, as in Python 3.0

**reset** (*align=8, clip=80, code=False, derive=False, detail=0, ignored=True, infer=False, limit=100, stats=0, stream=None*)  
Reset options, state, etc.

The available options and default values are:

*align=8* – size alignment  
*clip=80* – clip repr() strings  
*code=False* – incl. (byte)code size  
*derive=False* – derive from super type  
*detail=0* – Asized refs level  
*ignored=True* – ignore certain types  
*infer=False* – try to infer types  
*limit=100* – recursion limit  
*stats=0.0* – print statistics, see function **asizeof**  
*stream=None* – output stream for printing

See function **asizeof** for a description of the options.

**set** (*align=None, code=None, detail=None, limit=None, stats=None*)  
Set some options. See also **reset**.

*align* – size alignment  
*code* – incl. (byte)code size  
*detail* – Asized refs level  
*limit* – recursion limit  
*stats* – print statistics, see function **asizeof**

Any options not set remain unchanged from the previous setting.

## Public Functions

`pympler.asizeof.adict` (*\*classes*)  
Install one or more classes to be handled as dict.

`pympler.asizeof.asized` (*\*objs, \*\*opts*)  
Return a tuple containing an **Asized** instance for each object passed as positional argument using the following options.

*align=8* – size alignment  
*clip=80* – clip repr() strings  
*code=False* – incl. (byte)code size  
*derive=False* – derive from super type  
*detail=0* – Asized refs level  
*ignored=True* – ignore certain types  
*infer=False* – try to infer types



*limit=100* – recursion limit

*stats=0.0* – print statistics

If only one object is given, the return value is the **Asized** instance for that object. Otherwise, the length of the returned tuple matches the number of given objects.

Set *detail* to the desired referents level (recursion depth).

See function **asizeof** for descriptions of the other options.

`pympler.asizeof.asizeof(*objs, **opts)`

Return the combined size in bytes of all objects passed as positional arguments.

The available options and defaults are the following.

*align=8* – size alignment

*all=False* – all current objects

*clip=80* – clip `repr()` strings

*code=False* – incl. (byte)code size

*derive=False* – derive from super type

*ignored=True* – ignore certain types

*infer=False* – try to infer types

*limit=100* – recursion limit

*stats=0.0* – print statistics

Set *align* to a power of 2 to align sizes. Any value less than 2 avoids size alignment.

All current module, global and stack objects are sized if *all* is True and if no positional arguments are supplied.

A positive *clip* value truncates all `repr()` strings to at most *clip* characters.

The (byte)code size of callable objects like functions, methods, classes, etc. is included only if *code* is True.

If *derive* is True, new types are handled like an existing (super) type provided there is one and only of those.

By default certain base types like object, super, etc. are ignored. Set *ignored* to False to include those.

If *infer* is True, new types are inferred from attributes (only implemented for dict types on callable attributes as `get`, `has_key`, `items`, `keys` and `values`).

Set *limit* to a positive value to accumulate the sizes of the referents of each object, recursively up to the limit. Using *limit=0* returns the sum of the `flat[4]` sizes of the given objects. High *limit* values may cause runtime errors and miss objects for sizing.

A positive value for *stats* prints up to 8 statistics, (1) a summary of the number of objects sized and seen, (2) a simple profile of the sized objects by type and (3+) up to 6 tables showing the static, dynamic, derived, ignored, inferred and dict types used, found resp. installed. The fractional part of the *stats* value (x100) is the cutoff percentage for simple profiles.

[4] See the documentation of this module for the definition of flat size.

`pympler.asizeof.asizesof(*objs, **opts)`

Return a tuple containing the size in bytes of all objects passed as positional arguments using the following options.

*align=8* – size alignment

*clip=80* – clip `repr()` strings

*code=False* – incl. (byte)code size  
*derive=False* – derive from super type  
*ignored=True* – ignore certain types  
*infer=False* – try to infer types  
*limit=100* – recursion limit  
*stats=0.0* – print statistics

See function **sizeof** for a description of the options.

The length of the returned tuple equals the number of given objects.

`pympler.asizeof.basicsize(obj, **opts)`

Return the basic size of an object (in bytes).

Valid options and defaults are

*derive=False* – derive type from super type  
*infer=False* – try to infer types  
*save=False* – save typedef if new

`pympler.asizeof.flatsize(obj, align=0, **opts)`

Return the flat size of an object (in bytes), optionally aligned to a given power of 2.

See function **basicsize** for a description of the other options. See the documentation of this module for the definition of flat size.

`pympler.asizeof.itemsize(obj, **opts)`

Return the item size of an object (in bytes).

See function **basicsize** for a description of the options.

`pympler.asizeof.leng(obj, **opts)`

Return the length of an object (in items).

See function **basicsize** for a description of the options.

`pympler.asizeof.refs(obj, **opts)`

Return (a generator for) specific referents of an object.

See function **basicsize** for a description of the options.

## 7.1.7 Tracking class instances

### Introduction

The *ClassTracker* is a facility delivering insight into the memory distribution of a Python program. It can introspect memory consumption of certain classes and objects. Facilities are provided to track and size individual objects or all instances of certain classes. Tracked objects are sized recursively to provide an overview of memory distribution between the different tracked objects.

### Usage

Let's start with a simple example. Suppose you have this module:

```

>>> class Employee:
...     pass
...
>>> class Factory:
...     pass
...
>>> def create_factory():
...     factory = Factory()
...     factory.name = "Assembly Line Unlimited"
...     factory.employees = []
...     return factory
...
>>> def populate_factory(factory):
...     for x in xrange(1000):
...         worker = Employee()
...         worker.assigned = factory.name
...         factory.employees.append(worker)
...
>>> factory = create_factory()
>>> populate_factory(factory)

```

The basic tools of the *ClassTracker* are tracking objects or classes, taking snapshots, and printing or dumping statistics. The first step is to decide what to track. Then spots of interest for snapshot creation have to be identified. Finally, the gathered data can be printed or saved:

```

>>> factory = create_factory()
>>> from pympler.classtracker import ClassTracker
>>> tracker = ClassTracker()
>>> tracker.track_object(factory)
>>> tracker.track_class(Employee)
>>> tracker.create_snapshot()
>>> populate_factory(factory)
>>> tracker.create_snapshot()
>>> tracker.stats.print_summary()
----- SUMMARY -----

```

	active	1.22 MB	average	pct
Factory	1	344 B	344 B	0%
__main__.Employee	0	0 B	0 B	0%
	active	1.42 MB	average	pct
Factory	1	4.75 KB	4.75 KB	0%
__main__.Employee	1000	195.38 KB	200 B	13%

```

-----

```

## Basic Functionality

### Instance Tracking

The purpose of instance tracking is to observe the size and lifetime of an object of interest. Creation and destruction timestamps are recorded and the size of the object is sampled when taking a snapshot.

To track the size of an individual object:

```

from pympler.classtracker import ClassTracker
tracker = ClassTracker()
obj = MyClass()
tracker.track_object(obj)

```

### Class Tracking

Most of the time it's cumbersome to track individual instances manually. Instead, all instances of a class can automatically be tracked with `track_class`:

```
tracker.track_class(MyClass)
```

All instances of `MyClass` (or a class that inherits from `MyClass`) created hereafter are tracked.

### Tracked Object Snapshot

Tracking alone will not reveal the size of an object. The idea of the `ClassTracker` is to sample the sizes of all tracked objects at configurable instants in time. The `create_snapshot` function computes the size of all tracked objects:

```
tracker.create_snapshot('Before juggling with tracked objects')
...
tracker.create_snapshot('Juggling aftermath')
```

With this information, the distribution of the allocated memory can be apportioned to tracked classes and instances.

### Print Statistics

The gathered data can be investigated with `print_stats`. This prints all available data. To filter and limit the output the more powerful “Off-line analysis” API can be used instead.

### Advanced Functionality

#### Per-referent Sizing

It may not be enough to know the total memory consumption of an object. Detailed per-referent statistics can be gathered recursively up to a given resolution level. Resolution level 1 means that all direct referents of an object will be sized. Level 2 also include the referents of the direct referents, and so forth. Note that the member variables of an instance are typically stored in a dictionary and are therefore second order referents.

```
tracker.track_object(obj, resolution_level=2)
```

The resolution level can be changed if the object is already tracked:

```
tracker.track_change(obj, resolution_level=2)
```

The new setting will become effective for the next snapshot. This can help to raise the level of detail for a specific instance of a tracked class without logging all the class' instances with a high verbosity level. Nevertheless, the resolution level can also be set for all instances of a class:

```
tracker.track_class(MyClass, resolution_level=1)
```

**Warning:** Please note the per-referent sizing is very memory and computationally intensive. The recorded meta-data must be stored for each referent of a tracked object which might easily quadruplicate the memory footprint of the build. Handle with care and don't use too high resolution levels, especially if set via `track_class`.

## Instantiation traces

Sometimes it is not trivial to observe where an object was instantiated. The *ClassTracker* can record the instantiation stack trace for later evaluation.

```
tracker.track_class(MyClass, trace=1)
```

This only works with tracked classes, and **not** with individual objects.

## Background Monitoring

The *ClassTracker* can be configured to take periodic snapshots automatically. The following example will take 10 snapshots a second (approximately) until the program has exited or the periodic snapshots are stopped with *stop\_periodic\_snapshots*. Background monitoring also works if no object is tracked. In this mode, the *ClassTracker* will only record the total virtual memory associated with the program. This can be useful in combination with background monitoring to detect memory usage which is transient or not associated with any tracked object.

```
tracker.start_periodic_snapshots(interval=0.1)
```

**Warning:** Take care if you use automatic snapshots with tracked objects. The sizing of individual objects might be inconsistent when memory is allocated or freed while the snapshot is being taken.

