Software Transactional Memory with PyPy

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- PyCon ZA 2013

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- sponsored by crowdfunding (thanks!)

Introduction

- what is PyPy: an alternative implementation of Python

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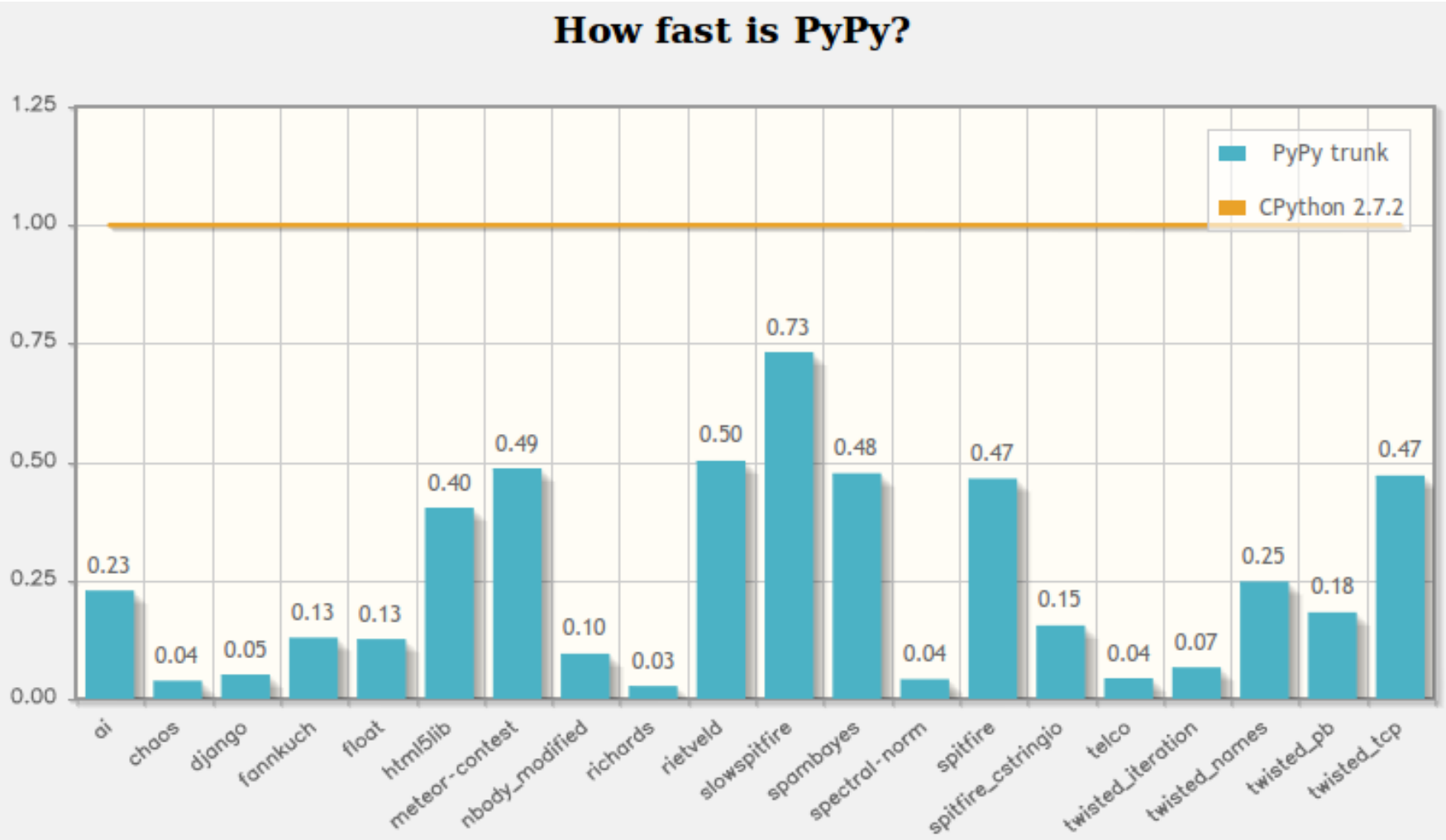
- main focus is on speed

Introduction



Plot 1: The above plot represents PyPy trunk (with JIT) benchmark times normalized to CPython. Smaller is better.

