Web Server from Scratch

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Why

Understand
foundation

questionmark guy: http://s3.amazonaws.com/rapgenius/1365193232_Guy-with-Question-Mark-over-his-headFotolia_102829_XS.jpeg

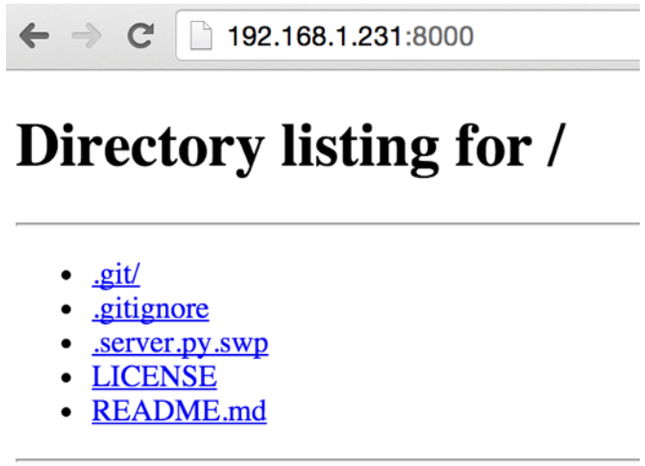
Implementation

- Python modules
  - socket
  - socketserver
  - http.server

Sidenote: http.server

python2 -m BaseHTTPServer

python3 -m http.server



Basic server using socket

socket - Echo Server

```python
import socket

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as sock:
    sock.bind(('0.0.0.0', 8000))
    sock.listen()
    conn, addr = sock.accept()
    print('connected by', addr)
    while True:
        data = conn.recv(1024)
        if not data: break
        conn.sendall(data)
    conn.close()
```

https://docs.python.org/3/library/socket.html#example

socket - Echo Server

```
> python3 server.py
connected by ('127.0.0.1', 46784)
```

```
> telnet localhost 8000
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
server will echo everything I enter
server will echo everything I enter
hurray
hurray
^]

telnet> Connection closed.
```

- Won’t accept any connections other than the first

socket - Multi-connection Echo Server

```python
import socket

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as sock:
    sock.bind(('0.0.0.0', 8000))
    sock.listen()
    while True:
        conn, addr = sock.accept()
        print('connected by', addr)
        while True:
            data = conn.recv(1024)
            if not data: break
            conn.sendall(data)
        conn.close()
```

https://docs.python.org/3/library/socket.html#example

Let’s make it speak

snakeimg: http://labs.codernity.com/codernitydb-http/_images/CodernityDB_HTTP.png

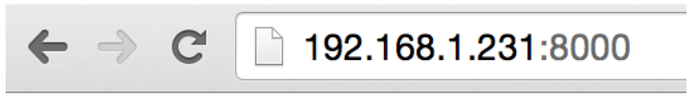
HTTP

```
› telnet google.com 80
Trying 216.58.217.46...
Connected to google.com.
Escape character is '^]'.
HEAD / HTTP/1.1

HTTP/1.1 200 OK
Date: Tue, 22 Sep 2015 04:40:43 GMT
Expires: -1
Cache-Control: private, max-age=0
Content-Type: text/html; charset=ISO-8859-1
P3P: CP="This is not a P3P policy! See http://www.google.com/support/
accounts/bin/answer.py?hl=en&answer=151657 for more info."
Server: gws
X-XSS-Protection: 1; mode=block
X-Frame-Options: SAMEORIGIN
Set-Cookie:
PREF=ID=1111111111111111:FF=0:TM=1442896843:LM=1442896843:V=1:S=GBKCIpFhpuQ
xr2L6; expires=Thu, 31-Dec-2015 16:02:17 GMT; path=/; domain=.google.com
Set-Cookie:
NID=71=jj3ch6SpQ_DNSDs5iTfTv_OAsGYZIq2faSMMbk0_KEC9ulJCtXLmwYXs4aOnvMHuXCd1
y--grI_af0Ied9n-QMG2DtAEshxHqitm2VFR1M-
fAQ49mJYanihx2ROtZxwZP8DUFCLUvNzhPSO7jqnaRxqjfshgiptB; expires=Wed, 23-
Mar-20y
Transfer-Encoding: chunked
Accept-Ranges: none
Vary: Accept-Encoding
```

