For the intrepid programmer who has decided to explore the asynchronous part of Python, welcome to our "Asyncio How-to".

Of course, you can successfully use Python without needing or even knowing about the asynchronous paradigm. However, if you are interested in how things work under the hood in that respect, asyncio is absolutely worth checking out.

What asynchronous means

In a standard sequential program, all the instructions you send to the interpreter will be executed one by one. It is easy to visualize and predict the output of such a code. But…

Let's say you have a script that requests data from 3 different servers. Sometimes the request to one of those servers may take unexpectedly too much time to execute. Imagine that it takes 10 seconds to get data from the second server. While you are waiting, the whole script is actually doing nothing.

What if you could write a script that, instead of waiting for the second request, simply skip it and start executing the third request, then go back to the second one, and proceed from where it left off? That's the nature of an asynchronous program. You minimize idle time by switching tasks.

Still, you don't want to use an asynchronous code when you need a simple script, with little to no input/output (I/O).

One more important thing to mention is that all the code is running in a single thread. So if you expect that one part of the program will be executed in the background while your program will be doing something else, this won't happen.

Getting Started

Here are the most basic definitions of asyncio main concepts:

- **Coroutine**—generator that consumes data, but doesn't generate it. Python 2.5 introduced a new syntax that made it possible to send a value to a generator. I recommend checking David

Beazley's "A Curious Course on Coroutines and Concurrency" for a detailed description of coroutines.

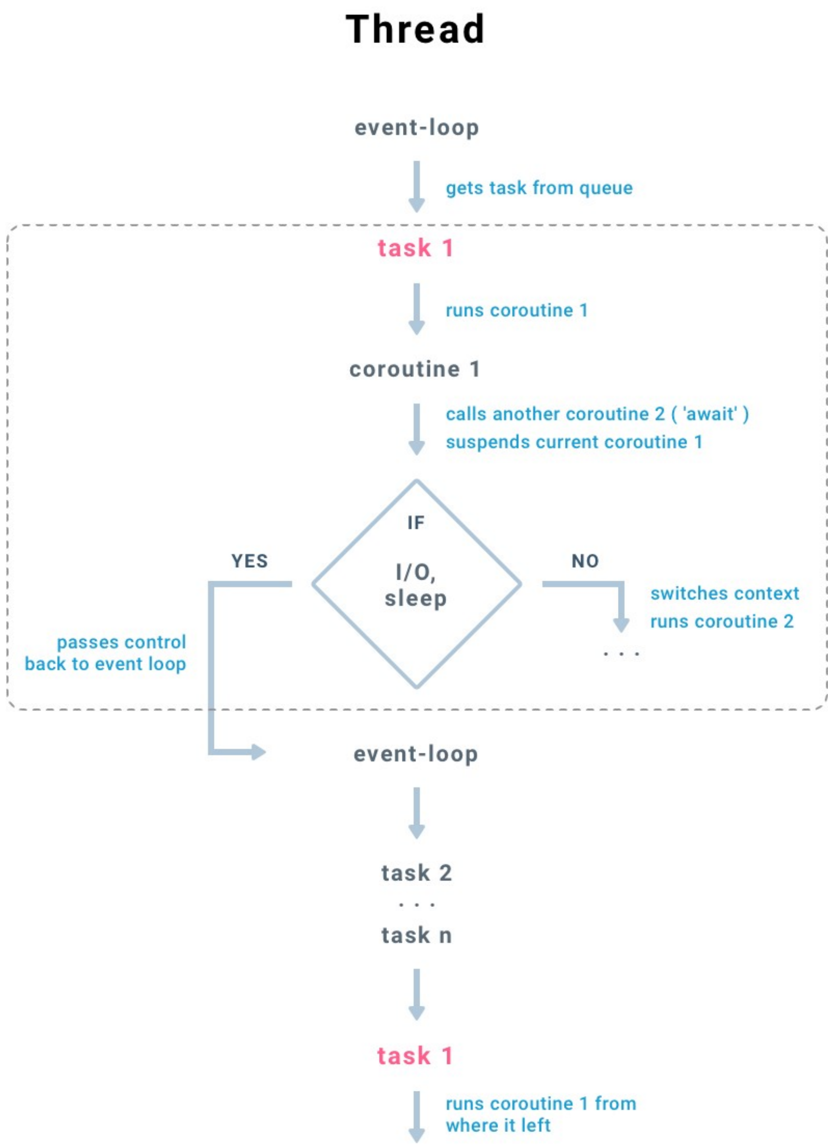
- **Tasks**—schedulers for coroutines. If you check a source code below, you'll see that it just says `event_loop` to run its `_step` as soon as possible, meanwhile `_step` just calls next step of coroutine.

```
class Task(futures.Future):
    def __init__(self, coro, loop=None):
        super().__init__(loop=loop)
        ...
        self._loop.call_soon(self._step)


    def _step(self):
            ...
        try:
            ...
            result = next(self._coro)
        except StopIteration as exc:
            self.set_result(exc.value)
        except BaseException as exc:
            self.set_exception(exc)
            raise
        else:
            ...
            self._loop.call_soon(self._step)
```

- **Event Loop**—think of it as the central executor in asyncio.

