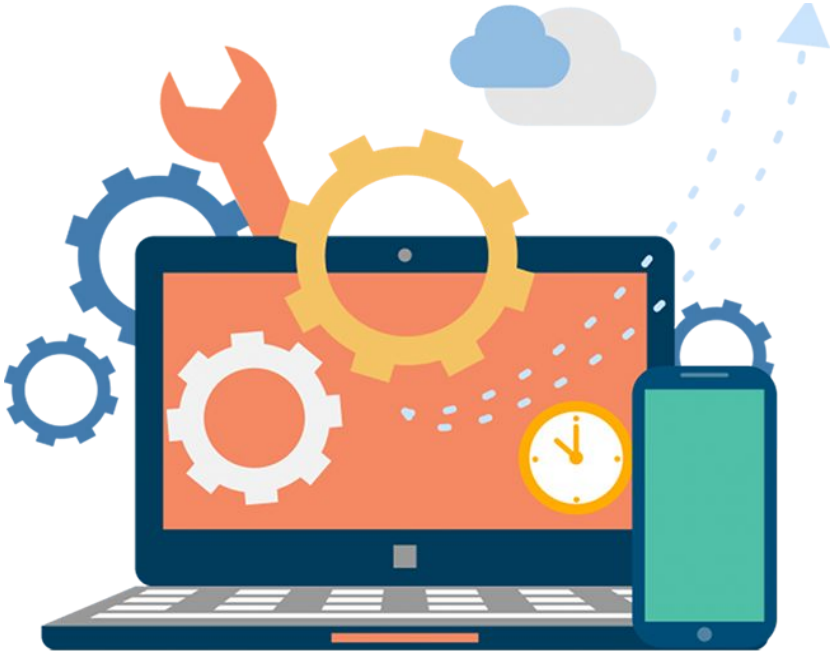
Python Performance Profiling



PyCon PAKISTAN

HELLO!

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What is Profiling?

Profiling Definition?

- Measuring the execution time.
- Insight of run time performance of a given piece of code.
- Frequently used to optimize execution time.
- Used to analyze other characteristics such as memory consumption.

What is Python Profiling?

Measure Performance

Why Profile?

You can use a profiler to answer questions like these:

- Why is this program slow?
- Why does it slow my computer to a crawl?
- What is actually happening when this code executes?
- Is there anything I can improve?
- How much memory consumed by program?
- How much time taken by each function execution?

Why You should care about Performance

- “If You Can’t Measure It, You Can’t Manage It.”
- Writing efficient code saves money in modern "cloud economy" (e.g. you need fewer VM instances).
- Even if you don't use clouds, a particular problem domain can have strict performance requirements (e.g. when you have to process a chunk of data in time before the next chunk arrives).

Available options for measuring Performance

- Command Line
- time Module
- timeit Module
- cProfile Module

Command Line

The **time** command is available in *nix systems.

```
$ time python some_program.py
```

```
real    0m4.536s
user    0m3.411s
sys     0m0.979s
```

Command Line

PROS

- Easy to use

CONS

- Very limited information
- Not very deterministic
- Not available on Windows

Python time Module

Naive approach: **time.time()** statements

```
import time

initial_time = time.time()
time.sleep(1)
final_time = time.time()
print('Duration: {}'.format(final_time - initial_time))
```

```
Duration: 1.0035021305084229
```

Python time Module

PROS

- Easy to use
- Simple to understand

CONS

- Very limited information
- Not very deterministic
- Manual code modification and analysis

Python timeit Module

Better approach: timeit

```
import timeit

print('Plus:', timeit.timeit("['Hello world: ' + str(n) for n in range(100)]", number=1000))
print('Format:', timeit.timeit("['Hello world: {0}'.format(n) for n in range(100)]",
number=1000))
print('Percent:', timeit.timeit("['Hello world: %s' % n for n in range(100)]", number=1000))
```

```
Plus: 0.02512072999889146
Format: 0.035365013000046 02
Percent: 0.017073806000553304
```

timeit Module

PROS

- Easy to use
- Simple to understand
- Measure execution time of small code snippets

CONS

- Simple code only
- Not very deterministic
- Have to manually create runnable code snippets
- Manual analysis

cProfile Module

Best approach: cProfile

- Python comes with two profiling tools, profile and cProfile.
- Both share the same API, and should act the same.

```
>>> import cProfile
>>> cProfile.run('2 + 2')
```

```
3 function calls in 0.000 seconds
Ordered by: standard name
  ncalls  tottime  percall  cumtime  percall filename:lineno(function)
       1    0.000    0.000    0.000    0.000 <string>:1(<module>)
       1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'}
```