## Off-line Analysis

The more data is gathered by the *ClassTracker* the more noise is produced on the console. The acquired *ClassTracker* log data can also be saved to a file for off-line analysis:

```
tracker.stats.dump_stats('profile.dat')
```

The *Stats* class of the *ClassTracker* provides means to evaluate the collected data. The API is inspired by the *Stats* class of the Python profiler. It is possible to sort the data based on user preferences, filter by class and limit the output noise to a manageable magnitude.

The following example reads the dumped data and prints the ten largest Node objects to the standard output:

```
from pympler.classtracker_stats import ConsoleStats

stats = ConsoleStats()
stats.load('profile.dat')
stats.sort_stats('size').print_stats(limit=10, clsname='Node')
```

## HTML Statistics

The *ClassTracker* data can also be emitted in HTML format together with a number of charts (needs *python-matplotlib*). HTML statistics can be emitted using the *HtmlStats* class:

```
from pympler.classtracker_stats import HtmlStats
HtmlStats(tracker=tracker).create_html('profile.html')
```

However, you can also reprocess a previously generated dump:

```
from pympler.classtracker_stats import HtmlStats

stats = HtmlStats(filename='profile.dat')
stats.create_html('profile.html')
```

## Limitations and Corner Cases

### Inheritance

Class tracking allows to observe multiple classes that might have an inheritance relationship. An object is only tracked once. The tracking parameters of the most specialized tracked class control the actual tracking of an instance.

### Shared Data

Data shared between multiple tracked objects won't lead to overestimations. Shared data will be assigned to the first (evaluated) tracked object it is referenced from, but is only counted once. Tracked objects are evaluated in the order they were announced to the *ClassTracker*. This should make the assignment deterministic from one run to the next, but has two known problems. If the *ClassTracker* is used concurrently from multiple threads, the announcement order will likely change and may lead to random assignment of shared data to different objects. Shared data might also be assigned to different objects during its lifetime, see the following example:

```
class A():
    pass

from pympler.classtracker import ClassTracker
tracker = ClassTracker()

a = A()
tracker.track_object(a)
b = A()
tracker.track_object(b)
b.content = range(100000)
tracker.create_snapshot('#1')
a.notmine = b.content
tracker.create_snapshot('#2')
```

In the snapshot #1, *b*'s size will include the size of the large list. Then the list is shared with *a*. The snapshot #2 will assign the list's footprint to *a* because it was registered before *b*.

If a tracked object *A* is referenced from another tracked object *B*, *A*'s size is not added to *B*'s size, regardless of the order in which they are sized.

### Accuracy

*ClassTracker* uses the *sizer* module to gather size informations. *sizeof* makes assumptions about the memory footprint of the various data types. As it is implemented in pure Python, there is no way to know how the actual Python implementation allocates data and lays it out in memory. Thus, the size numbers are not really accurate and there will always be a divergence between the virtual size of the Python process as reported by the OS and the sizes *sizeof* estimates.

Most recent C/Python versions contain a [facility to report accurate size informations](#) of Python objects. If available, *sizeof* uses it to improve the accuracy.

## Morphing objects

Some programs instate the (anti-)pattern of changing an instance' class at runtime, for example to morph abstract objects into specific derivations during runtime. The pattern looks like the following in the code:

```
obj.__class__ = OtherClass
```

If the instance which is morphed is already tracked, the instance will continue to be tracked by the *ClassTracker*. If the target class is tracked but the instance is not, the instance will only be tracked if the constructor of the target class is called as part of the morphing process. The object will not be re-registered to the new class in the tracked object index. However, the new class is stored in the representation of the object as soon as the object is sized.

## 7.1.8 Identifying memory leaks

Muppy tries to help developers to identify memory leaks of Python applications. It enables the tracking of memory usage during runtime and the identification of objects which are leaking. Additionally, tools are provided which allow to locate the source of not released objects.

Muppy is (yet another) Memory Usage Profiler for Python. The focus of this toolset is laid on the identification of memory leaks. Let's have a look what you can do with muppy.

### The muppy module

Muppy allows you to get hold of all objects,

```
>>> from pympler import muppy
>>> all_objects = muppy.get_objects()
>>> len(all_objects)
19700
```

or filter out certain types of objects.

```
>>> import types
>>> types = muppy.filter(all_objects, Type=types.ClassType)
>>> len(types)
72
>>> for t in types:
...     print t
...
UserDict.IterableUserDict
UserDict.UserDict
UserDict.DictMixin
os._Environ
sre_parse.Tokenizer
sre_parse.SubPattern
re.Scanner
string._multimap
distutils.log.Log
encodings.utf_8.StreamWriter
encodings.utf_8.StreamReader
codecs.StreamWriter
codecs.StreamReader
codecs.StreamReaderWriter
codecs.Codec
codecs.StreamRecoder
tokenize.Untokenizer
```

```
inspect.BlockFinder
sre_parse.Pattern
. . .
```

This result, for example, tells us that the number of lists remained the same, but the memory allocated by lists has increased by 8 bytes. The correct increase for a LP64 system (see [64-Bit\\_Programming\\_Models](#)).

## The summary module

You can create summaries

```
>>> from pympler import summary
>>> sum1 = summary.summarize(all_objects)
>>> summary.print_(sum1)
```

types	# objects	total size
dict	546	953.30 KB
str	8270	616.46 KB
list	127	529.44 KB
tuple	5021	410.62 KB
code	1378	161.48 KB
type	70	61.80 KB
wrapper_descriptor	508	39.69 KB
builtin_function_or_method	515	36.21 KB
int	900	21.09 KB
method_descriptor	269	18.91 KB
weakref	177	15.21 KB
<class 'abc.ABCMeta	16	14.12 KB
set	48	10.88 KB
function (__init__)	81	9.49 KB
member_descriptor	131	9.21 KB

and compare them with other summaries.

```
>>> sum2 = summary.summarize(muppy.get_objects())
>>> diff = summary.get_diff(sum1, sum2)
>>> summary.print_(diff)
```

types	# objects	total size
list	1097	1.07 MB
str	1105	68.21 KB
dict	14	21.08 KB
wrapper_descriptor	215	16.80 KB
int	121	2.84 KB
tuple	30	2.02 KB
member_descriptor	25	1.76 KB
weakref	14	1.20 KB
getset_descriptor	15	1.05 KB
method_descriptor	12	864 B
frame (codename: get_objects)	1	488 B
builtin_function_or_method	6	432 B
frame (codename: <module>)	1	424 B
classmethod_descriptor	3	216 B
code	1	120 B



## The tracker module

Of course we don't have to do all these steps manually, instead we can use muppy's tracker.

```
>>> from pympler import tracker
>>> tr = tracker.SummaryTracker()
>>> tr.print_diff()
```

	types	# objects	total size
	=====	=====	=====
	list	1095	160.78 KB
	str	1093	66.33 KB
	int	120	2.81 KB
	dict	3	840 B
frame (codename: create_summary)	1	560 B	
frame (codename: print_diff)	1	480 B	
frame (codename: diff)	1	464 B	
function (store_info)	1	120 B	
cell	2	112 B	

A tracker object creates a summary (that is a summary which it will remember) on initialization. Now whenever you call `tracker.print_diff()`, a new summary of the current state is created, compared to the previous summary and printed to the console. As you can see here, quite a few objects got in between these two invocations. But if you don't do anything, nothing will change.

```
>>> tr.print_diff()
types | # objects | total size
===== | ===== | =====
```

Now check out this code snippet

```
>>> i = 1
>>> l = [1,2,3,4]
>>> d = {}
>>> tr.print_diff()
types | # objects | total size
===== | ===== | =====
dict | 1 | 280 B
list | 1 | 192 B
```

As you can see both, the new list and the new dict appear in the summary, but not the 4 integers used. Why is that? Because they existed already before they were used here, that is some other part in the Python interpreter code makes already use of them. Thus, they are not new.

## The refbrowser module

In case some objects are leaking and you don't know where they are still referenced, you can use the referrers browser. At first let's create a root object which we then reference from a tuple and a list.

```
>>> from pympler import refbrowser
>>> root = "some root object"
>>> root_ref1 = [root]
>>> root_ref2 = (root, )
```

```
>>> def output_function(o):
...     return str(type(o))
...
>>> cb = refbrowser.ConsoleBrowser(root, maxdepth=2, str_func=output_function)
```

Then we create a `ConsoleBrowser`, which will give us a referrers tree starting at `root`, printing to a maximum depth of 2, and uses `str_func` to represent objects. Now it's time to see where we are at.

```
>>> cb.print_tree()
<type 'str'>--<type 'dict'>--<type 'list'>
      |               +-<type 'list'>
      |               +-<type 'list'>
      |
      +-<type 'dict'>--<type 'module'>
      |               +-<type 'list'>
      |               +-<type 'frame'>
      |               +-<type 'function'>
      |               +-<type 'list'>
      |               +-<type 'frame'>
      |               +-<type 'list'>
      |               +-<type 'function'>
      |               +-<type 'frame'>
      |
      +-<type 'list'>--<type 'dict'>
      +-<type 'tuple'>--<type 'dict'>
      +-<type 'dict'>--<class 'muppy.refbrowser.ConsoleBrowser'>
```

What we see is that the root object is referenced by the tuple and the list, as well as by three dictionaries. These dictionaries belong to the environment, e.g. the `ConsoleBrowser` we just started and the current execution context.

