Tuning Python Applications Can Dramatically Increase Performance

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Agenda

Why do we need Python optimization?

How one finds the code to tune?

Overview of existing tools

An example

Intel® VTune Amplifier capabilities and comparison

Q & A

Why do we need Python optimization?

- Python is used to power wide range of software, including those where application performance matters
- Some Python code may not scale well, but you won't know it unless you give it enough workload to chew on
- Sometimes you are just not happy with the speed of your code

All in all, there are times when you want to make your code run faster, be more responsive, *(insert your favorite buzzword here)*.

So, you need to **optimize** (or tune) your code.

How one finds the code to tune – measuring vs guessing

- **Hard stare** = Often wrong

- **Logging** = Analysis is tedious

- **Profile** = Accurate, Easy

Not All Profilers Are Equal

There are different profiling techniques, for example:

- **Event-based**
  - Example: built-in Python cProfile profiler

- **Instrumentation-based**
  - Usually requires modifying the target application (source code, compiler support, etc.)
  - Example: line_profiler

- **Statistical**
  - Accurate enough & less intrusive
  - Example: vmstat, statprof

Most Profilers – High Overhead, No Line Info

Tool	Description	Platforms	Profile level	Avg. overhead
cProfile (built-in)	• Text interactive mode: “pstats” (built-in) • GUI viewer: RunSnakeRun • Open Source	Any	Function	1.3x-5x
Python Tools	• Visual Studio (2010+) • Open Source	Windows	Function	~2x
PyCharm	• Not free • cProfile/yappi based	Any	Function	1.3x-5x (same as cProfile)
line_profiler	• Pure Python • Open Source • Text-only viewer	Any	Line	Up to 10x or more

Example performance hogs

Task	Slow way	Faster way

Concatenate a list	`s = ''`
	`for ch in some_lst:`
	`    s += ch`
		`s = ''.join(some_lst)`

reason		

Remove some value from a list	`while some_value in lst:`
	`    lst.remove(some_value)`
		`while True:`
		`    try:`
		`        lst.remove(some_value)`
		`    except ValueError:`
		`        break`

reason		

Python example to profile: **demo.py**

```
class Encoder:
    CHAR_MAP = {'a': 'b', 'b': 'c'}
    def __init__(self, input):
        self.input = input

    def process_slow(self):
        result = ''
        for ch in self.input:
            result += self.CHAR_MAP.get(ch, ch)
        return result

    def process_fast(self):
        result = []
        for ch in self.input:
            result.append(self.CHAR_MAP.get(ch, ch))
        return ''.join(result)
```

Python sample to profile: **run.py**

```
import demo
import time

def slow_encode(input):
    return demo.Encoder(input).process_slow()

def fast_encode(input):
    return demo.Encoder(input).process_fast()

if __name__ == '__main__':
    input = 'a' * 10000000 # 10 millions of 'a'
    start = time.time()
    s1 = slow_encode(input)
    slow_stop = time.time()
    print 'slow: %.2f sec' % (slow_stop - start)
    s2 = fast_encode(input)
    print 'fast: %.2f sec' % (time.time() - slow_stop)
```