Running a script with cProfile

```
# slow.py
import time
def main():
    sum = 0
    for i in range(10):
      sum += expensive(i // 2)
    return sum

def expensive(t):
    time.sleep(t)
    return t

if __name__ == '__main__':
    print(main())
```

python -m cProfile slow.py

```
 25 function calls in 20.030 seconds

Ordered by: standard name

 ncalls  tottime  percall  cumtime  percall filename:lineno(function)
  10    0.000    0.000   20.027    2.003 slow.py:11(expensive)
   1    0.002    0.002   20.030   20.030 slow.py:2(<module>)
   1    0.000    0.000   20.027   20.027 slow.py:5(main)
   1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'objects}
   1    0.000    0.000    0.000    0.000 {print}
   1    0.000    0.000    0.000    0.000 {range}
  10   20.027    2.003   20.027    2.003 {time.sleep}
```

cProfile sort by options

ncalls

For the number of calls

tottime

for the total time spent in the given function

percall

is the quotient of tottime divided by ncalls

cumtime

is the cumulative time spent in this and all subfunctions.

percall

is the quotient of cumtime divided by primitive calls

filename:lineno(function)

provides the respective data of each function

cProfile result sorted by tottime

python -m cProfile -s tottime slow.py

```
25 function calls in 20.015 seconds

Ordered by: internal time

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
 10     20.015    2.001   20.015    2.001 {built-in method time.sleep}
 1      0.000     0.000    0.000    0.000 {built-in method builtins.print}
 1      0.000     0.000   20.015   20.015 slow.py:6(main)
 10     0.000     0.000   20.015    2.001 slow.py:13(expensive)
 1      0.000     0.000   20.015   20.015 slow.py:3(<module>)
 1      0.000     0.000   20.015   20.015 {built-in method builtins.exec}
 1      0.000     0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler' objects}
```

cProfile result sorted by ncalls

python -m cProfile -s ncalls slow.py

```
25 function calls in 20.015 seconds

Ordered by: call count

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
    10   20.020    2.002   20.020    2.002 {built-in method time.sleep}
    10    0.000    0.000   20.020    2.002 slow.py:13(expensive)
     1    0.000    0.000   20.020   20.020 {built-in method builtins.exec}
     1    0.000    0.000    0.000    0.000 {built-in method builtins.print}
     1    0.000    0.000   20.020   20.020 slow.py:6(main)
     1    0.000    0.000   20.020   20.020 slow.py:3(<module>)
     1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler' objects}
```

Easiest way to profile Python code

```
def main():
    sum = 0
    for i in range(10):
       sum += expensive(i // 2)
    return sum
def expensive(t):
    time.sleep(t)
    return t

if __name__ == '__main__':
    pr = cProfile.Profile()
    pr.enable()
    main()
    pr.disable()
    pr.print_stats()
```

cProfile output

```
 25 function calls in 20.030 seconds

Ordered by: standard name

ncalls  tottime  percall  cumtime  percall filename:lineno(function)
  10   0.000    0.000   20.027    2.003 slow.py:11(expensive)
   1    0.002    0.002   20.030   20.030 slow.py:2(<module>)
   1    0.000    0.000   20.027   20.027 slow.py:5(main)
   1    0.000    0.000    0.000    0.000 {method 'disable' of '_lsprof.Profiler'objects}
   1    0.000    0.000    0.000    0.000 {print}
   1    0.000    0.000    0.000    0.000 {range}
  10   20.027    2.003   20.027    2.003 {time.sleep}
```

We can also save the output!

```
if __name__ == '__main__':
    pr = cProfile.Profile()
    pr.enable()
    main()
    pr.disable()
    pr.dump_stats("profile.output")
```

How do we use the profiling information?

pstats Module

- You can use pstats to format the output in various ways.
- pstats provides sorting options. **(calls, time, cumulative)**

```
import pstats

p = pstats.Stats("profile.output")
p.strip_dirs().sort_stats("calls").print_stats()
```

pstats module Output

```
 23 function calls in 20.019 seconds

Ordered by: call count

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
       10   20.019    2.002   20.019    2.002 {built-in method time.sleep}
       10    0.000    0.000   20.019    2.002  slow.py:14(expensive)
        1    0.000    0.000    0.000    0.000 {built-in method builtins.print}
        1    0.000    0.000   20.019   20.019  slow.py:7(main)
```

