Asynchronous Network Requests in Web Applications

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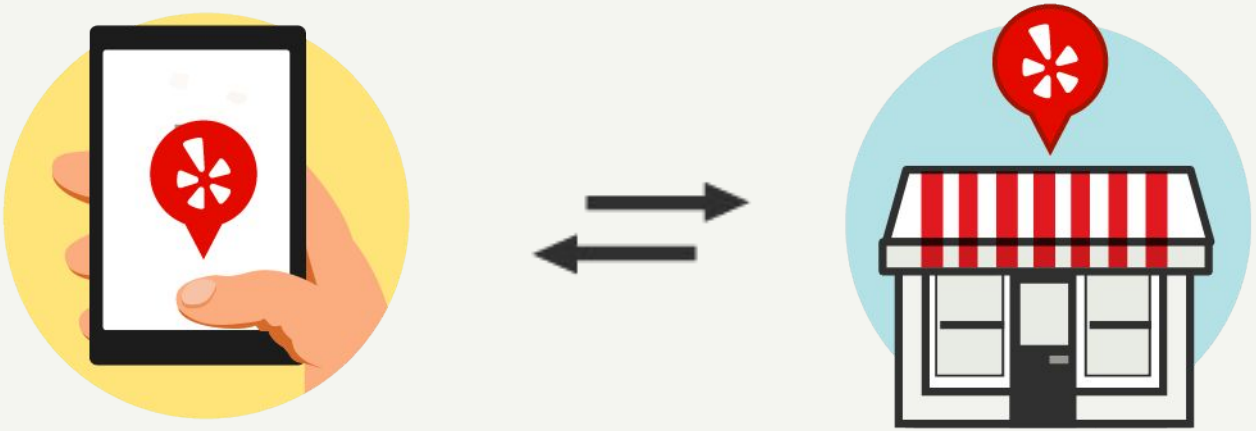
Yelp's Mission

Connecting people with great local businesses.



Yelp Stats

As of Q1 2016

90M

102M

70%

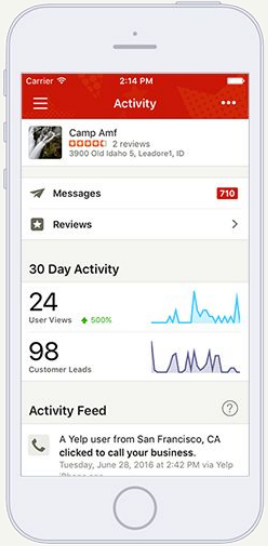
32

What is this talk about?

- Why would you want to do that?
- Why can it be complicated?
- What’s a deployment server (uWSGI)
- How To: Code Examples and ideas

What is the problem we are trying to solve?

