The speed of PyPy

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Story about Python's speed

Speed of Python

- Python is slow

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- Is Python really slow?

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Speed of Python

- Is Python really slow?
- Sometimes, for some usecases
- Let’s have a look at some examples

Nomenclature

- Python - a programming language
- CPython - main implementation of Python
- JVM - Java Virtual Machine - VM used to run Java, among others
- JIT - Just in time compiler
- Psyco - JIT for Python

Example run

- Float example, stolen from factor blog

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- Same example, using numpy and vectorization about 3x faster than JVM

Python’s speed

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- Better: “Why is Python hard to optimize?”

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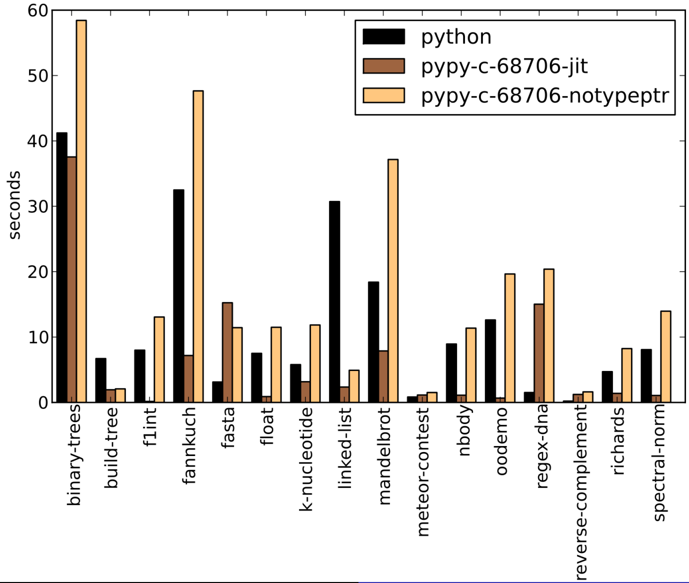
- Instead of: “Why is Python slow?”
- Better: “Why is Python hard to optimize?”
- Even better: “How are we going to fix it?”

Some evidence



Why is Python hard to optimize?

- Duck typing (dynamic dispatch)
- Frames
- Object encapsulation
- Dictionaries of instances
- Changing globals
- Ability to dynamically change builtins

Duck typing

- Dispatching over item type
- `z = x + y`
- Needs to check what the type of `x` and `y` is

Frames

- Python interpreters use frames on heap (instead of stack)
- Locals are stored on those frames
- Intermediate results are store on valuestack of frames
- In fact, you can access frames via `sys._getframe()` `or` `traceback`

Object encapsulation

- Also called boxing
- Each object, even `int`, has to be boxed
- Requires allocations and indirection

Example - addition

- `z = x + y`
- read value for `x` from frame, store on valuestack
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- allocate new integer
- read two values from valuestack, add and store the result in freshly allocated integer
- move the result from valuestack to locals

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- in fact, should be one assembler instruction

Dictionaries of instances

- Need to perform a dictionary lookup for `x.y`
- There are **three** lookups per method call (descriptor, object, type)
- **Two** for attribute access (descriptor, object)
- Looks like list lookup should be enough

Changing globals

- Global symbols can change at any moment in time
- Makes for example inlining hard
- Requires global dict lookups, even for constants

Ability to dynamically change builtins

- You can say `int = my_function`
- But you can't `int.__add__ = my_method`
- Still messes up optimizations
- Global lookup is also a dictionary lookup, even if globals don't change

Interpreting vs compiling

- Apparently, processors are good at branch prediction
- We didn't measure much of a difference, less than 2x overall

CPython specific problems

- In general, CPython is fairly well optimized
- refcounting is an inefficient garbage collection scheme
- GIL

Dynamic compilation to the rescue

- You don’t pay for feature, until you actually use it
- In static compilation, compiler has to prove that bad things can’t happen
- Impossible in Python
- With dynamic compilation, you just throw away compiled code in case things go wrong or start over

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- Be able to reconstruct frame on demand (for example `sys._getframe() was called`)
- The effect is that you don't pay for frames, unless you really use them

Dealing with dynamic dispatch

- The answer is to simply specialize over types
- Provides possibly multiple versions of compiled code for single Python code

Dealing with object encapsulation

- “Virtual objects”
- Also known as escape analysis
- If object does not “escape”, don’t allocate it at all

How does it work in practice?

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- XXXX speedup over CPython

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- Fairly complex task
- Sharing dict, more or less the same effect as V8's hidden classes
- Python is a very complex language
- Shadowing methods with attributes
- Descriptors before attributes

Other important optimizations

- Caching globals
- Caching builtins
- A lot of smaller ones

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- But personally, I hope to change it in next months
- ... in places where performance matters, but that don't depend on third party C modules (like numpy)
- ... like building and developing PyPy

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- or bugs

Examples of working programs

- Django (sqlite only)
- Twisted
- PyPy's translation toolchain
- ctypes

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- yet!

Adapt today!

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- Examples:

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  - Exact naming of list comprehension variable
  - Immediate finalization

Profit tomorrow!

- We plan to release JIT-ready version somewhere early 2010 xxx

How you can help

- It's all open source after all ...
- Try running existing programs
- Profile, report bugs

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- Talk to your boss (XXX)

Thank you!

- This talk is already online (with all examples): `http://codespeak.net/svn/pypy/dist/extradoc/talk`
- `http://morepypy.blogspot.com`
- #pypy on freenode
- If you want to know more about PyPy, feel free to bug me around (like, how does the JIT work?)
- Any questions?