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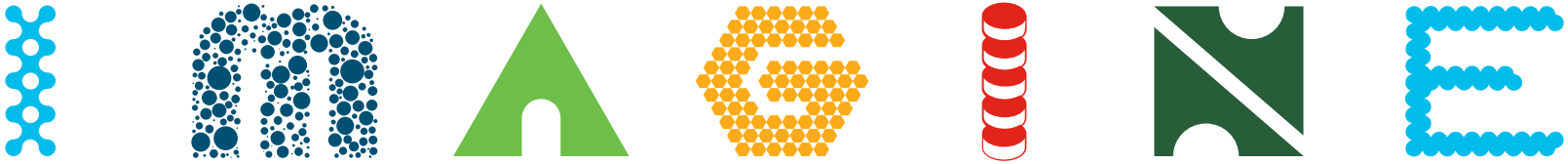

INTUITIVE

DEVWKS-3627

Make Python applications faster with asyncio!

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About me

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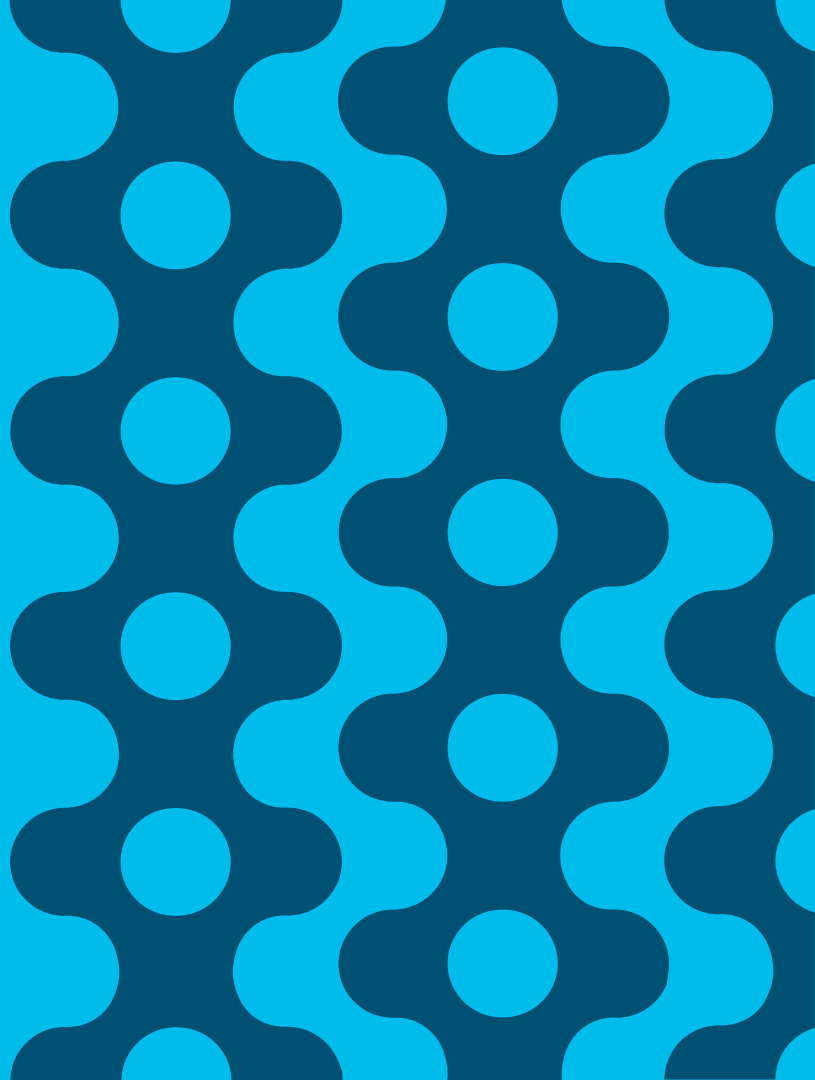
Agenda

- Python performance
- Concurrency and parallelism in Python
- asyncio library building blocks
- asyncio examples in networking

Python performance



Python speed

- Everyone says Python is slow, but …
  - Is it really?
- What is the bottleneck?
  - Often it is not CPU, it is input/output (I/O) – database queries, network

If Python was fast, it wouldn't really help

Takeaway: Python is actually slow, but it doesn't matter for many use-cases

Python implementations

- CPython (default)
- Cython
- PyPy

Use Python implementations to increase Python performance!