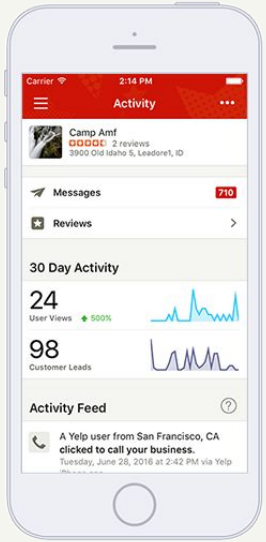
High level view

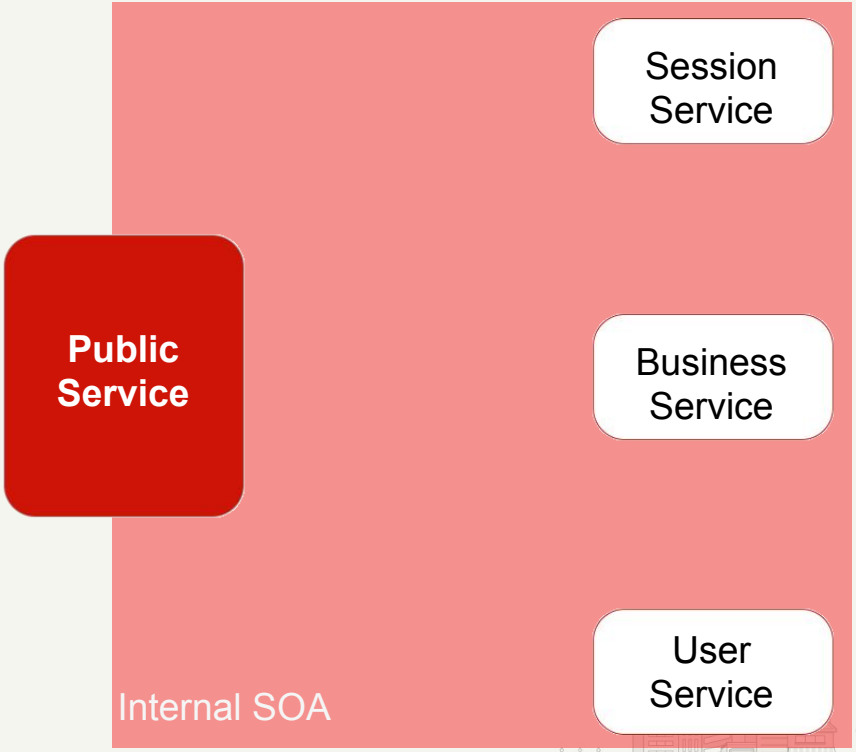


Public Service

What is the problem we are trying to solve?

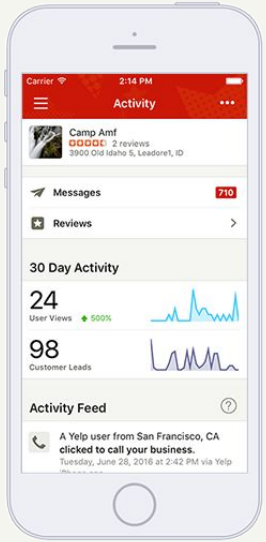
With a SOA

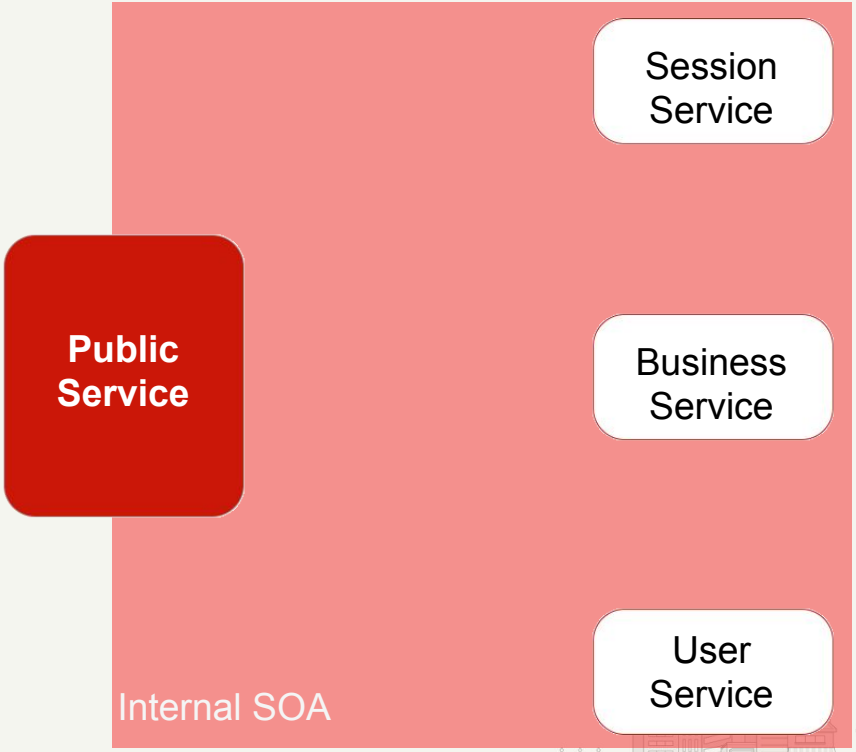




What is the problem we are trying to solve?

Async !