slow: 9.15 sec = 1.00x
fast: 3.16 sec = 1.00x

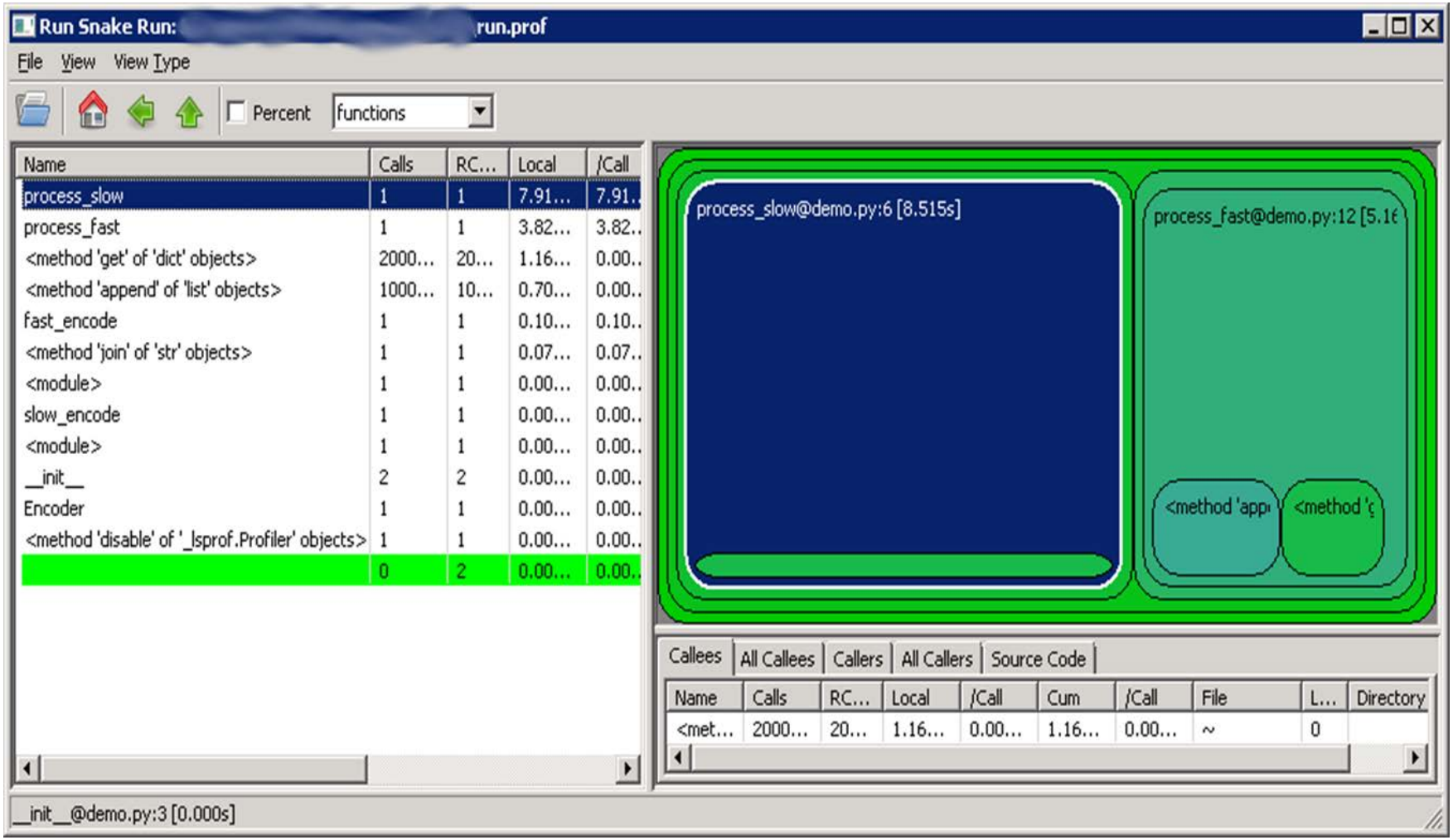
No profiling overhead - a baseline for tools' overhead comparison