Now let's see how all these work together. As I've already mentioned, asynchronous code is running in a single thread:



As you can see from the chart:

- The event loop is running in a thread
- It gets tasks from the queue
- Each task calls the next step of a coroutine
- If coroutine calls another coroutine (`await <coroutine_name>`), the current coroutine gets suspended and context switch occurs. Context of the current coroutine (variables, state) is saved and context of a called coroutine is loaded

- If coroutine comes across a blocking code (I/O, sleep), the current coroutine gets suspended and control is passed back to the event loop
- Event loop gets next tasks from the queue 2, …n
- Then the event loop goes back to task 1 from where it left off

Asynchronous vs. Synchronous Code

Let's try to prove that asynchronous approach really works. I will compare two scripts, that are nearly identical, except the `sleep` method. In the first one I am going to use a standard `time.sleep`, and in the second one— `asyncio.sleep`.

Sleep is used here because it is the simplest way to show the main idea, how asyncio handles I/O.

Here we use synchronous sleep inside async code:

```
import asyncio
import time
from datetime import datetime



async def custom_sleep():
    print('SLEEP', datetime.now())
    time.sleep(1)


async def factorial(name, number):
    f = 1
    for i in range(2, number+1):
        print('Task {}: Compute factorial({})'.format(name,
i))
        await custom_sleep()
        f *= i
    print('Task {}: factorial({}) is {}\n'.format(name,
number, f))



start = time.time()
loop = asyncio.get_event_loop()


tasks = [
    asyncio.ensure_future(factorial("A", 3)),
    asyncio.ensure_future(factorial("B", 4)),
]
```

```
loop.run_until_complete(asyncio.wait(tasks))
loop.close()


end = time.time()
print("Total time: {}".format(end - start))
```

Output:

```
Task A: Compute factorial(2)
SLEEP 2017-04-06 13:39:56.207479
Task A: Compute factorial(3)
SLEEP 2017-04-06 13:39:57.210128
Task A: factorial(3) is 6


Task B: Compute factorial(2)
SLEEP 2017-04-06 13:39:58.210778
Task B: Compute factorial(3)
SLEEP 2017-04-06 13:39:59.212510
Task B: Compute factorial(4)
SLEEP 2017-04-06 13:40:00.217308
Task B: factorial(4) is 24


Total time: 5.016386032104492
```

Now the same code, but with the asynchronous sleep method:

```
import asyncio
import time
from datetime import datetime



async def custom_sleep():
    print('SLEEP {}\n'.format(datetime.now()))
    await asyncio.sleep(1)


async def factorial(name, number):
    f = 1
    for i in range(2, number+1):
        print('Task {}: Compute factorial({})'.format(name,
i))
        await custom_sleep()
        f *= i
    print('Task {}: factorial({}) is {}\n'.format(name,
number, f))
```

```
start = time.time()
loop = asyncio.get_event_loop()


tasks = [
    asyncio.ensure_future(factorial("A", 3)),
    asyncio.ensure_future(factorial("B", 4)),
]
loop.run_until_complete(asyncio.wait(tasks))
loop.close()


end = time.time()
print("Total time: {}".format(end - start))
```

Output:

```
Task A: Compute factorial(2)
SLEEP 2017-04-06 13:44:40.648665


Task B: Compute factorial(2)
SLEEP 2017-04-06 13:44:40.648859


Task A: Compute factorial(3)
SLEEP 2017-04-06 13:44:41.649564


Task B: Compute factorial(3)
SLEEP 2017-04-06 13:44:41.649943


Task A: factorial(3) is 6


Task B: Compute factorial(4)
SLEEP 2017-04-06 13:44:42.651755


Task B: factorial(4) is 24


Total time: 3.008226156234741
```

As you can see, the asynchronous version is 2 seconds faster. When asynchronous sleep is used (each time we call `await asyncio.sleep(1)`), control is passed back to the event loop, that runs another task from the queue (either Task A or Task B).

In the case of standard sleep, nothing happens. A thread basically just hangs out. In fact, because of standard sleep, the current thread