This console browsing is of course kind of inconvenient. Much better would be an `InteractiveBrowser`. Let's see what we got.

```
>>> from pympler import refbrowser
>>> ib = refbrowser.InteractiveBrowser(root)
>>> ib.main()
```



Now you can click through all referrers of the root object.

## 7.1.9 Library

Some functions of the library work on the entire object set of your running Python application. Expect some time-intensive computations.

### Modules

#### `pympler.sizeof`

**Introduction** This module exposes 9 functions and 2 classes to obtain lengths and sizes of Python objects (for Python 2.2 or later <sup>6</sup>).

#### **Public Functions** <sup>7</sup>

Function **sizeof** calculates the combined (approximate) size of one or several Python objects in bytes. Function **sizesof** returns a tuple containing the (approximate) size in bytes for each given Python object separately. Function **sized** returns for each object an instance of class **Asized** containing all the size information of the object and a tuple with the referents.

<sup>6</sup> Tested with Python 2.2.3, 2.3.7, 2.4.5, 2.5.1, 2.5.2, 2.6 or 3.0 on CentOS 4.6, SuSE 9.3, MacOS X 10.4.11 Tiger (Intel) and Panther 10.3.9 (PPC), Solaris 10 and Windows XP all 32-bit Python and on RHEL 3u7 and Solaris 10 both 64-bit Python.

<sup>7</sup> The functions and classes in this module are not thread-safe.

Functions **basicsize** and **itemsize** return the basic resp. item size of the given object.

Function **flatsize** returns the flat size of a Python object in bytes defined as the basic size plus the item size times the length of the given object.

Function **leng** returns the length of an object, like standard `len` but extended for several types, e.g. the **leng** of a multi-precision int (or long) is the number of `digits`<sup>8</sup>. The length of most mutable sequence objects includes an estimate of the over-allocation and therefore, the **leng** value may differ from the standard `len` result.

Function **refs** returns (a generator for) the referents of the given object, i.e. the objects referenced by the given object.

Certain classes are known to be sub-classes of or to behave as dict objects. Function **adict** can be used to install other class objects to be treated like dict.

## Public Classes<sup>1</sup>

An instance of class **Asized** is returned for each object sized with the **asized** function or method.

Class **Asizer** may be used to accumulate the results of several **asizeof** or **asizesof** calls. After creating an **Asizer** instance, use methods **asizeof** and **asizesof** as needed to size any number of additional objects.

Call methods **exclude\_refs** and/or **exclude\_types** to exclude references to resp. instances or types of certain objects. Use one of the **print\_... methods** to report the statistics.

## Duplicate Objects

Any duplicate, given objects are sized only once and the size is included in the combined total only once. But functions **asizesof** and **asized** do return a size value resp. an **Asized** instance for each given object, including duplicates.

## Definitions<sup>9</sup>

The size of an object is defined as the sum of the flat size of the object plus the sizes of any referents. Referents are visited recursively up to a given limit. However, the size of objects referenced multiple times is included only once.

The flat size of an object is defined as the basic size of the object plus the item size times the number of allocated items. The flat size does include the size for the items (references to the referents), but not the referents themselves.

The flat size returned by function **flatsize** equals the result of the **asizeof** function with options `code=True`, `ignored=False`, `limit=0` and option `align` set to the same value.

The accurate flat size for an object is obtained from function `sys.getsizeof()` where available. Otherwise, the length and size of sequence objects as dicts, lists, sets, etc. is based on an estimate for the number of allocated items. As a result, the reported length and size may substantially differ from the actual length and size.

The basic and item sizes are obtained from the `__basicsize__` resp. `__itemsize__` attributes of the (type of the) object. Where necessary (e.g. sequence objects), a zero `__itemsize__` is replaced by the size of a corresponding C type. The basic size (of GC managed objects) objects includes the overhead for Python's garbage collector (GC) as well as the space needed for `refcounts` (used only in certain Python builds).

Optionally, size values can be aligned to any power of 2 multiple.

## Size of (byte)code

---

<sup>8</sup> See Python source file `.../Include/longint.h` for the C typedef of `digit` used in multi-precision int (or long) objects. The `C sizeof(digit)` in bytes can be obtained in Python from the `int (or long) __itemsize__` attribute. Function **leng** determines the number of `digits` of an int (or long) value.

<sup>9</sup> These definitions and other assumptions are rather arbitrary and may need corrections or adjustments.

The (byte)code size of objects like classes, functions, methods, modules, etc. can be included by setting option `code=True`.

Iterators are handled similar to sequences: iterated object(s) are sized like referents, only if the recursion *limit* permits. Also, function `gc.get_referents()` must return the referent object of iterators.

Generators are sized as (byte)code only, but the generated objects are never sized.

### Old- and New-style Classes

All old- and new-style class, instance and type objects, are handled uniformly such that (a) instance objects are distinguished from class objects and (b) instances of different old-style classes can be dealt with separately.

Class and type objects are represented as `<class ...* def>` resp. `<type ... def>` where an ‘\*’ indicates an old-style class and the `def` suffix marks the definition object. Instances of old-style classes are shown as new-style ones but with an ‘\*’ at the end of the name, like `<class module.name*>`.

### Ignored Objects

To avoid excessive sizes, several object types are ignored<sup>3</sup> by default, e.g. built-in functions, built-in types and classes<sup>10</sup>, function globals and module referents. However, any instances thereof are sized and module objects will be sized when passed as given objects. Ignored object types are included if option *ignored* is set accordingly.

In addition, many `__...__` attributes of callable objects are ignored<sup>3</sup>, except crucial ones, e.g. class attributes `__dict__`, `__doc__`, `__name__` and `__slots__`. For more details, see the type-specific `__...__refs()` and `__len__...()` functions below.

### Asizer

**class** `pympler.asizeof.Asized` (*size, flat, refs=(), name=None*)

Store the results of an **asized** object in these 4 attributes:

*size* – total size of the object

*flat* – flat size of the object

*name* – name or `repr` of the object

*refs* – tuple containing an **Asized** instance for each referent

**class** `pympler.asizeof.Asizer` (\*\**opts*)

Sizer state and options.

**asized** (*\*objs, \*\*opts*)

Size each object and return an **Asized** instance with size information and referents up to the given detail level (and with modified options, see method **set**).

If only one object is given, the return value is the **Asized** instance for that object.

**asizeof** (*\*objs, \*\*opts*)

Return the combined size of the given objects (with modified options, see method **set**).

**asizesof** (*\*objs, \*\*opts*)

Return the individual sizes of the given objects (with modified options, see method **set**).

**exclude\_refs** (*\*objs*)

Exclude any references to the specified objects from sizing.

While any references to the given objects are excluded, the objects will be sized if specified as positional arguments in subsequent calls to methods **asizeof** and **asizesof**.

<sup>10</sup> Types and classes are considered built-in if the `__module__` of the type or class is listed in `__builtin_modules` below.

**exclude\_types** (*\*objs*)

Exclude the specified object instances and types from sizing.

All instances and types of the given objects are excluded, even objects specified as positional arguments in subsequent calls to methods **sizeof** and **asizesof**.

**print\_profiles** (*w=0, cutoff=0, \*\*print3opts*)

Print the profiles above *cutoff* percentage.

*w=0* – indentation for each line

*cutoff=0* – minimum percentage printed

*print3options* – print options, ala Python 3.0

**print\_stats** (*objs=(), opts={}, sized=(), sizes=(), stats=3.0, \*\*print3opts*)

Print the statistics.

*w=0* – indentation for each line

*objs=()* – optional, list of objects

*opts={}* – optional, dict of options used

*sized=()* – optional, tuple of **Asized** instances returned

*sizes=()* – optional, tuple of sizes returned

*stats=0.0* – print stats, see function **sizeof**

*print3options* – print options, as in Python 3.0

**print\_summary** (*w=0, objs=(), \*\*print3opts*)

Print the summary statistics.

*w=0* – indentation for each line

*objs=()* – optional, list of objects

*print3options* – print options, as in Python 3.0

**print\_typedefs** (*w=0, \*\*print3opts*)

Print the types and dict tables.

*w=0* – indentation for each line

*print3options* – print options, as in Python 3.0

**set** (*align=None, code=None, detail=None, limit=None, stats=None*)

Set some options. See also **reset**.

*align* – size alignment

*code* – incl. (byte)code size

*detail* – Asized refs level

*limit* – recursion limit

*stats* – print statistics, see function **sizeof**

Any options not set remain unchanged from the previous setting.

**reset** (*align=8, clip=80, code=False, derive=False, detail=0, ignored=True, infer=False, limit=100,*

*stats=0, stream=None*)

Reset options, state, etc.

The available options and default values are:

*align=8* – size alignment  
*clip=80* – clip repr() strings  
*code=False* – incl. (byte)code size  
*derive=False* – derive from super type  
*detail=0* – Asized refs level  
*ignored=True* – ignore certain types  
*infer=False* – try to infer types  
*limit=100* – recursion limit  
*stats=0.0* – print statistics, see function **asizeof**  
*stream=None* – output stream for printing

See function **asizeof** for a description of the options.

### Public Functions

`pympler.asizeof.adict(*classes)`

Install one or more classes to be handled as dict.

`pympler.asizeof.asized(*objs, **opts)`

Return a tuple containing an **Asized** instance for each object passed as positional argument using the following options.

*align=8* – size alignment  
*clip=80* – clip repr() strings  
*code=False* – incl. (byte)code size  
*derive=False* – derive from super type  
*detail=0* – Asized refs level  
*ignored=True* – ignore certain types  
*infer=False* – try to infer types  
*limit=100* – recursion limit  
*stats=0.0* – print statistics

If only one object is given, the return value is the **Asized** instance for that object. Otherwise, the length of the returned tuple matches the number of given objects.