But this talk is about I/O

I/O in Python - scenario

- A network engineer just recently learned Python and how to interact with network devices using SSH or API
- Needs to collect memory statistics, ARP table and parse this data
- One week of trial and error… and success! Working great for one device
- …but need to do the same for 1000+ devices
- Let's add for loop and it should be fine… right?

RIGHT??

Demo – sequential SSH to network devices with netmiko

I/O can be very slow

Introducing concurrency

- Concurrency – several tasks are running at overlapping time periods
- Parallelism – several tasks happening at the same time

Typical approaches:

- Multiple processes
- Threads
- Asynchronous programming

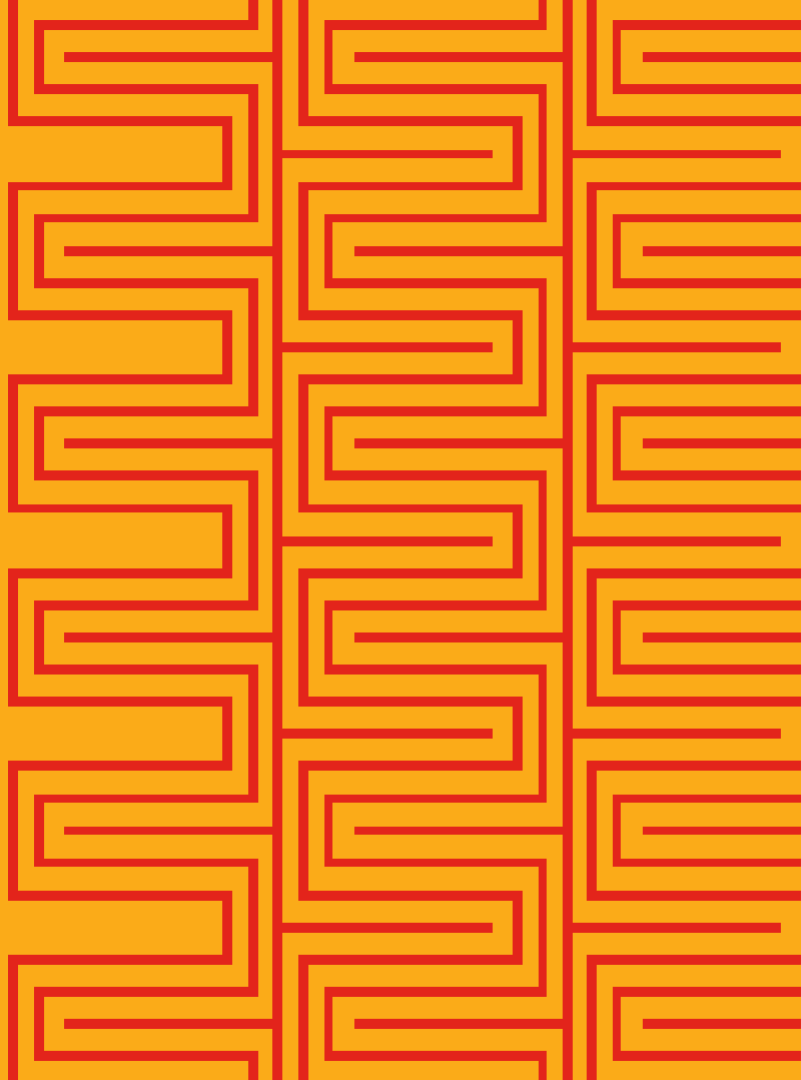
Multiprocessing in Python

- Spawns multiple Python interpreters as forks which may run across multiple CPU cores
- Higher overhead than threads
- Harder to communicate between processes
- Higher memory footprint
- Effective to distribute CPU heavy (computation) load across several cores