An easy way to visualize cProfile results

- Snakeviz library
- PyCallGraph library

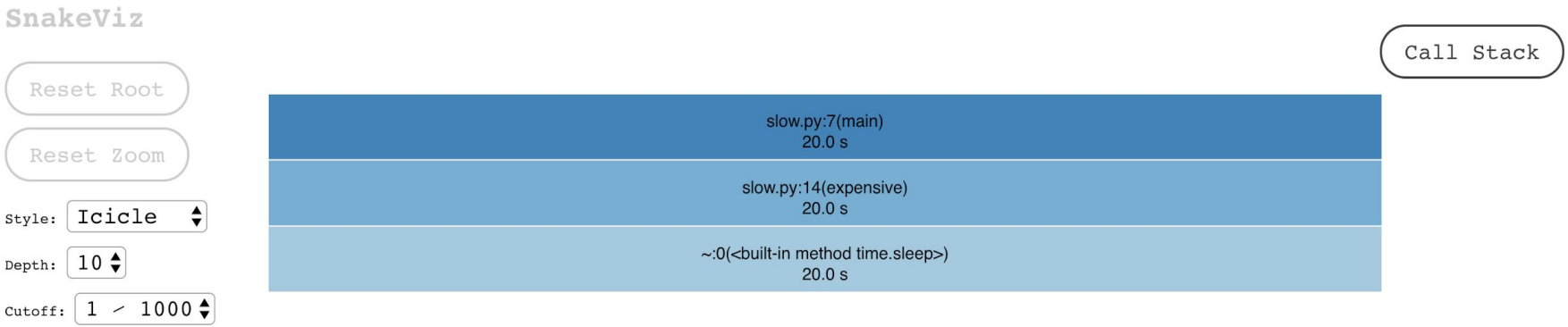
SNAKEVIZ

pip install snakeviz

```
$ snakeviz profile.output
```

- Snakeviz provides two ways to explore profiler data
- Summaries Times
- You can choose the sorting criterion in the output table

SNAKEVIZ Browser View



Search:

ncalls	tottime	percall	cumtime	percall	filename:lineno(function)
10	20.01	2.001	20.01	2.001	~:0(<built-in method time.sleep>)
1	0.00011	0.00011	20.01	20.01	slow.py:7(main)
10	7.7e-05	7.7e-06	20.01	2.001	slow.py:14(expensive)
1	6.4e-05	6.4e-05	6.4e-05	6.4e-05	~:0(<built-in method builtins.print>)
1	1e-06	1e-06	1e-06	1e-06	~:0(<method 'disable' of '_lsprof.Profiler' objects>)

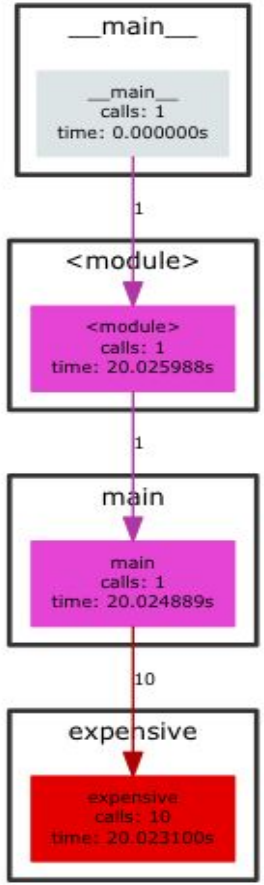
Showing 1 to 5 of 5 entries

PyCallGraph

pip install pycallgraph

```
$ pycallgraph graphviz -- python slow.py
```

- Visual extension of cProfile.
- Understand code structure and Flow
- Summaries Times
- Darker color represent more time spent



Other profiling options

Line profiler

- line_profiler will profile the time individual lines of code take to execute.
- https://github.com/rkern/line_profiler

Memory profiler

- Monitoring memory consumption of a process.
- line-by-line analysis of memory consumption.
- https://pypi.org/project/memory_profiler/

Live Example Interlude

Profiling Example Code

https://github.com/akkefa/pycon-python-performance-profiling

Thank you.

Questions?

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