Set *detail* to the desired referents level (recursion depth).

See function **asizeof** for descriptions of the other options.

`pympler.asizeof.asizeof(*objs, **opts)`

Return the combined size in bytes of all objects passed as positional arguments.

The available options and defaults are the following.

*align=8* – size alignment  
*all=False* – all current objects  
*clip=80* – clip repr() strings  
*code=False* – incl. (byte)code size  
*derive=False* – derive from super type

*ignored=True* – ignore certain types

*infer=False* – try to infer types

*limit=100* – recursion limit

*stats=0.0* – print statistics

Set *align* to a power of 2 to align sizes. Any value less than 2 avoids size alignment.

All current module, global and stack objects are sized if *all* is True and if no positional arguments are supplied.

A positive *clip* value truncates all repr() strings to at most *clip* characters.

The (byte)code size of callable objects like functions, methods, classes, etc. is included only if *code* is True.

If *derive* is True, new types are handled like an existing (super) type provided there is one and only of those.

By default certain base types like object, super, etc. are ignored. Set *ignored* to False to include those.

If *infer* is True, new types are inferred from attributes (only implemented for dict types on callable attributes as get, has\_key, items, keys and values).

Set *limit* to a positive value to accumulate the sizes of the referents of each object, recursively up to the limit. Using *limit=0* returns the sum of the flat[4] sizes of the given objects. High *limit* values may cause runtime errors and miss objects for sizing.

A positive value for *stats* prints up to 8 statistics, (1) a summary of the number of objects sized and seen, (2) a simple profile of the sized objects by type and (3+) up to 6 tables showing the static, dynamic, derived, ignored, inferred and dict types used, found resp. installed. The fractional part of the *stats* value (x100) is the cutoff percentage for simple profiles.

[4] See the documentation of this module for the definition of flat size.

`pympler.asizeof.asizesof(*objs, **opts)`

Return a tuple containing the size in bytes of all objects passed as positional arguments using the following options.

*align=8* – size alignment

*clip=80* – clip repr() strings

*code=False* – incl. (byte)code size

*derive=False* – derive from super type

*ignored=True* – ignore certain types

*infer=False* – try to infer types

*limit=100* – recursion limit

*stats=0.0* – print statistics

See function **asizeof** for a description of the options.

The length of the returned tuple equals the number of given objects.

`pympler.asizeof.basicsize(obj, **opts)`

Return the basic size of an object (in bytes).

Valid options and defaults are

*derive=False* – derive type from super type

*infer=False* – try to infer types

*save=False* – save typedef if new



`pympler.asizeof.flatsize` (*obj*, *align=0*, *\*\*opts*)

Return the flat size of an object (in bytes), optionally aligned to a given power of 2.

See function **basicsize** for a description of the other options. See the documentation of this module for the definition of flat size.

`pympler.asizeof.itemsize` (*obj*, *\*\*opts*)

Return the item size of an object (in bytes).

See function **basicsize** for a description of the options.

`pympler.asizeof.leng` (*obj*, *\*\*opts*)

Return the length of an object (in items).

See function **basicsize** for a description of the options.

`pympler.asizeof.refs` (*obj*, *\*\*opts*)

Return (a generator for) specific referents of an object.

See function **basicsize** for a description of the options.

## pympler.classtracker

The *ClassTracker* is a facility delivering insight into the memory distribution of a Python program. It can introspect memory consumption of certain classes and objects. Facilities are provided to track and size individual objects or all instances of certain classes. Tracked objects are sized recursively to provide an overview of memory distribution between the different tracked objects.

### Classes

**class** `pympler.classtracker.ClassTracker` (*stream=None*)

**clear** ()

Clear all gathered data and detach from all tracked objects/classes.

**create\_snapshot** (*description=''*, *compute\_total=False*)

Collect current per instance statistics and saves total amount of memory associated with the Python process.

If *compute\_total* is *True*, the total consumption of all objects known to *asizeof* is computed. The latter might be very slow if many objects are mapped into memory at the time the snapshot is taken. Therefore, *compute\_total* is set to *False* by default.

The overhead of the *ClassTracker* structure is also computed.

Snapshots can be taken asynchronously. The function is protected with a lock to prevent race conditions.

**detach\_all** ()

Detach from all tracked classes and objects. Restore the original constructors and cleanse the tracking lists.

**detach\_all\_classes** ()

Detach from all tracked classes.

**detach\_class** (*cls*)

Stop tracking class '*cls*'. Any new objects of that type are not tracked anymore. Existing objects are still tracked.

**start\_periodic\_snapshots** (*interval=1.0*)

Start a thread which takes snapshots periodically. The *interval* specifies the time in seconds the thread

waits between taking snapshots. The thread is started as a daemon allowing the program to exit. If periodic snapshots are already active, the interval is updated.

**stop\_periodic\_snapshots** ()

Post a stop signal to the thread that takes the periodic snapshots. The function waits for the thread to terminate which can take some time depending on the configured interval.

**track\_class** (*cls*, *name=None*, *resolution\_level=0*, *keep=False*, *trace=False*)

Track all objects of the class *cls*. Objects of that type that already exist are *not* tracked. If *track\_class* is called for a class already tracked, the tracking parameters are modified. Instantiation traces can be generated by setting *trace* to True. A constructor is injected to begin instance tracking on creation of the object. The constructor calls *track\_object* internally.

#### Parameters

- **cls** – class to be tracked, may be an old-style or a new-style class
- **name** – reference the class by a name, default is the concatenation of module and class name
- **resolution\_level** – The recursion depth up to which referents are sized individually. Resolution level 0 (default) treats the object as an opaque entity, 1 sizes all direct referents individually, 2 also sizes the referents of the referents and so forth.
- **keep** – Prevent the object’s deletion by keeping a (strong) reference to the object.
- **trace** – Save instantiation stack trace for each instance

**track\_object** (*instance*, *name=None*, *resolution\_level=0*, *keep=False*, *trace=False*)

Track object ‘instance’ and sample size and lifetime information. Not all objects can be tracked; trackable objects are class instances and other objects that can be weakly referenced. When an object cannot be tracked, a *TypeError* is raised.

#### Parameters

- **resolution\_level** – The recursion depth up to which referents are sized individually. Resolution level 0 (default) treats the object as an opaque entity, 1 sizes all direct referents individually, 2 also sizes the referents of the referents and so forth.
- **keep** – Prevent the object’s deletion by keeping a (strong) reference to the object.

## pympler.classtracker\_stats

Provide saving, loading and presenting gathered *ClassTracker* statistics.

### Classes

**class** `pympler.classtracker_stats.Stats` (*tracker=None*, *filename=None*, *stream=None*)

Presents the memory statistics gathered by a *ClassTracker* based on user preferences.

**\_\_init\_\_** (*tracker=None*, *filename=None*, *stream=None*)

Initialize the data log structures either from a *ClassTracker* instance (argument *tracker*) or a previously dumped file (argument *filename*).

#### Parameters

- **tracker** – *ClassTracker* instance
- **filename** – filename of previously dumped statistics
- **stream** – where to print statistics, defaults to `sys.stdout`

**dump\_stats** (*fdump*, *close=True*)

Dump the logged data to a file. The argument *file* can be either a filename or an open file object that requires write access. *close* controls if the file is closed before leaving this method (the default behaviour).

**load\_stats** (*fdump*)

Load the data from a dump file. The argument *fdump* can be either a filename or an open file object that requires read access.

**reverse\_order** ()

Reverse the order of the tracked instance index *self.sorted*.

**sort\_stats** (*\*args*)

Sort the tracked objects according to the supplied criteria. The argument is a string identifying the basis of a sort (example: 'size' or 'classname'). When more than one key is provided, then additional keys are used as secondary criteria when there is equality in all keys selected before them. For example, `sort_stats('name', 'size')` will sort all the entries according to their class name, and resolve all ties (identical class names) by sorting by size. The criteria are fields in the tracked object instances. Results are stored in the `self.sorted` list which is used by `Stats.print_stats()` and other methods. The fields available for sorting are:

**'classname'** the name with which the class was registered

**'name'** the classname

**'birth'** creation timestamp

**'death'** destruction timestamp

**'size'** the maximum measured size of the object

**'tsize'** the measured size during the largest snapshot

**'repr'** string representation of the object

Note that sorts on size are in descending order (placing most memory consuming items first), whereas name, repr, and creation time searches are in ascending order (alphabetical).

The function returns self to allow calling functions on the result:

```
stats.sort_stats('size').reverse_order().print_stats()
```

```
class pympler.classtracker_stats.ConsoleStats (tracker=None, filename=None,
                                              stream=None)
```

Presentation layer for *Stats* to be used in text-based consoles.

**\_\_init\_\_** (*tracker=None*, *filename=None*, *stream=None*)

Initialize the data log structures either from a *ClassTracker* instance (argument *tracker*) or a previously dumped file (argument *filename*).

#### Parameters

- **tracker** – *ClassTracker* instance
- **filename** – filename of previously dumped statistics
- **stream** – where to print statistics, defaults to `sys.stdout`

**print\_stats** (*clsname=None*, *limit=1.0*)

Write tracked objects to stdout. The output can be filtered and pruned. Only objects are printed whose classname contain the substring supplied by the *clsname* argument. The output can be pruned by passing a *limit* value.

#### Parameters

- **clsname** – Only print objects whose classname contain the given substring.

- **limit** – If *limit* is a float smaller than one, only the supplied percentage of the total tracked data is printed. If *limit* is bigger than one, this number of tracked objects are printed. Tracked objects are first filtered, and then pruned (if specified).