socket - HTTP Server

```python
import socket

with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as sock:
    sock.bind(('0.0.0.0', 8000))
    sock.listen()
    while True:
        conn, addr = sock.accept()
        print('connected by', addr)

        data = conn.recv(1024)
        print('received', data)

        response = b'''\
HTTP/1.1 200 OK

Hello World!
'''
        conn.sendall(response)
        conn.close()
```

socket - HTTP Server



Hello World!

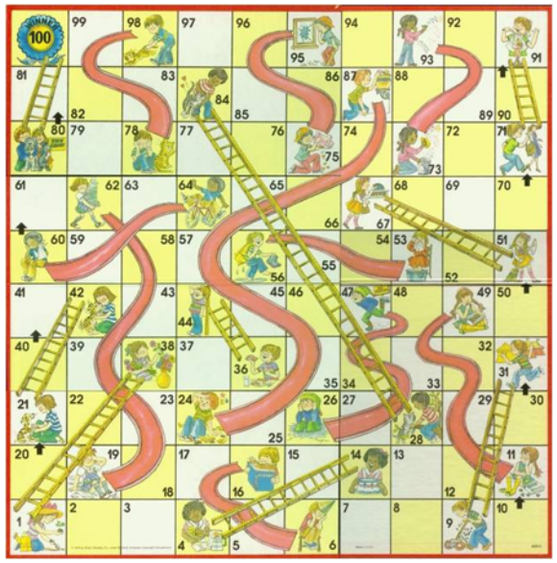
```
› python3 server.py
connected by ('192.168.1.114', 53276)
received b'GET / HTTP/1.1\r\nHost:
192.168.1.231:8000\r\nConnection: keep-alive\r
\nAccept: text/html,application/xhtml
+xml,application/xml;q=0.9,image/webp,*/
*;q=0.8\r\nUpgrade-Insecure-Requests: 1\r
\nUser-Agent: Mozilla/5.0 (Macintosh; Intel Mac
OS X 10_10_4) AppleWebKit/537.36 (KHTML, like
Gecko) Chrome/45.0.2454.93 Safari/537.36\r
\nAccept-Encoding: gzip, deflate, sdch\r
\nAccept-Language: en-US,en;q=0.8\r\n\r\n'
```

Parsing

```python
data = conn.recv(1024)
content = data.decode('utf-8')
lines = content.split('\r\n')
method, path, protocol = lines[0].split()
print('method:', method)
print('path:', path)
print('protocol:', protocol)
headers = lines[1:-1]
print('headers:\n\t' + '\n\t'.join(headers))
```

```
connected by ('192.168.1.114', 64955)
method: GET
path: /
protocol: HTTP/1.1
headers:
        Host: 192.168.1.231:8000
        Connection: keep-alive
        Cache-Control: max-age=0
        Accept: text/html,application/xhtml+xml
        Upgrade-Insecure-Requests: 1
        User-Agent: Mozilla/5.0 (Macintosh; Int
        Accept-Encoding: gzip, deflate, sdch
        Accept-Language: en-US,en;q=0.8
        Cookie: csrftoken=zxsPglk4cMjRPQSMe9x0c
```