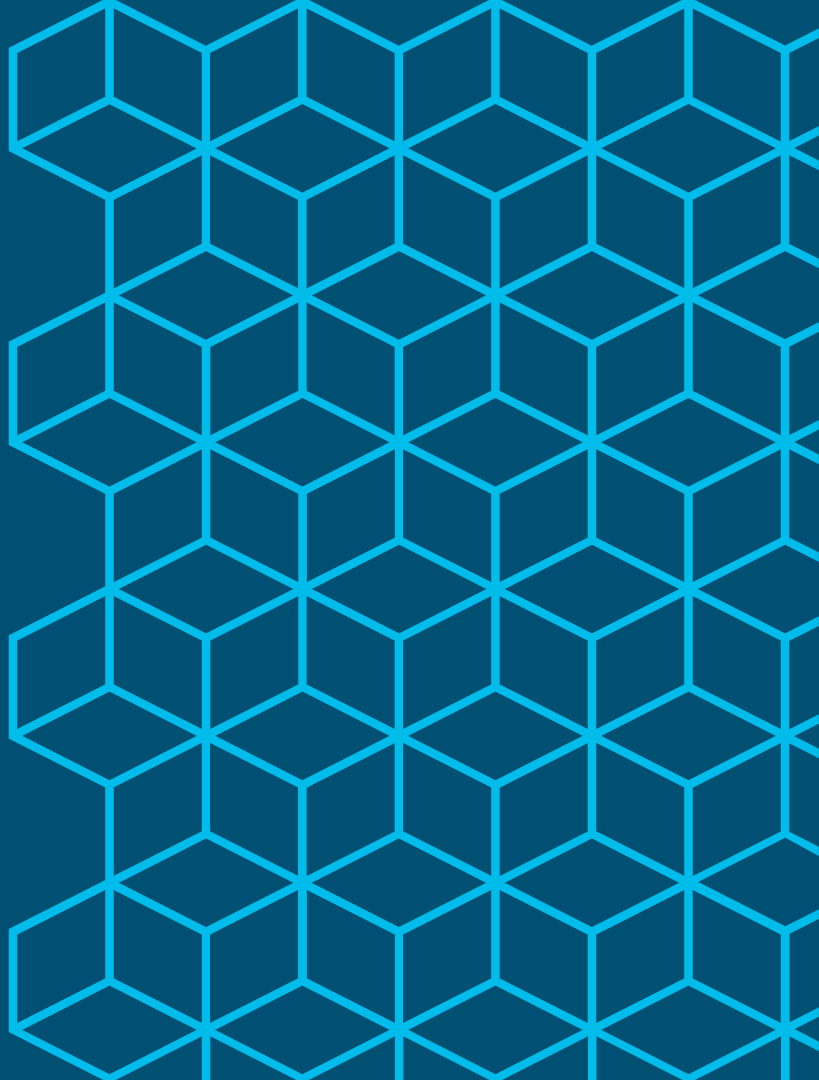
Threading in Python

- Running multiple threads (functions calls) concurrently
- Shared state
- Low overhead
- Thread switching at random time by the scheduler
- Global Interpreter Lock (GIL) – only one thread can run at the same time
  - Because of GIL, makes sense only for I/O heavy applications
- Easy to add, hard to get right – shared state can cause racing conditions
- Requires locks and queues to be safe, but most importantly experience

Demo – SSH to network device with netmiko and threads



Python asyncio



Asynchronous programming

- Intuition: when I am doing I/O and waiting for the response, I could do something else instead!
- By default, runs a single thread and single process
- Python 3.4 introduced new standard library: asyncio
- Python 3.5 introduced new syntax: async/await
- Python 3.7 – asyncio API was cleaned, new asyncio.run() entrypoint
- Completely different programming style which relies on Coroutines, Futures and Event Loop