**print\_summary** ()

Print per-class summary for each snapshot.

**class** `pympler.classtracker_stats.HtmlStats` (*tracker=None, filename=None, stream=None*)

Output the *ClassTracker* statistics as HTML pages and graphs.

**\_\_init\_\_** (*tracker=None, filename=None, stream=None*)

Initialize the data log structures either from a *ClassTracker* instance (argument *tracker*) or a previously dumped file (argument *filename*).

#### Parameters

- **tracker** – *ClassTracker* instance
- **filename** – filename of previously dumped statistics
- **stream** – where to print statistics, defaults to `sys.stdout`

**create\_html** (*fname, title='ClassTracker Statistics'*)

Create HTML page *fname* and additional files in a directory derived from *fname*.

## pympler.garbagegraph

Garbage occurs if objects refer too each other in a circular fashion. Such reference cycles cannot be freed automatically and must be collected by the garbage collector. While it is sometimes hard to avoid creating reference cycles, preventing such cycles saves garbage collection time and limits the lifetime of objects. Moreover, some objects cannot be collected by the garbage collector.

Reference cycles can be visualized with the help of [graphviz](#).

### Classes

**class** `pympler.garbagegraph.GarbageGraph` (*reduce=False, collectable=True*)

The *GarbageGraph* is a *ReferenceGraph* that illustrates the objects building reference cycles. The garbage collector is switched to debug mode (all identified garbage is stored in `gc.garbage`) and the garbage collector is invoked. The collected objects are then illustrated in a directed graph.

Large graphs can be reduced to the actual cycles by passing `reduce=True` to the constructor.

It is recommended to disable the garbage collector when using the *GarbageGraph*.

```
>>> from pympler.garbagegraph import GarbageGraph, start_debug_garbage
>>> start_debug_garbage()
>>> l = []
>>> l.append(l)
>>> del l
>>> gb = GarbageGraph()
>>> gb.render('garbage.eps')
True
```

**\_\_init\_\_** (*reduce=False, collectable=True*)

Initialize the *GarbageGraph* with the objects identified by the garbage collector. If *collectable* is true, every reference cycle is recorded. Otherwise only uncollectable objects are reported.

**render** (*filename, cmd='dot', format='ps', unflatten=False*)

Render the graph to *filename* using *graphviz*. The *graphviz* invocation command may be overridden by specifying *cmd*. The *format* may be any specifier recognized by the graph renderer ('-Txxx' command).

The graph can be preprocessed by the *unflatten* tool if the *unflatten* parameter is True. If there are no objects to illustrate, the method does not invoke *graphviz* and returns False. If the renderer returns successfully (return code 0), True is returned.

An *OSError* is raised if the *graphviz* tool cannot be found.

#### **split()**

Split the graph into sub-graphs. Only connected objects belong to the same graph. *split* yields copies of the Graph object. Shallow copies are used that only replicate the meta-information, but share the same object list *self.objects*.

```
>>> from pympler.refgraph import ReferenceGraph
>>> a = 42
>>> b = 'spam'
>>> c = {a: b}
>>> t = (1, 2, 3)
>>> rg = ReferenceGraph([a, b, c, t])
>>> for subgraph in rg.split():
...     print subgraph.index
0
1
```

#### **write\_graph(filename)**

Write raw graph data which can be post-processed using *graphviz*.

#### **print\_stats(stream=None)**

Log annotated garbage objects to console or file.

**Parameters** *stream* – open file, uses *sys.stdout* if not given

## Functions

`pympler.garbagegraph.start_debug_garbage()`

Turn off garbage collector to analyze *collectable* reference cycles.

`pympler.garbagegraph.end_debug_garbage()`

Turn garbage collection on and disable debug output.

## pympler.muppy

## Functions

`pympler.muppy.get_objects(remove_dups=True, include_frames=False)`

Return a list of all known objects excluding frame objects.

If (outer) frame objects shall be included, pass *include\_frames=True*. In order to prevent building reference cycles, the current frame object (of the caller of *get\_objects*) is ignored. This will not prevent creating reference cycles if the object list is passed up the call-stack. Therefore, frame objects are not included by default.

Keyword arguments: *remove\_dups* – if True, all duplicate objects will be removed. *include\_frames* – if True, includes frame objects.

`pympler.muppy.get_size(objects)`

Compute the total size of all elements in objects.

`pympler.muppy.get_diff(left, right)`

Get the difference of both lists.

The result will be a dict with this form { '+': [], '-': [] }. Items listed in '+' exist only in the right list, items listed in '-' exist only in the left list.

`pympler.muppy.sort` (*objects*)

Sort objects by size in bytes.

`pympler.muppy.filter` (*objects*, *Type=None*, *min=-1*, *max=-1*)

Filter objects.

The filter can be by type, minimum size, and/or maximum size.

Keyword arguments: *Type* – object type to filter by *min* – minimum object size *max* – maximum object size

`pympler.muppy.get_referents` (*object*, *level=1*)

Get all referents of an object up to a certain level.

The referents will not be returned in a specific order and will not contain duplicate objects. Duplicate objects will be removed.

Keyword arguments: *level* – level of indirection to which referents considered.

This function is recursive.

## **pympler.process**

This module queries process memory allocation metrics from the operating system. It provides a platform independent layer to get the amount of virtual and physical memory allocated to the Python process.

Different mechanisms are implemented: Either the process stat file is read (Linux), the *ps* command is executed (BSD/OSX/Solaris) or the resource module is queried (Unix fallback). On Windows try to use the win32 module if available. If all fails, return 0 for each attribute.

Windows without the win32 module is not supported.

```
>>> from pympler.process import ProcessMemoryInfo
>>> pmi = ProcessMemoryInfo()
>>> print "Virtual size [Byte]:", pmi.vsz
Virtual size [Byte]: ...
```

## **Classes**

**class** `pympler.process._ProcessMemoryInfo`

Stores information about various process-level memory metrics. The virtual size is stored in attribute *vsz*, the physical memory allocated to the process in *rss*, and the number of (major) pagefaults in *pagefaults*. On Linux, *data\_segment*, *code\_segment*, *shared\_segment* and *stack\_segment* contain the number of Bytes allocated for the respective segments. This is an abstract base class which needs to be overridden by operating system specific implementations. This is done when importing the module.

**update** ()

Refresh the information using platform instruments. Returns true if this operation yields useful values on the current platform.

`pympler.process.is_available` ()

Convenience function to check if the current platform is supported by this module.

## **pympler.refbrowser**

Tree-like exploration of object referrers.

This module provides a base implementation for tree-like referrers browsing. The two non-interactive classes `ConsoleBrowser` and `FileBrowser` output a tree to the console or a file. One graphical user interface for referrers browsing is provided as well. Further types can be subclassed.

All types share a similar initialisation. That is, you provide a root object and may specify further settings such as the initial depth of the tree or an output function. Afterwards you can print the tree which will be arranged based on your previous settings.

The interactive browser is based on a `TreeWidget` implemented in IDLE. It is available only if you have `Tcl/Tk` installed. If you try to instantiate the interactive browser without having `Tkinter` installed, an `ImportError` will be raised.

## Classes

```
class pympler.refbrowser.RefBrowser (rootobject, maxdepth=3, str_func=<function
    _repr>, repeat=True, stream=None)
```

Base class to other `RefBrowser` implementations.

This base class provides means to extract a tree from a given root object and holds information on already known objects (to avoid repetition if requested).

```
get_tree ()
```

Get a tree of referrers of the root object.

```
class pympler.refbrowser.ConsoleBrowser (*args, **kwargs)
    RefBrowser that prints to the console (stdout).
```

```
print_tree (tree=None)
```

Print referrers tree to console.

keyword arguments `tree` – if not `None`, the passed tree will be printed. Otherwise it is based on the rootobject.

```
class pympler.refbrowser.FileBrowser (rootobject, maxdepth=3, str_func=<function _repr>, re-
    peat=True, stream=None)
```

`RefBrowser` implementation which prints the tree to a file.

```
print_tree (filename, tree=None)
```

Print referrers tree to file (in text format).

keyword arguments `tree` – if not `None`, the passed tree will be printed.

```
class pympler.refbrowser.InteractiveBrowser (rootobject, maxdepth=3, str_func=<function
    gui_default_str_function>, repeat=True)
```

Interactive referrers browser.

The interactive browser is based on a `TreeWidget` implemented in IDLE. It is available only if you have `Tcl/Tk` installed. If you try to instantiate the interactive browser without having `Tkinter` installed, an `ImportError` will be raised.

```
main (standalone=False)
```

Create interactive browser window.

keyword arguments `standalone` – Set to true, if the browser is not attached to other windows

## pympler.refgraph

This module exposes utilities to illustrate objects and their references as (directed) graphs. The current implementation requires ‘`graphviz`’ to be installed.

## Classes

**class** `pympler.refgraph.ReferenceGraph` (*objects*, *reduce=False*)

The ReferenceGraph illustrates the references between a collection of objects by rendering a directed graph. That requires that 'graphviz' is installed.

```
>>> from pympler.refgraph import ReferenceGraph
>>> a = 42
>>> b = 'spam'
>>> c = {a: b}
>>> gb = ReferenceGraph([a,b,c])
>>> gb.render('spam.eps')
True
```

**\_\_init\_\_** (*objects*, *reduce=False*)

Initialize the ReferenceGraph with a collection of *objects*.