Routing and Views

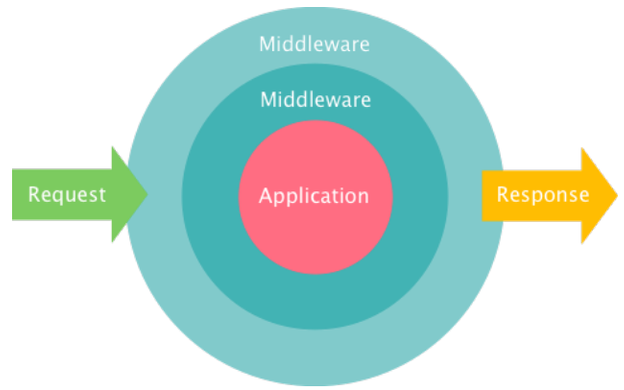


```python
from collections import namedtuple

Request = namedtuple('Request', ['method', 'path', 'headers'])

def hello_view(request):
    return '''HTTP/1.1 200 OK\r\n\r\nHello World!'''

def echo_headers(request):
    lines = ''.join('<p>{}</p>'.format(h) for h in request.headers)
    return '''HTTP/1.1 200 OK\r\n\r\n<html>{}</html>'''.format(lines)

def make_404(request):
    return '''HTTP/1.1 404 Not Found\r\n\r\nResource doesn't exist'''
```

(After parsing code)

```python
request = Request(method, path, headers)
if path == '/':
    response = hello_view(request)
elif path == '/headers':
    response = echo_headers(request)
else:
    response = make_404(request)
response = response.encode('utf-8')

conn.sendall(response)
```

Middleware



```python
cache = {}

def cache_response(request, response):
    cache[request.path] = response
    return response

def return_cached(request):
    return cache.get(request.path)

request_middleware = ['return_cached']
response_middleware = ['cache_response']
```

```python
response = None
request = Request(method, path, headers)
for layer in request_middleware:
    response = locals()[layer](request)
    if response: break

if not response:
    print('performing render')
    if path == '/':
        response = hello_view(request)
    elif path == '/headers':
        response = echo_headers(request)
    else:
        response = make_404(request)
    response = response.encode('utf-8')

for layer in response_middleware:
    response = locals()[layer](request, response)
```

set Content-Length (required for curl to show request body, it seems)
other middleware: sessions, auth, csrf, messages, xframe, security
process_request: if return HttpResponse it’s returned directly

Concurrency

```python
time.sleep(15)
response = '''HTTP/1.1 200 OK\r\n\r\nHello World!'''
response = response.encode('utf-8')
```

Name	Method	Status	Type	Initiator	Size	Time	Timeline – Start Time
192.168.1.231	GET	200	docu...	Other	31 B	15.02 s	

Name	Method	Status	Type	Initiator	Size	Time	Timeline – Start Time
192.168.1.231	GET	200	docu...	Other	31 B	28.70 s	40.00 s

Name	Method	Status	Type	Initiator	Size	Time	Timeline – Start Time
192.168.1.231	GET	200	docu...	Other	31 B	42.45 s	1.0 mi

1. Forking/threading pre-2012 apache
2. Event-driven nginx
3. Coroutines

threading in python OK here b/c not cpu-bound
python threading can't be multicore b/c of GIL
http://learn-gevent-socketio.readthedocs.org/en/latest/general_concepts.html
—-
apache has thread-per-connection and process-per-connection modes (recent improvements in last 3 years move toward event-driven)
nginx usu 1-process-per-core, 1 thread-per-process which event-driven/async handles thousands of connections
https://anturis.com/blog/nginx-vs-apache/
nginx architecture: https://www.nginx.com/blog/inside-nginx-how-we-designed-for-performance-scale/

Forking

```python
def handle_request(client_connection):
    data = conn.recv(1024)
    content = data.decode('utf-8')

    time.sleep(15)
    response = '''HTTP/1.1 200 OK\r\n\r\nHello World!'''
    response = response.encode('utf-8')

    conn.sendall(response)
    conn.close()


with socket.socket(socket.AF_INET, socket.SOCK_STREAM) as sock:
    sock.bind(('0.0.0.0', 8000))
    sock.setsockopt(socket.SOL_SOCKET, socket.SO_REUSEADDR, 1)
    sock.listen()
    while True:
        conn, addr = sock.accept()
        print('connected by', addr)

        pid = os.fork()
        if pid == 0:  # child
            sock.close()  # close child copy
            handle_request(conn)
            conn.close()
            os._exit(0)  # child exits
        else:  # parent
            conn.close()  # close parent copy
```