ThreadPool Executor

concurrent.future

Changed in version 3.5: If *max_workers* is None or not given, **it will default to the number of processors on the machine, multiplied by 5**, assuming that **ThreadPoolExecutor is often used to overlap I/O** instead of CPU work and the number of workers should be higher than the number of workers for ProcessPoolExecutor.

```
import concurrent.futures
import urllib.request

URLS = [...]

def load_url(url, timeout):
    with urllib.request.urlopen(url, timeout=timeout) as conn:
        return conn.read()

with concurrent.futures.ThreadPoolExecutor(max_workers=5) as executor:
    future_to_url = {executor.submit(load_url, url, 60): url for url in URLS}
    for future in concurrent.futures.as_completed(future_to_url):
        url = future_to_url[future]
        data = future.result()
```

https://docs.python.org/dev/library/concurrent.futures.html

Deployment

How do I do that efficiently now?

Running a ...

Tornado/Twisted/... app ?

WSGI app ? (django, pyramid, flask ...)

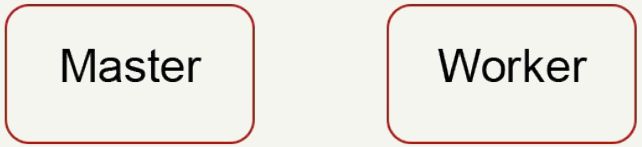
WSGI Deployment: uwsgi

Why uwsgi ?

- Widely used and well tested
- Very configurable: almost every combinations is possible (threads, process, events loop, greenlets, ...)
- Pre-forked (fork abusing) model

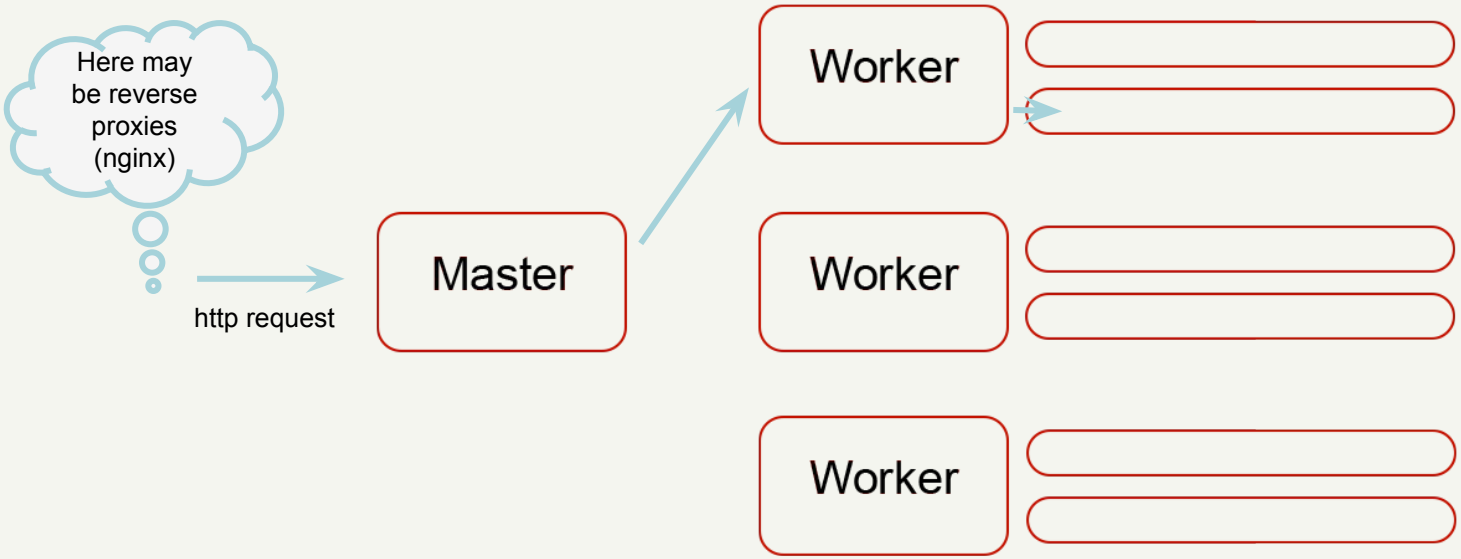
Deployment Server/Gateway

The pre-forked model



Deployment Server/Gateway

Serving requests to your app



Simple Synchronous App

```
import time
import requests


def application(env, start_response):
    start_response("200 OK", [("Content-Type","text/html")])
    start_time = time.time()
    calls = [long_network_call(i/8) for i in range(1,5)]
    end_time = time.time()

    return [
        b"This call lasted %0.3f seconds with synchronous calls.\n"
        % (end_time - start_time)
    ]

def long_network_call(duration):
    requests.get('http://localhost:7001/?duration={}'.format(duration))
```