cProfile + pstats UI example

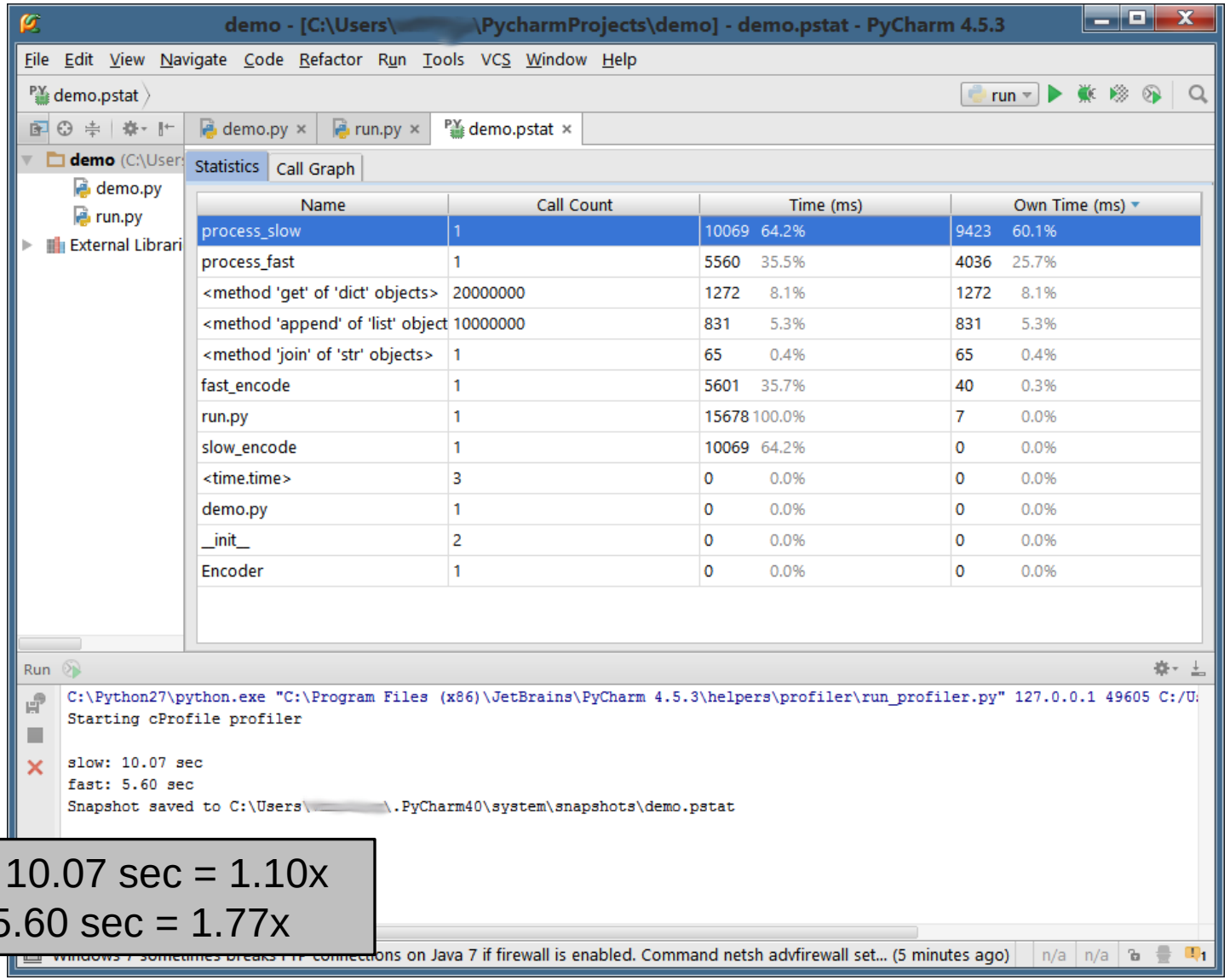
```
> python -m cProfile -o run.prof run.py
> python -m pstats run.prof

run.prof% sort time
run.prof% stats
Tue Jun 30 18:43:53 2015    run.prof

         30000014 function calls in 15.617 seconds

   Ordered by: internal time

   ncalls  tottime  percall  cumtime  percall filename:lineno(function)
        1    9.597    9.597   10.268   10.268 demo.py:6(process_slow)
        1    3.850    3.850    5.302    5.302 demo.py:12(process_fast)
 20000000    1.267    0.000    1.267    0.000 {method 'get' of 'dict' objects}
 10000000    0.790    0.000    0.790    0.000 {method 'append' of 'list' objects}
        1    0.066    0.066    0.066    0.066 {method 'join' of 'str' objects}
        1    0.038    0.038    5.340    5.340 run.py:7(fast_encode)
        1    0.009    0.009   15.617   15.617 run.py:1(<module>)
        1    0.000    0.000   10.268   10.268 run.py:4(slow_encode)
```

