Pikos: A Real-Time Python Profiling Framework

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Why Was Pikos Created?

- Working with large data sets requires careful optimization and design for memory usage
- There can be errors in complex algorithms that are not immediately obvious
  - Memory Leak
  - Large temporary allocation
- How do you locate these problems in large and unfamiliar code bases?

Existing Tools

- `Meliae` and `Heapy`
  - Both provide tools for detailed memory analysis
  - Slows down with large memory use
  - Knowing where to look (i.e. starting with Pikos) can help with this analysis
- `memory_profiler` is a line-by-line profiler for memory usage
  - Only discovered after Pikos was started
  - Pikos can wrap it to make the functionality available

Beginnings of Pikos

- Find memory leaks and large allocation in unknown codebase
- Use deterministic monitoring (trace execution) as periodic monitoring will not find all cases
- Simply record useful values for later analysis
- Manual analysis of plotted data required to find problem areas

Example Memory Profile

```
from pikos.api import monitor
from pikos.recorders.text_stream_recorder import TextStreamRecorder
from pikos.monitors.function_memory_monitor import FunctionMemoryMonitor, \
    FunctionMemoryRecordFormater

memory = FunctionMemoryMonitor(
    TextStreamRecorder(sys.stdout, auto_flush=True,
                       formater=FunctionMemoryRecordFormater()))

@monitor(memory)
def legacy(size):
    b = np.mat(np.random.random(size).T)
    # very bad example that makes copies of numpy arrays when converting them
    # to matrix
    a = np.matrix(np.random.random(size))
    final = a * b
    return final.I

@monitor(memory)
def fixed(size):
    # more approprate way using a numpy.mat
    b = np.mat(np.random.random(size).T)
    a = np.mat(np.random.random(size))
    final = a * b
    return final.I
```

Example Profile Output

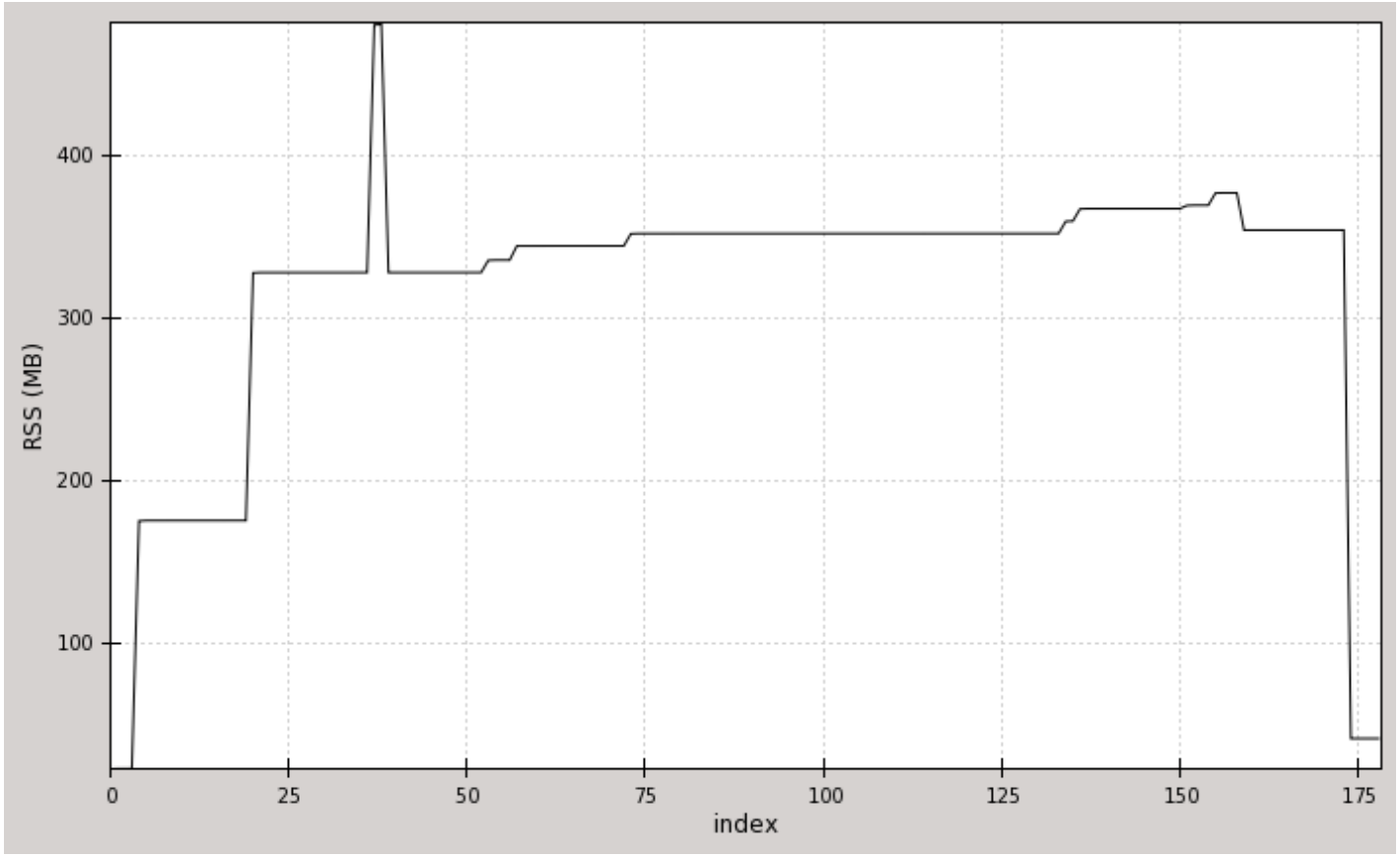
```
 index type        function                  RSS             VMS lineNo filename
-------------------------------------------------------------------------------
...
    18 return      asmatrix           181813248       307998720     85 <numpy>
    19 c_call      random_sample      181813248       307998720     33 spike.py
    20 c_return    random_sample      341577728       468000768     33 spike.py
    21 call        __new__            341815296       468000768    233 <numpy>
...
    36 return      __array_finalize__ 341827584       628002816    284 <numpy>
    37 c_return    copy               501592064       628002816    250 <numpy>
    38 return      __new__            501833728       628002816    250 <numpy>
    39 call        __mul__            341831680       468000768    327 <numpy>
...
```

We can see that line 33 in `spike.py` is the problem:

```
>>> a = np.matrix(np.random.random(size))
```

This copies the array to create a matrix, the temporary created by np.random creates a memory spike

Plotting The Profile



Generalizing Pikos

- Introduce general concepts to enable extensibility
  - Monitor: Top level machinery
  - Logger: Extensible concept to produce recordable data
    - Able to filter to produce limited set of records
  - Recorder: Extensible concept to format, serialize or process the data in some way
- These components can plug together in flexible configurations

Generalizing Pikos

- Logging functions
  - Trace program flow
  - Profile memory usage
  - Profile speed
- Recording functions
  - Write to Stdout
  - Write to disk
  - Send to ZeroMQ socket

Real-Time Profile Analysis

- If you don't know where to look for the problem, it can be useful to monitor the results while an application is running
  - Capture profile results "live"
- Analyse data while process under profiling is still running and producing more results
- Drill down into more detail about each data point

Future development

- Improve API / profiling user interface
- Improve support for existing tools (e.g. cProfile) to enable real-time analysis
- Add support for more tools (line_profiler, yappi, …)
- Improve real-time analysis tools
  - Profile multiple processes from a single location
  - Display more information about each data point

Availablility and Licence

- Available under the 3-clause BSD licence
- Now available on Github.com
  - https://github.com/sjagoe/pikos