**render** (*filename*, *cmd='dot'*, *format='ps'*, *unflatten=False*)

Render the graph to *filename* using graphviz. The graphviz invocation command may be overridden by specifying *cmd*. The *format* may be any specifier recognized by the graph renderer ('-Txxx' command). The graph can be preprocessed by the *unflatten* tool if the *unflatten* parameter is True. If there are no objects to illustrate, the method does not invoke graphviz and returns False. If the renderer returns successfully (return code 0), True is returned.

An *OSError* is raised if the graphviz tool cannot be found.

**split** ()

Split the graph into sub-graphs. Only connected objects belong to the same graph. *split* yields copies of the Graph object. Shallow copies are used that only replicate the meta-information, but share the same object list `self.objects`.

```
>>> from pympler.refgraph import ReferenceGraph
>>> a = 42
>>> b = 'spam'
>>> c = {a: b}
>>> t = (1,2,3)
>>> rg = ReferenceGraph([a,b,c,t])
>>> for subgraph in rg.split():
...     print subgraph.index
0
1
```

**write\_graph** (*filename*)

Write raw graph data which can be post-processed using graphviz.

## pympler.summary

A collection of functions to summarize object information.

This module provides several function which will help you to analyze object information which was gathered. Often it is sufficient to work with aggregated data instead of handling the entire set of existing objects. For example can a memory leak identified simple based on the number and size of existing objects.

A summary contains information about objects in a table-like manner. Technically, it is a list of lists. Each of these lists represents a row, whereas the first column reflects the object type, the second column the number of objects, and the third column the size of all these objects. This allows a simple table-like output like the following:



types	# objects	total size
<type 'dict'>	2	560
<type 'str'>	3	126
<type 'int'>	4	96
<type 'long'>	2	66
<type 'list'>	1	40

Another advantage of summaries is that they influence the system you analyze only to a minimum. Working with references to existing objects will keep these objects alive. Most of the times this is no desired behavior (as it will have an impact on the observations). Using summaries reduces this effect greatly.

**output representation** The output representation of types is defined in `summary.representations`. Every type defined in this dictionary will be represented as specified. Each definition has a list of different representations. The later a representation appears in this list, the higher its verbosity level. From types which are not defined in `summary.representations` the default `str()` representation will be used.

Per default, summaries will use the verbosity level 1 for any encountered type. The reason is that several computations are done with summaries and rows have to remain comparable. Therefore information which reflect an objects state, e.g. the current line number of a frame, should not be included. You may add more detailed information at higher verbosity levels than 1.

## functions

`pympler.summary.summarize` (*objects*)

Summarize an objects list.

**Return a list of lists, whereas each row consists of::** [`str(type)`, number of objects of this type, total size of these objects].

No guarantee regarding the order is given.

`pympler.summary.get_diff` (*left*, *right*)

Get the difference of two summaries.

Subtracts the values of the right summary from the values of the left summary. If similar rows appear on both sides, the are included in the summary with 0 for number of elements and total size. If the number of elements of a row of the diff is 0, but the total size is not, it means that objects likely have changed, but not there number, thus resulting in a changed size.

`pympler.summary.print_` (*rows*, *limit=15*, *sort='size'*, *order='descending'*)

Print the rows as a summary.

Keyword arguments: `limit` – the maximum number of elements to be listed `sort` – sort elements by ‘size’, ‘type’, or ‘#’ order – sort ‘ascending’ or ‘descending’

## pympler.tracker

The tracker module allows you to track changes in the memory usage over time.

Using the `SummaryTracker`, you can create summaries and compare them with each other. Stored summaries can be ignored during comparision, avoiding the observer effect.

The `ObjectTracker` allows to monitor object creation. You create objects from one time and compare with objects from an earlier time.

## Classes

**class** `pympler.tracker.SummaryTracker` (*ignore\_self=True*)

Helper class to track changes between two summaries taken.

Detailed information on single objects will be lost, e.g. object size or object id. But often summaries are sufficient to monitor the memory usage over the lifetime of an application.

On initialisation, a first summary is taken. Every time *diff* is called, a new summary will be created. Thus, a diff between the new and the last summary can be extracted.

Be aware that filtering out previous summaries is time-intensive. You should therefore restrict yourself to the number of summaries you really need.

**diff** (*summary1=None, summary2=None*)

Compute diff between two summaries.

If no summary is provided, the diff from the last to the current summary is used. If *summary1* is provided the diff from *summary1* to the current summary is used. If *summary1* and *summary2* are provided, the diff between these two is used.

**print\_diff** (*summary1=None, summary2=None*)

Compute diff between two summaries and print it.

If no summary is provided, the diff from the last to the current summary is used. If *summary1* is provided the diff from *summary1* to the current summary is used. If *summary1* and *summary2* are provided, the diff between these two is used.

**store\_summary** (*key*)

Store a current summary in `self.summaries`.

**class** `pympler.tracker.ObjectTracker`

Helper class to track changes in the set of existing objects.

Each time you invoke a *diff* with this tracker, the objects which existed during the last invocation are compared with the objects which exist during the current invocation.

Please note that in order to do so, strong references to all objects will be stored. This means that none of these objects can be garbage collected. A use case for the `ObjectTracker` is the monitoring of a state which should be stable, but you see new objects being created nevertheless. With the `ObjectTracker` you can identify these new objects.

**get\_diff** (*ignore=[]*)

Get the diff to the last time the state of objects was measured.

keyword arguments *ignore* – list of objects to ignore

**print\_diff** (*ignore=[]*)

Print the diff to the last time the state of objects was measured.

keyword arguments *ignore* – list of objects to ignore

## pympler.web

This module provides a web-based memory profiling interface. The Pympler web frontend exposes process information, tracker statistics, and garbage graphs. The web frontend uses `Bottle`, a lightweight Python web framework. `Bottle` is packaged with Pympler.

The web server can be invoked almost as easily as setting a breakpoint using *pdb*:

```
from pympler.web import start_profiler
start_profiler()
```

Calling `start_profiler` suspends the current thread and executes the Pympler web server, exposing profiling data and various facilities of the Pympler library via a graphic interface.

---

**Note:** This module requires Python 2.5 or newer.

---

## Functions

`pympler.web.start_profiler` (*host='localhost', port=8090, tracker=None, stats=None, debug=False, \*\*kwargs*)

Start the web server to show profiling data. The function suspends the Python application (the current thread) until the web server is stopped.

The only way to stop the server is to signal the running thread, e.g. press Ctrl+C in the console. If this isn't feasible for your application use `start_in_background` instead.

During the execution of the web server, profiling data is (lazily) cached to improve performance. For example, garbage graphs are rendered when the garbage profiling data is requested and are simply retransmitted upon later requests.

### Parameters

- **host** – the host where the server shall run, default is localhost
- **port** – server listens on the specified port, default is 8090 to allow coexistence with common web applications
- **tracker** – *ClassTracker* instance, browse profiling data (on-line analysis)
- **stats** – *Stats* instance, analyze *ClassTracker* profiling dumps (useful for off-line analysis)

`pympler.web.start_in_background` (*\*\*kwargs*)

Start the web server in the background. A new thread is created which serves the profiling interface without suspending the current application.

For the documentation of the parameters see `start_profiler`.

Returns the created thread object.

## 7.1.10 Pympler Tutorials

- [Tutorial - Track Down Memory Leaks](#) - This tutorial shows you ways in which *muppy* can be used to track down memory leaks.
- [Tutorial - Tracking Class Instances in SCons](#) - A tutorial illustrating how to use the *ClassTracker* facility.

## Table of Content

### Tutorial - Track Down Memory Leaks

This tutorial shows you ways in which *muppy* can be used to track down memory leaks. From my experience, this can be done in 3 steps, each answering a different question.

1. Is there a leak?
2. What objects leak?
3. Where does it leak?

**IDLE** My first real-life test for *muppy* was **IDLE**, which is “the Python IDE built with the Tkinter GUI toolkit.” It offers the following features:

- coded in 100% pure Python, using the Tkinter GUI toolkit
- cross-platform: works on Windows and Unix (on Mac OS, there are currently problems with Tcl/Tk)
- multi-window text editor with multiple undo, Python colorizing and many other features, e.g. smart indent and call tips
- Python shell window (a.k.a. interactive interpreter)
- debugger (not complete, but you can set breakpoints, view and step)

Because it is integrated in every Python distribution, runs locally and provides easy interactive feedback, it was a nice first candidate to test the tools of *muppy*.

The task was to check if **IDLE** leaks memory, if so, what objects are leaking, and finally, why are they leaking.

**Preparations** **IDLE** is part of every Python distribution and can be found at `Lib/idlelib`. The modified version which makes use of *muppy* can be found at <http://code.google.com/p/muppy/source/browse/trunk#trunk/playground/idlelib>.

With **IDLE** having a GUI, I also wanted to be able to interact with *muppy* through the GUI. This can be done in `Lib/idlelib/Bindings.py` and `Lib/idlelib/PyShell.py`. For details, please refer to the modified version mentioned above.

**Task 1: Is there a leak?** At first, we need to find out if there are any objects leaking at all. We will have a look at the objects, invoke an action, and look at the objects again.

```
from pympler import tracker

self.memory_tracker = tracker.SummaryTracker()
self.memory_tracker.print_diff()
```

The last step is repeated after each invocation. Let’s start with something simple which should not leak. We will check the Windows resize. You can invoke it in the menu at *Windows->Zoom Height*.

At first call *print\_diff* till it has calibrated. That is, the first one or two times, you will get some output because there is still something going on in the background. But then you should get this:

```
types | # objects | total size
===== | ===== | =====
```

Which means nothing has changed since the last invocation of *print\_diff*. Now let’s call *Windows->Zoom Height* and invoke *print\_diff* again.:

```
types | # objects | total size
===== | ===== | =====
dict | 1 | 280 B
list | 1 | 176 B
_sre.SRE_Pattern | 1 | 88 B
tuple | 1 | 80 B
str | 0 | 7 B
```

Seems as this requires some of the above mentioned objects. Let’s repeat it.:

```
types | # objects | total size
===== | ===== | =====
```

Okay, nothing changed, so nothing is leaking. But we see that often, the first call to a function creates some objects, which then exist on a second invocation.