slow: 10.27 sec = 1.12x
fast: 5.34 sec = 1.69x

cProfile + RunSnakeRun



cProfile in PyCharm



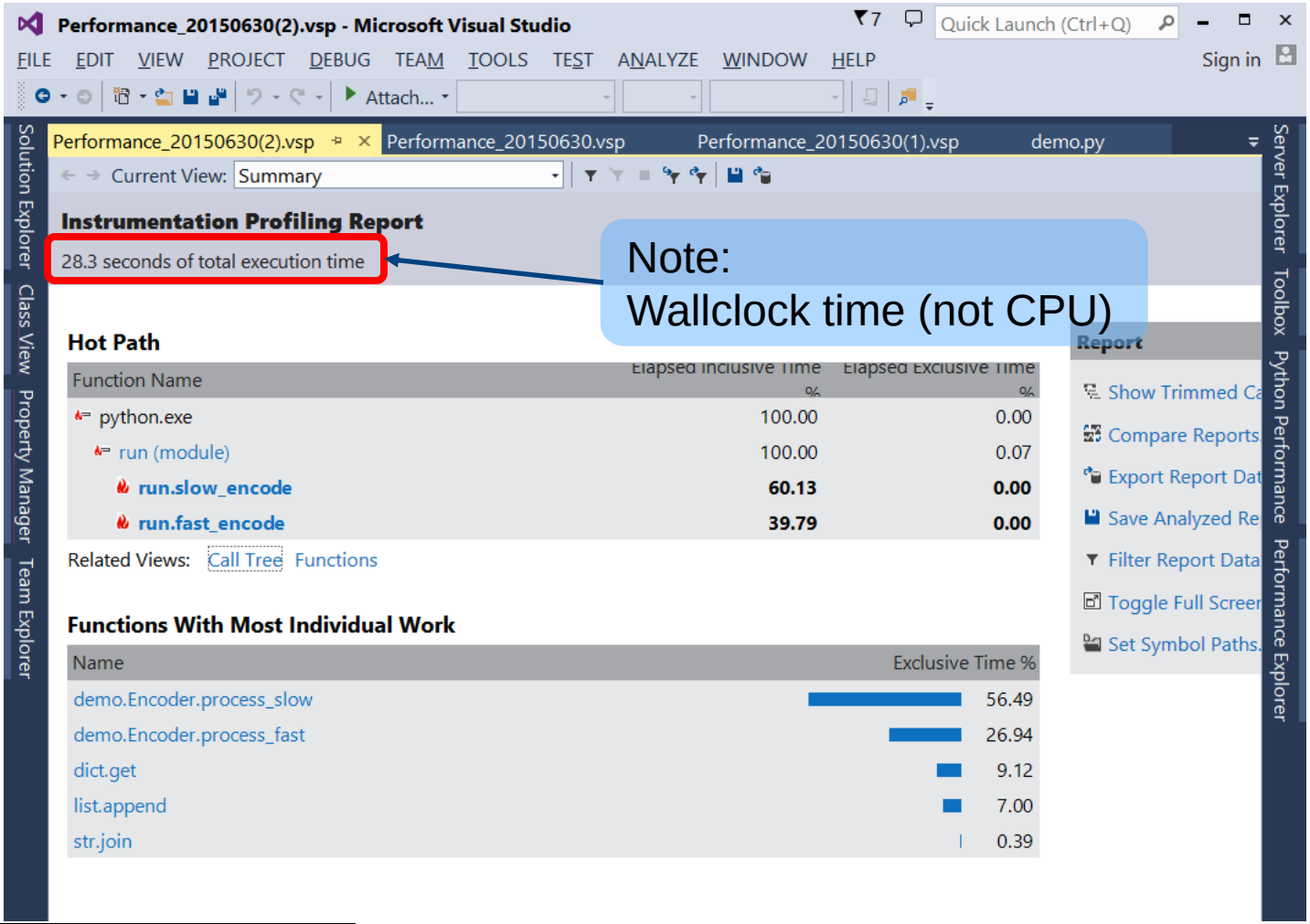
slow: 10.07 sec = 1.10x
fast: 5.60 sec = 1.77x

line_profiler results

```
Total time: 18.095 s
File: demo_lp.py
Function: process_slow at line 6
Line #      Hits     Time  Per Hit   % Time  Line Contents
==============================================================
     6                                           @profile
     7                                           def process_slow(self):
     8         1       14     14.0      0.0      result = ''
     9  10000001 10260548      1.0     23.3      for ch in self.input:
    10  10000000 33814644      3.4     76.7          result += self.CHAR_MAP.get(...
    11         1        4      4.0      0.0      return result

Total time: 16.8512 s
File: demo_lp.py
Function: process_fast at line 13
Line #      Hits     Time  Per Hit   % Time  Line Contents
==============================================================
    13                                           @profile
    14                                           def process_fast(self):
    15         1        7      7.0      0.0      result = []
    16  10000001 13684785      1.4     33.3      for ch in self.input:
    17  10000000 27048146      2.7     65.9          result.append(self.CHAR_MAP.get(...
    18         1   312611 312611.0      0.8      return ''.join(result)
```