Demo – asyncio building blocks

Coroutines

- Python 3.5 – async/await syntax for coroutines
- await expects values from I/O (e.g. HTTP response)
- I/O places in the code are marked explicitly using await
- await is used only in async coroutines marked by async def
- Usual functions can't call coroutine functions, only coroutine functions can call coroutine functions
  - This poisons the codebase, requiring coroutines everywhere
  - Loop entrypoint (`loop.run_until_complete` or `asyncio.run`) calls coroutines from synchronous context

Task/Future (asyncio)

- Task/Future – an object that wraps coroutine
  - Returned immediately
  - Placeholder for the future result or exception
  - Can be cancelled

Schedule tasks:

- `loop.create_task()`
- `asyncio.ensure_future()`
- `asyncio.create_task` – Python 3.7+ only

Event loop (asyncio)

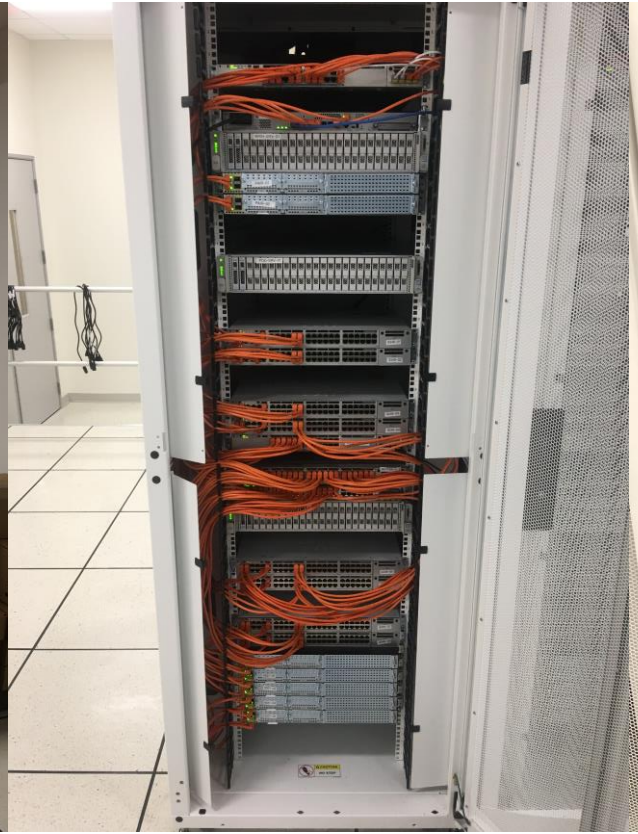
- Event loop – is a loop that executes tasks
  - Different ways to mix tasks, schedule, start and stop them
  - Directly impacts the performance
- Different loop implementations:
  - asyncio base loop – default
  - uvloop – speed increase x2-x4
  - trio event loop

Demo – asynchronous SSH to network devices with netdev

Demo – asynchronous HTTP using asyncio and aiohttp

Real world use-case

- Automated lab management system
- 5 racks of gear, 100 devices, 700+ cables



Real world use-case (cont.)

- 2 weeks for racking and stacking
- Did we actually do cabling correctly?
- Wrote a script to check that using CDP

```
-> % pipenv run python check_cabling.py
Loading .env environment variables…
Cabling 100% coincides with the documentation! Congratulations!
It took 17.43 seconds to run for 88 devices, which is 0.20 seconds per device
```

Demo – compare actual cabling with desired cabling using CDP output asynchronously

Wrap-up

Use-cases

All I/O heavy use-cases:

- Web back-end
- REST API interaction
- Database interaction
- Interaction with network devices

Problems with asyncio

- Shift in perspective and approach
- Hard to migrate existing codebase
  - Mixing synchronous and asynchronous code is complex
- Requires different libraries for I/O operations: aiohttp (HTTP client), asyncssh and netdev (SSH), aiofiles (files read/write), etc.

