Asyncio Internals

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October 22, 2020

Table of contents

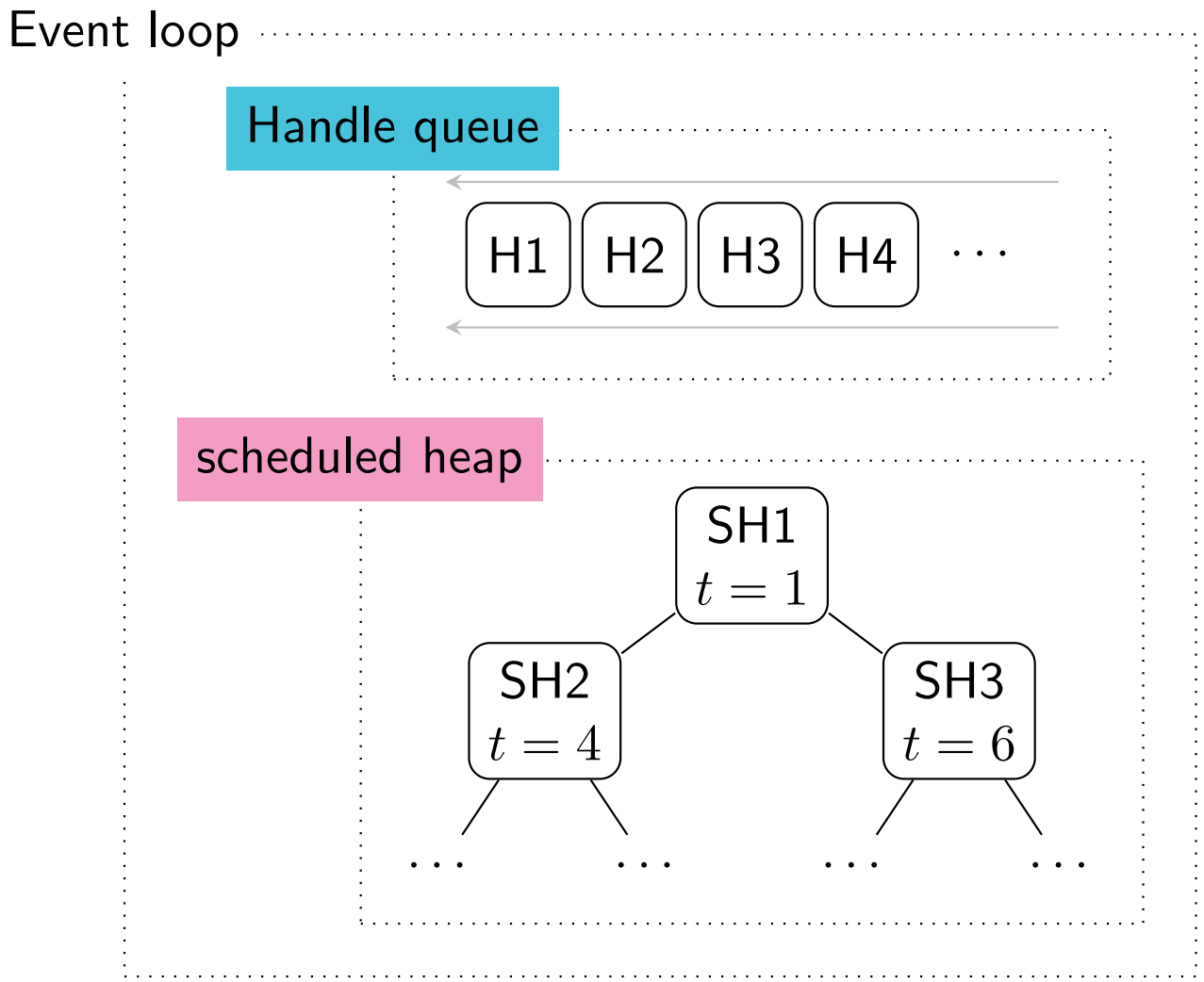
Generator internals

Secret: In cpython, generator = coroutine!

- `gen.send(?)`
- `next(gen)` ≡ `gen.send(None)`
- `gen.throw(exc)`
- `yield` ⇒ "pausing" of coroutine
- closure
- stack frame in heap