Name	Method	Status	Type	Initiator	Size	Time	Timeline – Start Time	20.00 s
192.168.1.231	GET	200	docu...	Other	31 B	15.02 s		

Name	Method	Status	Type	Initiator	Size	Time	Timeline – Start Time	20.00 s
192.168.1.231	GET	200	docu...	Other	31 B	15.01 s		

Name	Method	Status	Type	Initiator	Size	Time	Timeline – Start Time	20.00 s
192.168.1.231	GET	200	docu...	Other	31 B	15.03 s		

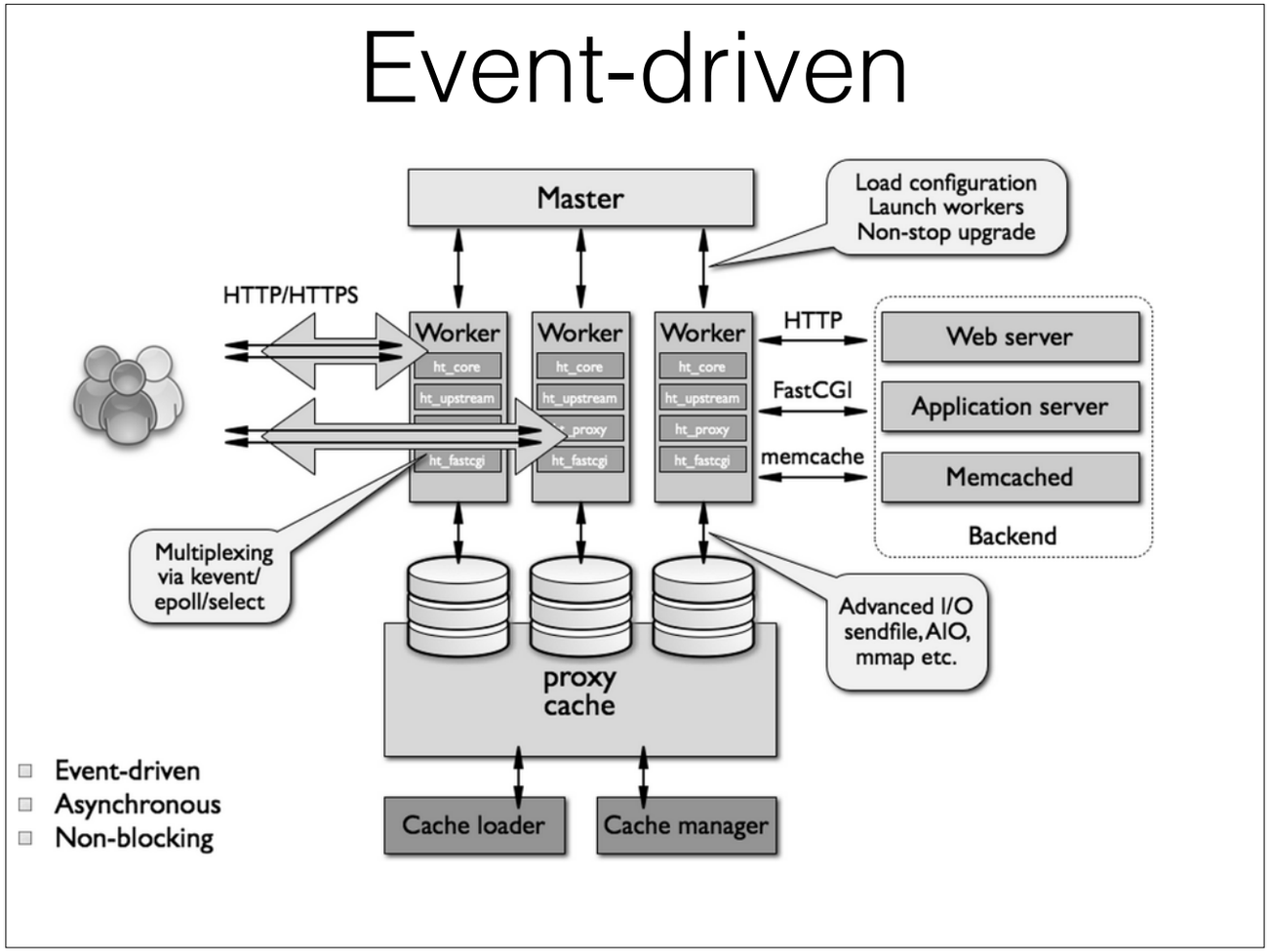
```
10535  0.3  0.3  31668  7232 pts/0    S+   05:49   0:00 python3 server.py
10537  0.0  0.2  31668  4756 pts/0    S+   05:49   0:00 python3 server.py
10540  0.0  0.2  31668  4756 pts/0    S+   05:49   0:00 python3 server.py
10541  0.0  0.2  31668  4756 pts/0    S+   05:49   0:00 python3 server.py
```

```
10535  0.1  0.3  31668  7232 pts/0    S+   05:49   0:00 python3 server.py
10537  0.0  0.0      0     0 pts/0    Z+   05:49   0:00 [python3] <defunct>
10540  0.0  0.0      0     0 pts/0    Z+   05:49   0:00 [python3] <defunct>
10541  0.0  0.0      0     0 pts/0    Z+   05:49   0:00 [python3] <defunct>
```