It depends greatly on the type of task being performed. The geometric average of all benchmarks is 0.16 or **6.3** times *faster* than CPython

SQL by example

```
BEGIN TRANSACTION;
SELECT * FROM ...;
UPDATE ...;
COMMIT;
```

Python by example

```
...
x = obj.value
obj.value = x + 1
...
```

Python by example

```
begin_transaction()
x = obj.value
obj.value = x + 1
commit_transaction()
```

Python by example

```
the_lock.acquire()
x = obj.value
obj.value = x + 1
the_lock.release()
```

Python by example

```
with the_lock:
    x = obj.value
    obj.value = x + 1
```

Python by example

```
with atomic:
    x = obj.value
    obj.value = x + 1
```

Locks != Transactions

```
BEGIN TRANSACTION;
SELECT * FROM ...;
UPDATE ...;
COMMIT;
```

```
BEGIN TRANSACTION;
SELECT * FROM ...;
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```
BEGI
SELE
UPDA
COMM
```

Locks != Transactions

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```
with
  x
  ob
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Locks != Transactions

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with atomic:
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```
with
  x
  ob
```

STM

- Transactional Memory

STM

- Transactional Memory
- advanced but not magic (same as databases)

STM versus HTM

- Software versus Hardware

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- CPU hardware specially to avoid the high overhead

STM versus HTM

- Software versus Hardware
- CPU hardware specially to avoid the high overhead
- too limited for now

Example 1

```
def apply_interest_rate(self):
    self.balance *= 1.05

for account in all_accounts:
    account.apply_interest_rate()
```

Example 1

```
def apply_interest_rate(self):
    self.balance *= 1.05

for account in all_accounts:
    add_task(account.apply_interest_rate)
run_tasks()
```

Internally

- *run_all_tasks()* manages a pool of threads

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- each thread runs tasks in a *with atomic*

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- *run_all_tasks()* manages a pool of threads
- each thread runs tasks in a *with atomic*
- uses threads, but internally only

Example 2

```
def next_iteration(all_trains):
    for train in all_trains:
        start_time = ...
        for othertrain in train.dependencies:
            if ...:
                start_time = ...
        train.start_time = start_time
```

Example 2

```
def compute_time(train):
    ...
    train.start_time = ...

def next_iteration(all_trains):
    for train in all_trains:
        add_task(compute_time, train)
    run_all_tasks()
```

Conflicts

- like database transactions

Conflicts

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- but with *objects* instead of *records*

Conflicts

- like database transactions
- but with *objects* instead of *records*
- the transaction aborts and automatically retries

Inevitable

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- handles I/O in a *with atomic*

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- means "unavoidable"
- handles I/O in a *with atomic*
- cannot abort the transaction any more

By the way

- STM replaces the GIL

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- any existing multithreaded program runs on multiple cores

Current status

- basics work, JIT compiler integration almost done

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- different executable called *pypy-stm*
- slow-down: around 3x (in bad cases up to 10x)
- speed-ups measured with 4 cores
- Linux 64-bit only

User feedback

- implemented:

```
Detected conflict:
  File "foo.py", line 17, in walk
    if node.left not in seen:
Transaction aborted, 0.000047 seconds lost
```

User feedback

- not implemented yet:

```
Forced inevitable:
  File "foo.py", line 19, in walk
    print >> log, logentry
Transaction blocked others for 0.xx seconds
```

Async libraries

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Async libraries

- future work
- tweak a Twisted reactor: run multithreaded, but use *with atomic*
- existing Twisted apps still work, but we need to look at conflicts/inevitables
- similar with Tornado, gevent, and so on

Async libraries

```
while True:
    events = epoll.poll()
    for event in events:
        queue.put(event)
```

And in several threads:

```
while True:
    event = queue.get()
    with atomic:
        handle(event)
```

More future work

- look at many more examples

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- tweak data structures to avoid conflicts

More future work

- look at many more examples
- tweak data structures to avoid conflicts
- reduce slow-down, port to other OS'es

Under the cover

- 10’000-feet overview

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- every object can have multiple versions

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- synchronization only when a thread "steals" another thread’s most recent version, to make it shared

Under the cover

- 10’000-feet overview
- every object can have multiple versions
- the shared versions are immutable
- the most recent version can belong to one thread
- synchronization only when a thread "steals" another thread’s most recent version, to make it shared
- integrated with a generational garbage collector, with one nursery per thread

Summary

- transactions in Python

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- a big change under the cover

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- a small change for Python users

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- *Q & A*