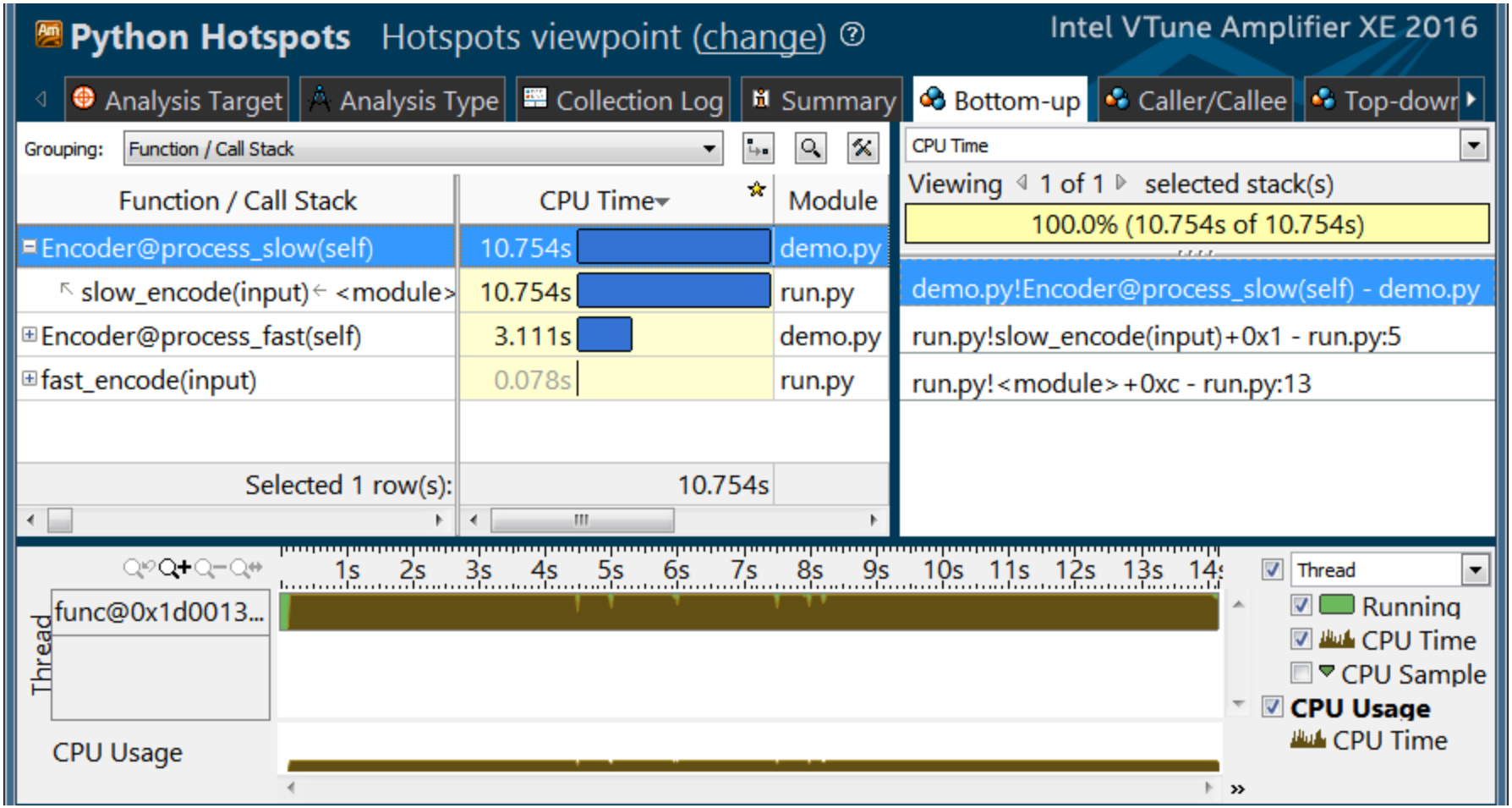
slow: 24.32 sec = 2.66x
fast: 25.37 sec = 8.03x