A zombie is a process that has terminated, but its parent has not waited for it and has not received its termination status yet
http://ruslanspivak.com/lsbaws-part3/
close sockets to avoid: Too many open files
avoid zombies or else: Resource temporarily available (limit for # child processes)

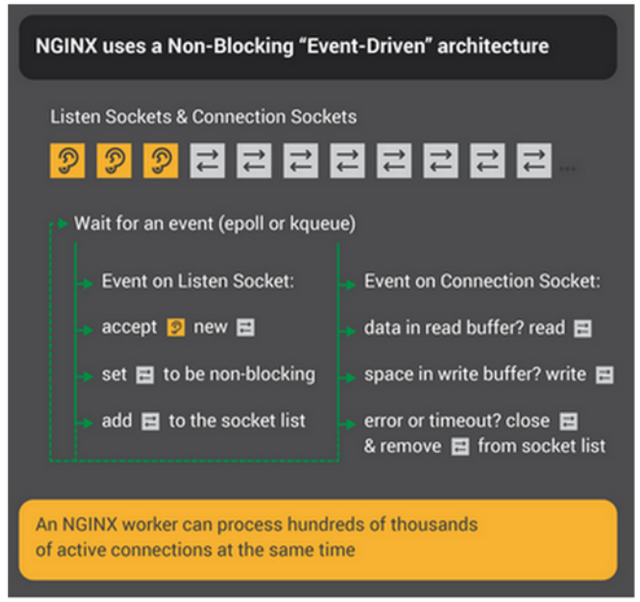
handle zombies by watching SIGCHLD and calling the non-blocking `os.waitpid()`