Next, we try something different. We will open a new window. Let's have a look at the Path Browser at *File->Path Browser*:

types	# objects	total size
dict	18	14.26 KB
tuple	146	13.17 KB
list	2	11.67 KB
str	97	7.85 KB
code	46	5.52 KB
function	45	5.40 KB
classobj	9	864 B
instancemethod (<function wakeup>)	3	240 B
instancemethod (<function __call__>)	3	240 B
instance(<class Tkinter.CallWrapper>)	3	216 B
module	3	168 B
instance(<class idlelib.WindowList.ListedToplevel>)	1	72 B

Let's repeat it:

types	# objects	total size
dict	5	2.17 KB
list	0	384 B
str	5	259 B
instancemethod (<function wakeup>)	3	240 B
instancemethod (<function __call__>)	3	240 B
instance(<class Tkinter.CallWrapper>)	3	216 B
instance(<class idlelib.WindowList.ListedToplevel>)	1	72 B

Mh, still some new objects. Repeating this procedure several times will reveal that here indeed we have a leak.

**Task 2: What objects leak?** So let's have a closer look at the diff. We see 5 new *dicts* and *strings*, a bit more memory usage by *lists*, 3 *wakeup* and *\_\_call\_\_* instance methods, 3 *CallWrapper* and 1 *ListedToplevel*. We know the standard types, but the last couple of objects seem to be from IDLE.

We ignore the standard type objects for now. It is more likely that these are only children of some other instances which are causing the leak.

We start with the *ListedTopLevel* object. One invocation of *File->Path Browser* and one more of this type looks like this object is not garbage collected, although it should have been. Searching for *ListedTopLevel* in *idlelib/* reveals that is the base class to all window objects of IDLE. We can assume that opening the Path Browser, a new window object is created, but closing the window does not remove the reference.

Next, we take a look at the *wakeup* instance method of which we have three more on each invocation. Searching the code, we find it to be defined in *idlelib/WindowList.py*. This piece of code is used to give users of IDLE a list of currently open windows. Every time a new window is created, it will be added to the *Windows* menu, from where the user can select any open window. *wakeup* is the method which will bring the selected window up front. Adding a window calls *menu.add\_command*, linking menu and the wakeup command together.

```
menu.add_command(label=title, command=window.wakeup)
```

So we are getting closer. Only *\_\_call\_\_* and *Tkinter.CallWrapper* are left. As the name indicates, the latter is located in the Tkinter module, which is part of the standard library of Python. So let's dive into it. The *CallWrapper* docstring states:

```
Internal class. Stores function to call when some user defined Tcl function is called e.g. after an event occurred.
```

Also, CallWrapper contains a method called `__call__`, which is used to invoke the stored function call. A CallWrapper is created by the method `_register` which then creates a command (Tk speak) and adds it's name to a list called `self._tclCommands`.

So what do we know so far? Every time a Path Browser is opened, a window is created, but not deleted when closed again. It has something to do with the `wakeup` method of the window. This method is wrapped as a Tcl command and then linked to the window list menu. Also, we have traced this wrapping back to Tkinter library, where names of the function wrappers are stored in a attribute called `_tclCommands`.

This brings us to the third question.

**Task 3: Where is the leak?** `_tclCommands` stores the names of all commands linked to a widget. The base class for interior widgets (of which the menu is one), has a method called `destroy` which:

```
Delete all Tcl commands created for this widget in the Tcl interpreter.
```

as well as a method `deletecommand` which deletes a single Tcl command. Both remove commands as by there name. Among them, we find our CallWrappers' `__call__` used to wrap the wakeup of the Path Browser window.

So we should expect at least either one to be invoked when a window is closed (best would be the invocation of only `deletecommand`). This would also go in line with `menu.add_command` we identified *above*. And indeed, in `idlelib/EditorWindow.py`, `menu.delete` is called. So where is the problem?

We return to `Tkinter.py` and have a closer look at `delete` method:

```
def delete(self, index1, index2=None):
    """Delete menu items between INDEX1 and INDEX2 (not included)."""
    self.tk.call(self._w, 'delete', index1, index2)
```

Mh, it looks like the menu item is deleted, but what about the attached command? Let's ask the Web for "tkinter deletecommand". Turns out that somebody some years ago filed a bug (see [bugreport](#)) which states:

```
Tkinter.Menu.delete does not delete the commands defined for the entries it deletes. Those objects will be retained until the menu itself is deleted. [...] the command function will still be referenced and kept in memory - until the menu object itself is destroyed.
```

Well, this seems to be the root of our memory leak. Let's adapt the `delete` method a bit, so that the associated commands are deleted as well:

```
def delete(self, index1, index2=None):
    """Delete menu items between INDEX1 and INDEX2 (not included)."""
    if index2 is None:
        index2 = index1
    cmds = []
    (num_index1, num_index2) = (self.index(index1), self.index(index2))
    if (num_index1 is not None) and (num_index2 is not None):
        for i in range(num_index1, num_index2 + 1):
            if 'command' in self.entryconfig(i):
                c = str(self.entrycget(i, 'command'))
                if c in self._tclCommands:
                    cmds.append(c)
```

```
self.tk.call(self._w, 'delete', index1, index2)
for c in cmds:
    self.deletecommand(c)
```

Now we restart IDLE, calibrate our tracker and do another round of *print\_diff*. After the first time the Path Browser is opened we get this:

types	# objects	total size
tuple	146	13.17 KB
dict	13	12.01 KB
list	2	11.26 KB
str	92	7.59 KB
code	46	5.52 KB
function	45	5.40 KB
classobj	9	864 B
module	3	168 B

Okay, still some objects created, but no more instances and instance methods. Let's do it again.:

types	# objects	total size

Yes, this looks definitely better. The memory leak is gone.

The problem is fixed for Python versions 2.5 and higher so updated installations will not face this leak.

## Tutorial - Tracking Class Instances in SCons

This tutorial demonstrates the class tracking facility to profile and optimize a non-trivial program. *SCons* is a next-generation build system with a quite elaborate architecture and thus an interesting candidate for profiling attempts.

Before we begin, it should be identified what shall be tracked, i.e. what classes we want to connect to and whose instances are to be sized and profiled. In this tutorial, the effect of a *patch* is analyzed that tries to size-optimize the very heart of *SCons* - the *Node* class. Naturally, we will connect to the *Node* base class and its sub-classes. It makes sense to put the profiling data in context and track additional classes that are believed to contribute significantly to the total memory consumption.

**Installing hooks into SCons** The first step is to find the proper spots for connecting to the classes that shall be tracked, taking snapshots, and printing the gathered profile data. *SCons* has a simple memory profiling tool that we will override. The *SCons MemStats* class provides all we need:

```
from pympler.classtracker import ClassTracker

class MemStats(Stats):
    def __init__(self):
        Stats.__init__(self)
        classes = [SCons.Node.Node, SCons.Node.FS.Base, SCons.Node.FS.File,
                  SCons.Node.FS.Dir, SCons.Executor.Executor]
        self.tracker = ClassTracker()
        for c in classes:
            self.tracker.track_class(c)
    def do_append(self, label):
        self.tracker.create_snapshot(label)
    def do_print(self):
        stats = self.tracker.stats
```

```
stats.print_summary()
stats.dump_stats('pympler.stats')
```

When SCons starts, MemStats is instantiated and the *ClassTracker* is connected to a number of classes. SCons has predefined spots where it invokes its statistics facilities with `do_append` being called. This is where snapshots will be taken of all objects tracked so far.

Because of the large number of instances, only a summary is printed to the console via `stats.print_summary()` and the profile data is dumped to a file in case per-instance profile information is needed later.

**Test run** Time for a test. In the following examples, SCons builds a non-trivial program with a fair number of nodes. Running SCons via `scons --debug=memory` will print the gathered data to the console:

```
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
scons: `.` is up to date.
scons: done building targets.
---- SUMMARY -----
before reading SConscript files:      active      4.17 MB      average  pct
  SCons.Executor.Executor             7           7.53 KB      1.08 KB  0%
  SCons.Node.FS.Base                   1           9.30 KB      9.30 KB  0%
  SCons.Node.FS.Dir                     6          17.77 KB      2.96 KB  0%
  SCons.Node.FS.File                    1           2.91 KB      2.91 KB  0%
  SCons.Node.Node                       0            0 B          0 B      0%
after reading SConscript files:      active      13.06 MB      average  pct
  [...]
before building targets:             active      13.41 MB      average  pct
  [...]
after building targets:               active      34.77 MB      average  pct
  SCons.Executor.Executor             1311         3.57 MB      2.79 KB  10%
  SCons.Node.FS.Base                   1102         4.84 MB      4.50 KB  13%
  SCons.Node.FS.Dir                     108          5.67 MB     53.72 KB  16%
  SCons.Node.FS.File                   2302        10.45 MB      4.65 KB  30%
  SCons.Node.Node                       1           84.93 KB     84.93 KB  0%
```