Simple Synchronous App

configs

```
# uwsgi_basic.ini
[uwsgi]
http = :5000
wsgi-file=app_sync.py
master = 1
```

```
# uwsgi_process.ini
[uwsgi]
http = :5001
wsgi-file=app_sync.py
master = 1
processes = 4
```

```
# uwsgi_thread.ini
[uwsgi]
http = :5002
wsgi-file=app_sync.py
master = 1
threads = 4
```

```
# uwsgi_mix.ini
[uwsgi]
http = :5003
wsgi-file=app_sync.py
master = 1
processes = 2
threads = 2
```

Simple Synchronous App

Results!

```
curl localhost:5000
  This call lasted 1.282 seconds with synchronous calls.

# uwsgi_basic (1 process)
python3 hammer.py --port 5000 --nb_requests 20
  We did 20 requests in 25.425450086593628

# uwsgi_process (4 processes)
python3 hammer.py --port 5001 --nb_requests 20
  We did 20 requests in 6.418

# uwsgi_thread (4 threads)
python3 hammer.py --port 5002 --nb_requests 20
  We did 20 requests in 6.479

# uwsgi_mix (2 process with 2 threads each)
python3 hammer.py --port 5003 --nb_requests 20
  We did 20 requests in 6.415
```

Simple Asynchronous App

```python
import asyncio
# ...
from aiohttp import ClientSession

def application(env, start_response):
    # ...
    loop = asyncio.get_event_loop()
    futures = [
        asyncio.ensure_future(long_network_call(i/8))
        for i in range(1,5)
    ]
    loop.run_until_complete(asyncio.wait(futures))
    # ...

async def long_network_call(duration):
    async with ClientSession() as session:
        async with session.get('http://localhost:7001/?duration={}'.format(duration)) as response:
            return await response.read()
```

```
# uwsgi.ini

[uwsgi]
http = :5100
wsgi-file=app_asyncio.py
master = 1
processes = 2
```

Simple Asynchronous App

Event loop

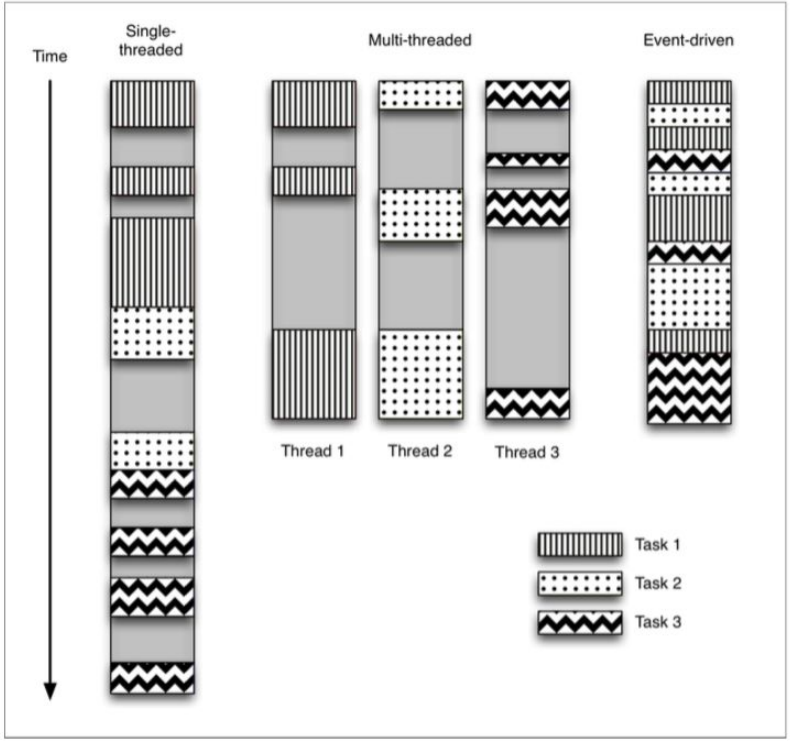


Figure 2-1. Comparing single-threaded, multithreaded, and event-driven program flow