Python Tools GUI example



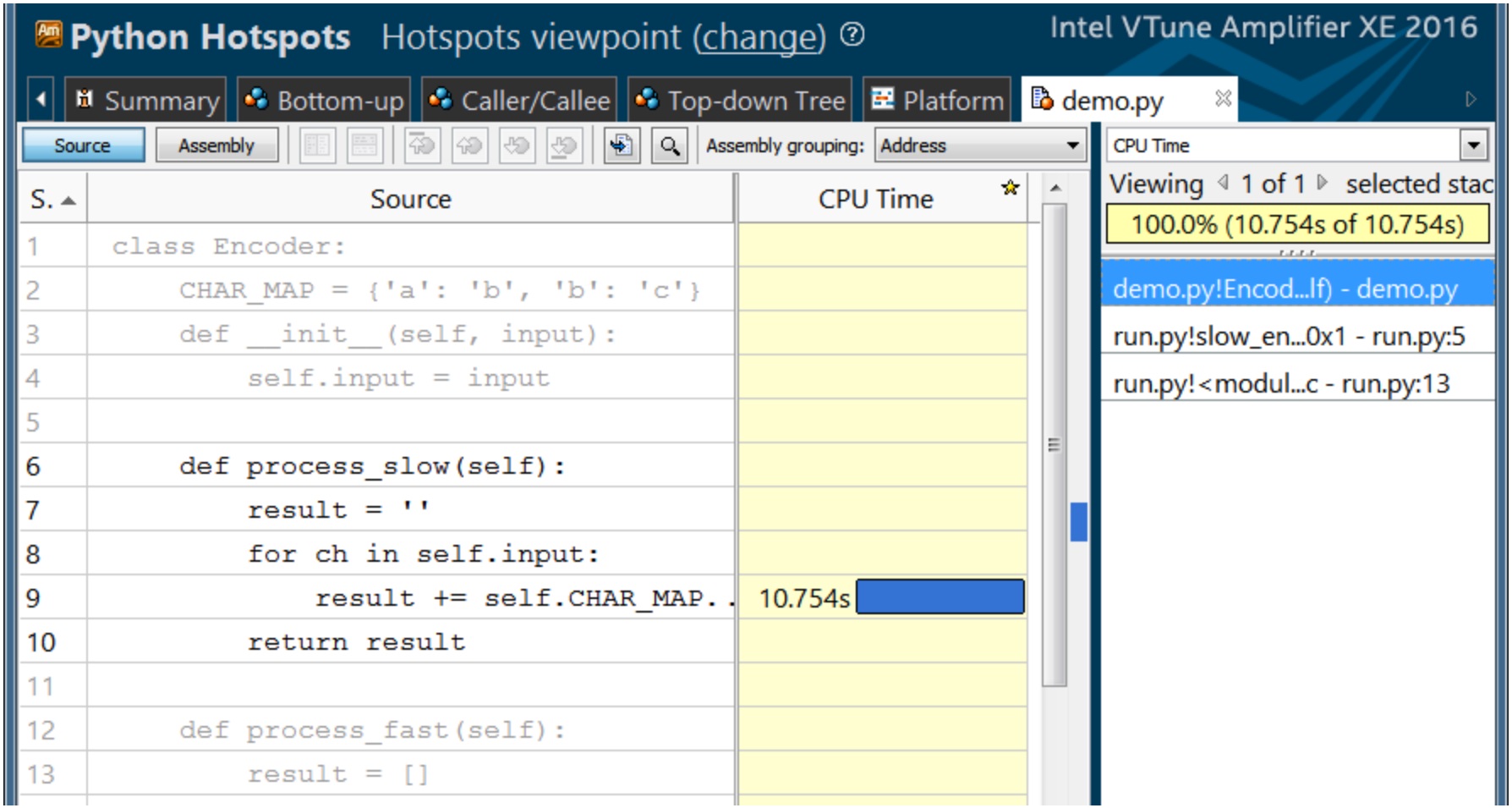
slow: 17.40 sec = 1.90x
fast: 12.08 sec = 3.82x