Event-driven



http://www.aosabook.org/en/nginx.html

Event-driven



https://www.nginx.com/blog/inside-nginx-how-we-designed-for-performance-scale/

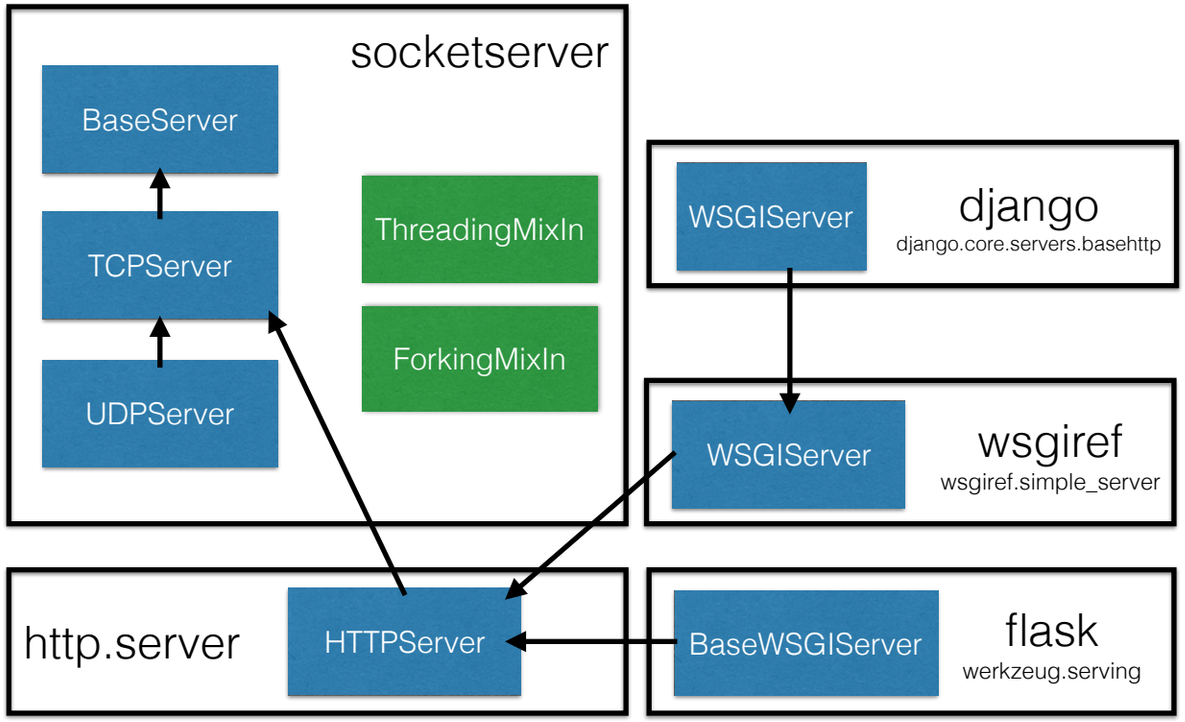
Coroutines

```python
import asyncio

async def handle_request(reader, writer):
    print('handling request')
    data = await reader.read(1024)
    content = data.decode('utf-8')

    addr = writer.get_extra_info('peername')
    print('received', content, 'from', addr)

    print('send hello world')
    writer.write(b'''HTTP/1.1 200 OK\r\n\r\nHello World!''')
    await writer.drain()

    print('close socket')
    writer.close()


loop = asyncio.get_event_loop()
coro = asyncio.start_server(handle_request, host='0.0.0.0', port=8000, loop=loop)
server = loop.run_until_complete(coro)

print('Serving on {}'.format(server.sockets[0].getsockname()))
try:
    loop.run_forever()
except KeyboardInterrupt:
    pass

server.close()
loop.run_until_complete(server.wait_closed())
loop.close()
```

Higher-Level Modules

```python
from http.server import HTTPServer, SimpleHTTPRequestHandler

class MyRequestHandler(SimpleHTTPRequestHandler):
    def do_GET(self):
        self.send_response(200)
        self.end_headers()
        self.wfile.write('Hello World!'.encode('utf-8'))

server_address = ('', 8000)
httpd = HTTPServer(server_address, MyRequestHandler)
httpd.serve_forever()
```

Higher-Level Modules



WSGI = web server gateway interface
interface between web servers and web applications
check out wsgiref python module

threading/forking mostly a way to hand off socket and separate state? threading isn't multi-core