Twisted Network Programming Essentials - 2nd edition - Jessica McKellar and Abe Fettig - O'Reilly 2013

Simple Asynchronous App

Performance and Cavehats

```
curl localhost:5100
  This lasted 0.518 seconds with async calls using asyncio

python3 hammer.py --port 5100 --nb_requests 20
  We did 20 requests in 5.010
```

Simple Asynchronous App

Performance and Cavehats

```
[pid: 16833|app: 0|req: 2/1] 127.0.0.1 () {32 vars in 369 bytes} [Mon Jul 11 14:14:01 2016] GET / => generated 0 bytes in 128 ms
ecs (HTTP/1.1 200) 1 headers in 44 bytes (0 switches on core 1)
Traceback (most recent call last):
  File "app_asyncio.py", line 13, in application
    loop = asyncio.get_event_loop()
  File "/usr/lib/python3.5/asyncio/events.py", line 626, in get_event_loop
    return get_event_loop_policy().get_event_loop()
  File "/usr/lib/python3.5/asyncio/events.py", line 572, in get_event_loop
    % threading.current_thread().name)
RuntimeError: There is no current event loop in thread "b'uWSGIWorker1Core1'".
[pid: 16833|app: 0|req: 3/2] 127.0.0.1 () {32 vars in 369 bytes} [Mon Jul 11 14:14:01 2016] GET / => generated 0 bytes in 1 msec
s (HTTP/1.1 200) 1 headers in 44 bytes (0 switches on core 1)
pid: 16834 : thread_id: b'uWSGIWorker2Core0' : start network call with duration 0.5
  File "app_asyncio.py", line 13, in application
    loop = asyncio.get_event_loop()
  File "/usr/lib/python3.5/asyncio/events.py", line 626, in get_event_loop
    return get_event_loop_policy().get_event_loop()
  File "/usr/lib/python3.5/asyncio/events.py", line 572, in get_event_loop
    % threading.current_thread().name)
RuntimeError: There is no current event loop in thread "b'uWSGIWorker2Core1'".
```

Running with --threads 2

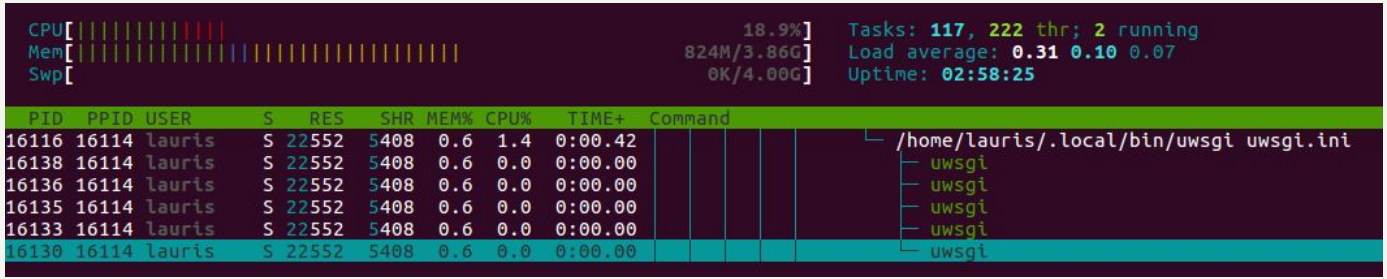
Making uwsgi threads option work requires changing the get_loop()

```
def get_loop():
    try:
        loop = asyncio.get_event_loop()
    except RuntimeError as e:
        loop = asyncio.new_event_loop()
        asyncio.set_event_loop(loop)
    finally:
        return loop
```

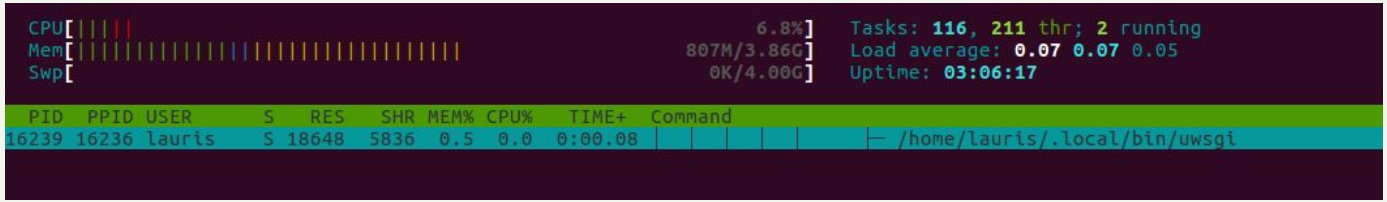
Simple Asynchronous App

Performance and Cavehats

aiohttp spawns extra threads for dns resolution (which is kind of what we don’t want)