Intel® VTune Amplifier example



slow: 10.85 sec = 1.19x
fast: 3.30 sec = 1.05x

Intel® VTune Amplifier – source view



Intel® VTune Amplifier: Accurate & Easy

Line-level profiling details:

- Uses sampling profiling technique
- Average overhead ~1.1x-1.6x (on certain benchmarks)

Cross-platform:

- Windows and Linux
- Python 32- and 64-bit; 2.7.x, 3.4.x, 3.5.0 versions

Rich Graphical UI

Supported workflows:

- Start application, wait for it to finish
- Attach to application, profile for a bit, detach

Low Overhead *and* Line-Level Info

Tool	Description	Platforms	Profile level	Avg. overhead
Intel® VTune Amplifier	• Rich GUI viewer	Windows Linux	Line	~1.1-1.6x
cProfile (built-in)	• Text interactive mode: “pstats” (built-in) • GUI viewer: RunSnakeRun (Open Source) • PyCharm	Any	Function	1.3x-5x
Python Tools	• Visual Studio (2010+) • Open Source	Windows	Function	~2x
line_profiler	• Pure Python • Open Source • Text-only viewer	Any	Line	Up to 10x or more

We've Had Success Tuning Our Python Code

- One widely-used web page in our internally set up Buildbot service: 3x speed up (from 90 seconds to 28)
- Report generator – from 350 sec to <2 sec for 1MB log file
  - Distilled version was the base for demo.py
- Internal SCons-based build system: several places sped up 2x or more
  - Loading all configs from scratch tuned from 6 minutes to 3 minutes

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- Technical Preview & Beta Participation – email us at scripting@intel.com
  - We're also working on Intel-accelerated Python (e.g. NumPy/SciPy, etc.), which is currently in Tech Preview. Sign up!
- Check out Intel Developer Zone – software.intel.com
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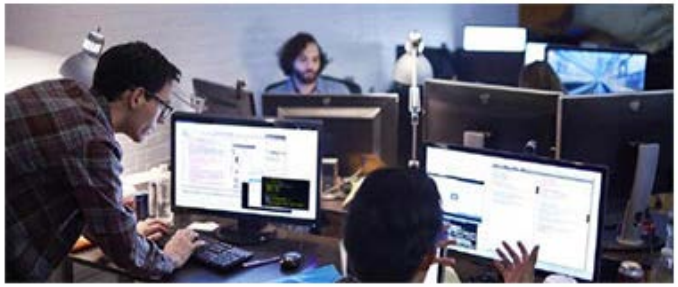

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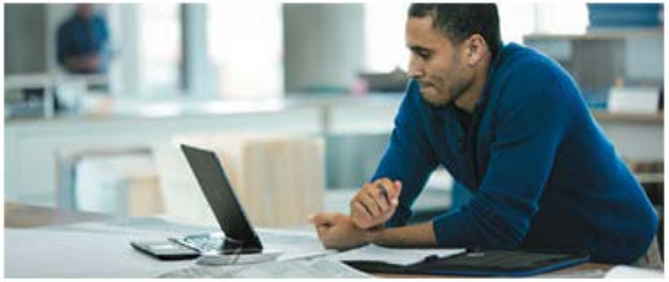

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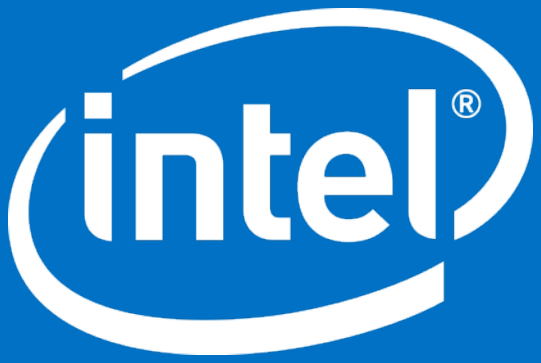
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