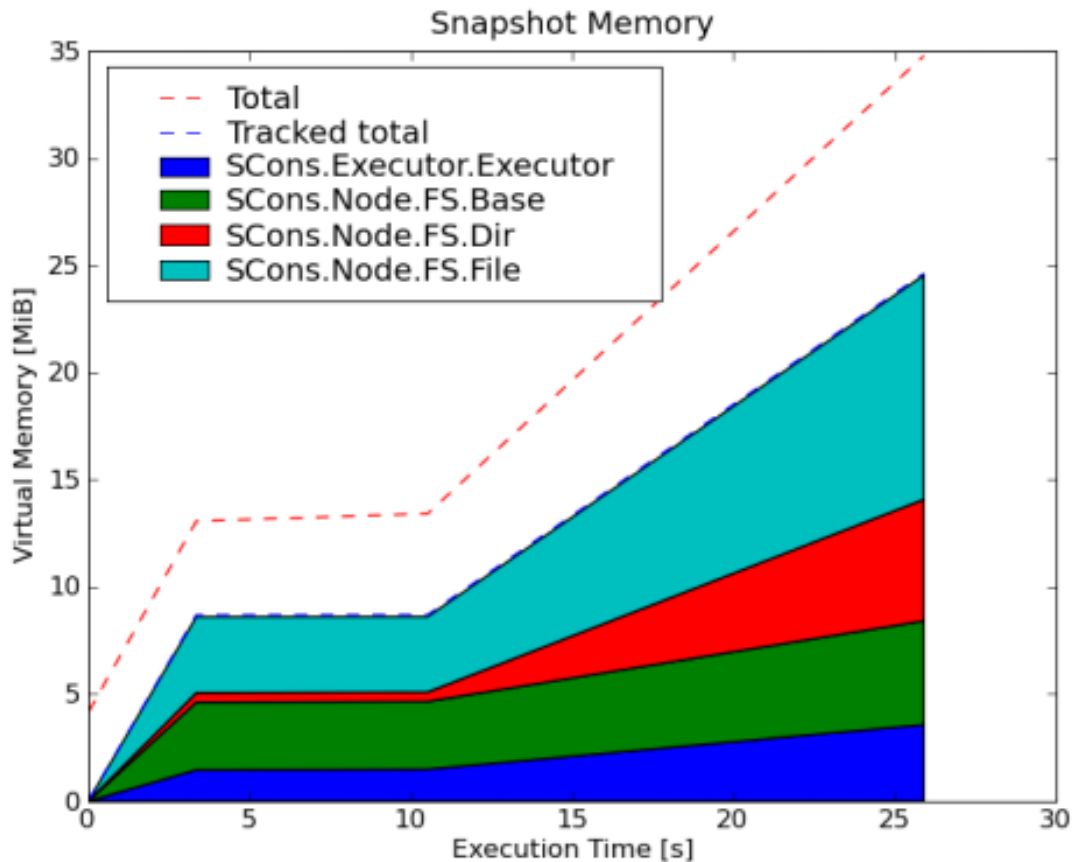
**Making sense of the data** The console output may give a brief overview how much memory is allocated by instances of the individual tracked classes. A more appealing and well arranged representation of the data can be generated with the `HtmlStats` class. The dump generated previously can be loaded and a set of HTML pages can be emitted:

```
from pympler.classtracker_stats import HtmlStats

stats = HtmlStats()
stats.load_stats('pympler.stats')
stats.create_html('pympler.html')
```

If `matplotlib` is installed, charts will be embedded in the HTML output:





At first sight it might seem suspicious that the tracked classes appear to be the sole contributors to the total memory footprint of the application. Because the tracked objects are sized recursively, referenced objects which are not tracked themselves are added to the referrers account. Thus, a root object's size will include the size of every leaf unless the leaf is also tracked by the *ClassTracker*.

**Optimization attempt** After applying the patch by Jean Brouwers, SCons is rerun under the supervision of the *ClassTracker*. The differences in the last snapshot show that the changes indeed reduce the memory footprint of Node instances:

```
$ scons --debug=memory
scons: Reading SConscript files ...
scons: done reading SConscript files.
scons: Building targets ...
scons: `.' is up to date.
scons: done building targets.
----- SUMMARY -----
[...]
after building targets:
      active      32.41 MB      average      pct
SCons.Executor.Executor      1311      3.50 MB      2.73 KB      10%
SCons.Node.FS.Base           1102      4.29 MB      3.98 KB      13%
SCons.Node.FS.Dir             108      5.52 MB      52.30 KB      17%
SCons.Node.FS.File           2302      8.82 MB      3.92 KB      27%
SCons.Node.Node                1      84.32 KB      84.32 KB      0%
```

The total measured memory footprint dropped from 34.8MB to 32.4MB, `File` nodes' average size from 4.6KB to 3.9KB.

**Summary** This tutorial illustrated how applications can be profiled with the *ClassTracker* facility. It has been shown how the memory impact of changes can be quantified.

### 7.1.11 Related Work

Pympler is a merger of several approaches toward memory profiling of Python applications. This page lists other known tools. If you know yet another one or find the description is not correct you can create a new issue at <http://code.google.com/p/pympler/issues>.

#### asizeof

Asizeof is a pure-Python module to estimate the size of objects by Jean Brouwers. This implementation has been published previously on [aspn.activestate.com](http://aspn.activestate.com). It is possible to determine the size of an object and its referents recursively up to a specified level. `asizeof` is also distributed with `muppy` and allows the usage of `muppy` with Python versions prior to Python 2.6.

`asizeof` has become a part of Pympler.

URL: <http://code.activestate.com/recipes/546530/>

#### Heapmonitor

“The Heapmonitor is a facility delivering insight into the memory distribution of SCons. It provides facilities to size individual objects and can track all objects of certain classes.” It was developed in 2008 by Ludwig Haehne.

URL: <http://www.scons.org/wiki/LudwigHaehne/HeapMonitor>

Heapmonitor has become a part of Pympler.

#### Heapy

Heapy was part of the Master thesis by Sverker Nilsson done in 2006. It is part of the umbrella project `guppy`. Heapy has a very mathematical approach as it works in terms of sets, partitions, and equivalence relations. It allows to gather information about objects at any given time, but only objects starting from a specific root object. Type information for standard objects is supported by default and type information for non-standard object types can be added through an interface.

URL: <http://guppy-pe.sourceforge.net>

#### muppy

“Muppy [...] enables the tracking of memory usage during runtime and the identification of objects which are leaking. Additionally, tools are provided which allow to locate the source of not released objects.” It was developed in 2008 by Robert Schuppenies.

`muppy` has become a part of Pympler.

## Python Memory Validator

A commercial Python memory validator which uses the Python Reflection API.

URL: <http://www.softwareverify.com/python/memory/index.html>

## PySizer

PySizer was a Google Summer of Code 2005 project by Nick Smallbone. It relies on the garbage collector to gather information about existing objects. The developer can create a summary of the current set of objects and then analyze the extracted data. It is possible to group objects by criteria like object type and apply filtering mechanisms to the sets of objects. Using a patched CPython version it is also possible to find out where in the code a certain object was created. Nick points out that “the interface is quite sparse, and some things are clunky”. The project is deprecated and the last supported Python version is 2.4.

URL: <http://pysizer.8325.org/>

## Support Tracking Low-Level Memory Usage in CPython

This is an experimental implementation of CPython-level memory tracking by Brett Cannon. Done in 2006, it tackles the problem at the core, the CPython interpreter itself. To trace the memory usage he suggests to tag every memory allocation and de-allocation. All actions involving memory take a *const char \** argument that specifies what the memory is meant for. Thus every allocation and freeing of memory is explicitly registered. On the Python level the total memory usage as well as “a dict with keys as the string names of the types being tracked and values of the amount of memory being used by the type” are available.

URL: <http://svn.python.org/projects/python/branches/bcannon-sandboxing/PEP.txt>

## 7.1.12 Glossary

**asizeof** Name of a formerly separate package. Now integrated into Pympler.

**HeapMonitor** Name of a formerly separate package. Now integrated into Pympler.

**muppy** Name of a formerly separate package. Now integrated into Pympler.

**pymple, to** Obtain detailed insight in the size and the lifetime of Python objects.

**pymple, a** Undesirable or unexpected runtime behavior like memory bloat.

**summary** A summary contains information about objects in a summarized format. Instead of having data of every object, information are grouped by object type. Each object type is represented by a row, whereas the first column reflects the object type, the second column the number of objects of this type, and the third column the size of all of these objects. The output looks like the following:

types	# objects	total size
<type 'dict'>	2	560
<type 'str'>	3	126
<type 'int'>	4	96
<type 'long'>	2	66
<type 'list'>	1	40

### 7.1.13 Changes in pympler

#### Release 0.2.1

- Fix static file retrieval when installed via `easy_install`
- Show class tracker instantiation traces and referent trees in web interface
- New style for web interface

#### Release 0.2

The second release is one of several steps to better integrate the different sub-systems of Pympler. All modules now directly reside in the `pympler` namespace which simplifies the import of Pympler modules. Pympler 0.2 introduces a web interface to facilitate memory profiling. Pympler now fully supports Python 3.x. This release also adds several modules replacing the *Heapmonitor* module with the new *class tracker* facility.

- Introduce web frontend
- Split *Heapmonitor* into several new modules
- New *process* module to obtain memory statistics of the Python process
- Improved garbage illustration which can directly render directed graphs using `graphviz`

#### Release 0.1

This initial release is the first step to unify three separate Python memory profiling tools. We aim to create a place-to-go for Python developers who want to monitor and analyze the memory usage of their applications. It is just the first step towards a further integration. There is still lots of work that needs to be done and we stress that the API is subject to change. Any feedback you want to give us, wishes, bug reports, or feature requests please send them to [pympler-dev@googlegroups.com](mailto:pympler-dev@googlegroups.com).

- First Public Release.

### 7.1.14 Copyright

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