app_asyncio worker htop



app_sync worker htop for comparison

Gevent App

```python
import time
from functools import partial

import gevent
import requests
from gevent import monkey

# Monkey-patch.
monkey.patch_all(thread=False, select=False)

def application(env, start_response):
    # ...
    jobs = [
        gevent.spawn(partial(long_network_call, i/8))
        for i in range(1,5)
    ]
    gevent.joinall(jobs)
    # ...

def long_network_call(duration):
    requests.get('http://localhost:7001/?duration={}'.format(duration))
```

```
# uwsgi.ini

[uwsgi]
http = :5200
gevent = 50
wsgi-file = app_gevent.py
master = 1
processes = 2
```

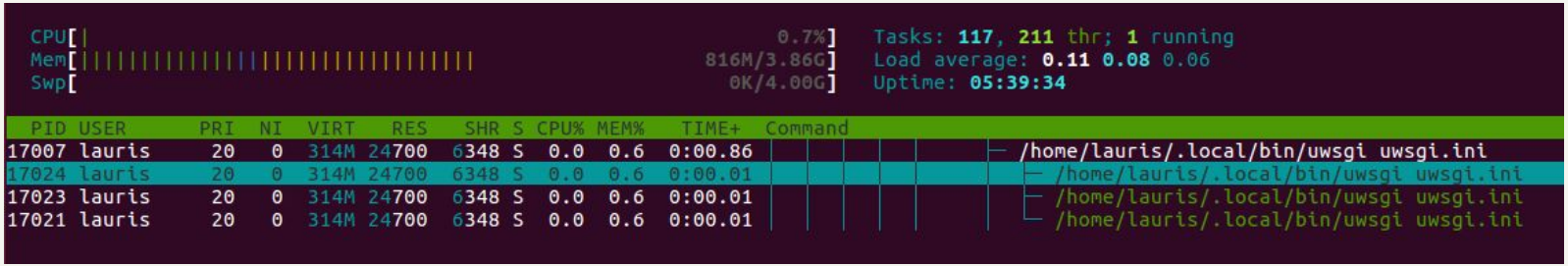
Gevent App

Perf

```
curl localhost:5200
  This lasted 0.539 seconds with async calls using gevent

python3 hammer.py --port 5200 --nb_requests 50
  We did 100 requests in 1.255

python3 hammer.py --port 5200 --nb_requests 100
  We did 100 requests in 1.373

python3 hammer.py --port 5200 --nb_requests 200
  We did 200 requests in 2.546
```

Gevent

DNS resolution ... again



app_gevent worker htop: we can see 4 threads, when we expect 1

```
futex(0x7fbeb5e00764, FUTEX_WAIT_BITSET_PRIVATE|FUTEX_CLOCK_REALTIME, 1419, {1468241261, 677450000}, ffffffff) = 0
futex(0x7fbeb5e007e0, FUTEX_WAIT_PRIVATE, 2, NULL) = 0
futex(0x7fbeb5e007e0, FUTEX_WAKE_PRIVATE, 1) = 0
stat("/etc/resolv.conf", {st_mode=S_IFREG|0644, st_size=197, ...}) = 0
open("/etc/hosts", O_RDONLY|O_CLOEXEC)  = 66
fstat(66, {st_mode=S_IFREG|0644, st_size=232, ...}) = 0
read(66, "127.0.0.1\tlocalhost\n127.0.1.1\tla"..., 4096) = 232
read(66, "", 4096)                      = 0
close(66)                               = 0
futex(0x7fbea0001190, FUTEX_WAIT_BITSET_PRIVATE|FUTEX_CLOCK_REALTIME, 0, NULL, ffffffff) = 0
futex(0x7fbeb5e00764, FUTEX_WAIT_BITSET_PRIVATE|FUTEX_CLOCK_REALTIME, 1425, {1468241261, 691793000}, ffffffff) = 0
futex(0x7fbeb5e007e0, FUTEX_WAIT_PRIVATE, 2, NULL) = 0
futex(0x7fbeb5e007e0, FUTEX_WAKE_PRIVATE, 1) = 0
stat("/etc/resolv.conf", {st_mode=S_IFREG|0644, st_size=197, ...}) = 0
open("/etc/hosts", O_RDONLY|O_CLOEXEC)  = 66
fstat(66, {st_mode=S_IFREG|0644, st_size=232, ...}) = 0
read(66, "127.0.0.1\tlocalhost\n127.0.1.1\tla"..., 4096) = 232
read(66, "", 4096)                      = 0
close(66)                               = 0
```