Summary: Why use asyncio

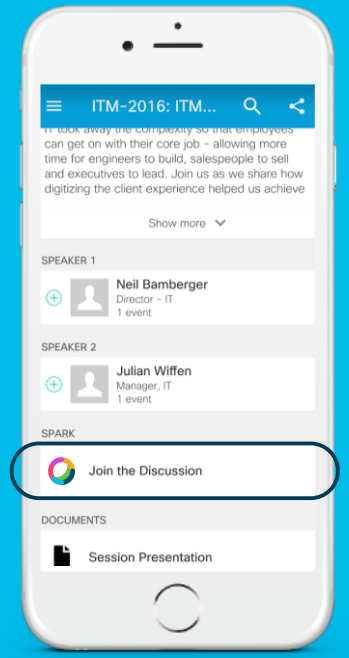
- Explicit control for task switching using await keyword
- Less overhead and slightly faster than threads
- Great scalability approach
- Easy for simple use-cases

Get Started with asyncio

- Raymond Hettinger – Keynote on Concurrency – PyBay 2017
- Async Techniques and Examples in Python course
- Miguel Grinberg – Asynchronous Python for the Complete Beginner – PyCon 2017
- Łukasz Langa – Thinking In Coroutines – PyCon 2016
- Armin Ronacher – I don't understand Python's Asyncio
- asyncio documentation
- Nathaniel J Smith – Python Concurrency for Mere Mortals – Pyninsula #10
- Useful asyncio libraries: aiohttp, asyncssh, netdev, sanic

Code

https://github.com/dmfigol/devwks-3627.git



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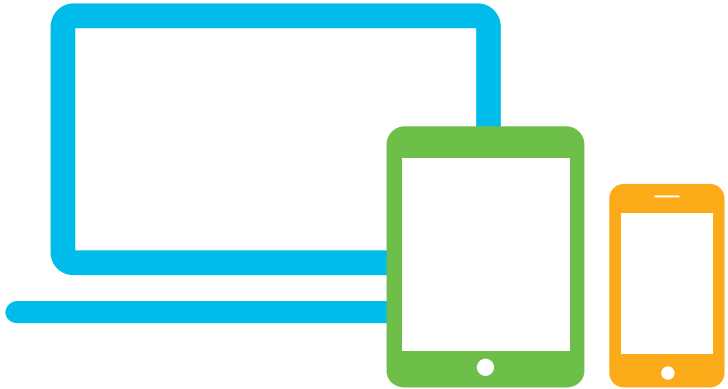

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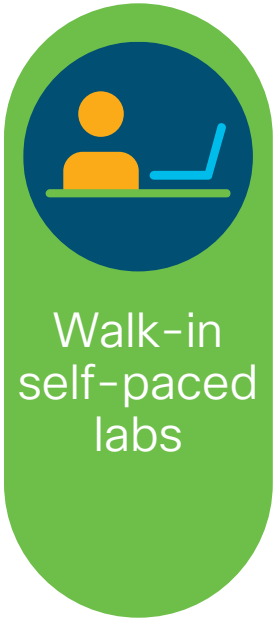

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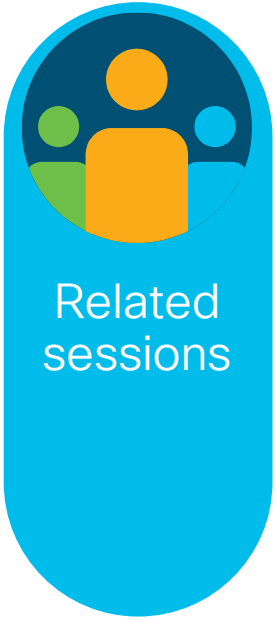

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