`strace -p 17024`

This is doing dns resolution!

Offloading in a separate loop thread

```
import atexit
import functools
from concurrent.futures import Future

from tornado.httpclient import AsyncHTTPClient
from tornado.ioloop import IOLoop

_loop = IOLoop()

def _event_loop():
    _loop.make_current()
    _loop.start()

def setup():
    t = threading.Thread(
        target=_event_loop,
        name="TornadoReactor",
    )
    t.start()
    def clean_up():
        _loop.stop()
        _loop.close()
    atexit.register(clean_up)
setup()
```

```
def long_network_call(duration):
    http_client = AsyncHTTPClient(_loop)

    # this uses the threadsafe loop.add_callback internally
    fetch_future = http_client.fetch(
        'http://localhost:7001/?duration={}'.format(duration)
    )

    result_future = Future()
    def callback(f):
        try:
            result_future.set_result(f.result())
        except BaseException as e:
            result_future.set_exception(e)

    fetch_future.add_done_callback(callback)

    return result_future
```

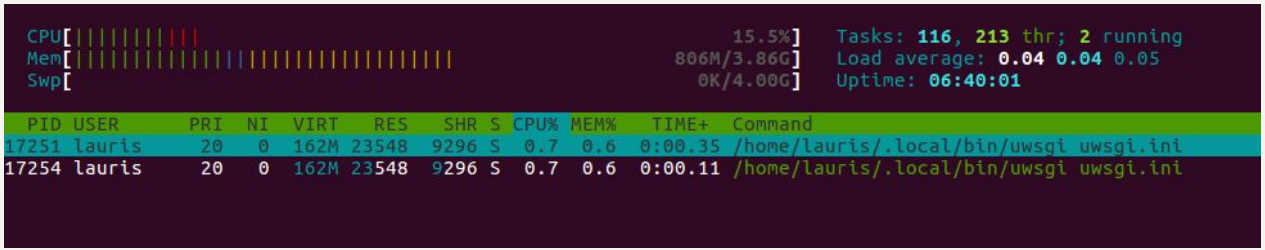
Offloading in a separate loop thread

```
def application(env, start_response):
    start_response("200 OK", [("Content-Type","text/html")])
    start_time = time.time()

    futures = [
        long_network_call(i/8) for i in range(1,5)
    ]
    # Let's do something heavy like ... waiting
    time.sleep(1)

    for future in futures:
        future.result()

    end_time = time.time()

    return [
        b"This call lasted %0.3f seconds with offloaded asynchronous calls.\n" % (end_time - start_time)
    ]
```

```
# uwsgi.ini

[uwsgi]
http = :5300
wsgi-file = app_tornado.py
master = 1
processes = 2
lazy-apps = 1
```

Offloading in a separate loop thread

```
curl localhost:5300
  This lasted 1.003 seconds with offloaded asynchronous calls.

python3 hammer.py --port 5300 --nb_requests 20
  We did 20 requests in 10.097
```



Offloading Event Loop Ready Made: Crochet

https://github.com/itamarst/crochet

- Uses twisted event loop
- Actually allows to run much more in the reactor than just network requests

- If you are after just the networking : **Fido**! https://github.com/Yelp/fido

Final notes

Use what fit your needs, or what needs to fit

- Tradeoff between speed and concurrency
- Beware of DNS resolutions

All code used for this presentation is available https://github.com/laucia/europython_2016/
You should probably not use it in production

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QUESTIONS?