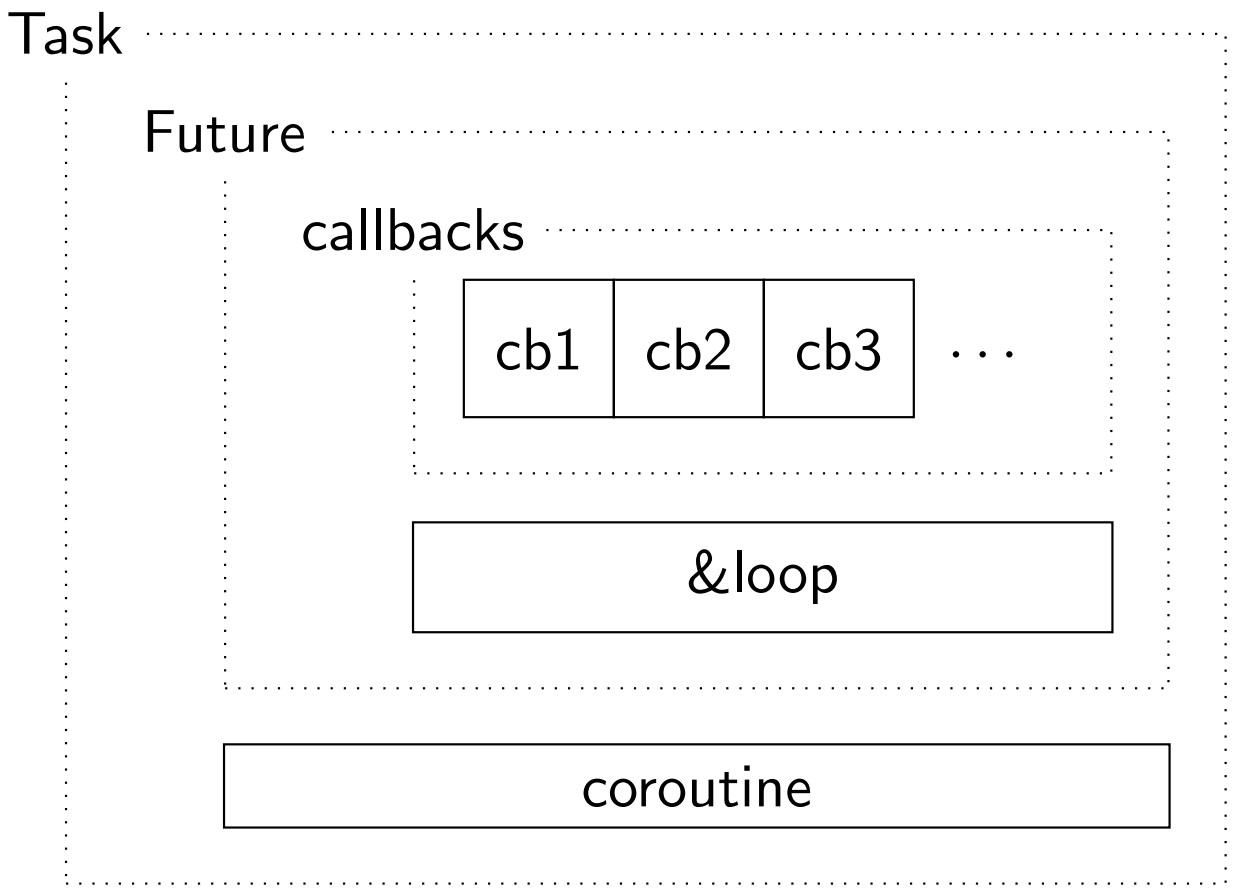
demo `gen_send.py`

Event loop



`Handle` **wraps** `def callback(fut)` (e.g. `Task.__step`)

Task



asyncio.run(main)

```
1  def run(main):
2      loop = new_event_loop()
3      return loop.run_until_complete(main)
4
5  class Loop:
6      def run_until_complete(coro_or_fut):
7          task = ensure_future(coro_or_fut,
8                               loop=self)
9          task.add_done_callback(<<stop loop>>)
10         loop.run_forever()
11         return task.result()
12
13 def ensure_future(coro_or_fut, *, loop):
14     if isinstance(coro_or_fut, Future)
15         return coro_or_fut
16     else: # coro
17         return Task(coro_or_fut, loop=loop)
```

Task

```
class Task(Future):
    def __init__(self, coro, loop, ...):
        super().__init__(loop)
        ...
        self._coro = coro
        self._loop.call_soon(self.__step, ...)
```

Future

```
1
2  class Future:
3      def __init__(self, loop):
4          self._loop = loop
5
6      def __iter__(self):
7          if not self.done():
8              yield self  # future is blocking
9          return self.result()
10
11     def add_done_callback(self, fn, ...):
12         if self.done():
13             self._loop.call_soon(fn, self)
14         else:
15             self._callbacks.append((fn,))
16     ...
```

Future

```
1
2  class Future:
3      ...
4
5      def set_result(self, result):  # similar for set_exception
6          self._result = result
7          self._state = _FINISHED  # done
8          self.__schedule_callbacks()
9
10     def __schedule_callbacks(self):
11         callbacks = self._callbacks[:]
12         self._callbacks[:] = []  # clear callbacks
13         for callback in callbacks:
14             self._loop.call_soon(callback, self)
15
16     def result(self):
17         if self._exception is not None:
18             raise self._exception
19         return self._result
```

`__schedule_callbacks()` effectively moves all callbacks to Handle queue

loop.call_soon(callback, *args)

```
class Loop:
    def call_soon(self, callback, *args, ...):
        handle = Handle(callback, *args)

        Handle queue.append(handle)

        return handle
```

loop.run_forever()

```
class Loop:
    def run_forever(self):
        while True:
            self._run_once()
            if self._stopping:
                break

    def _run_once(self):
        ...
```

loop._run_once()

def `_run_once()`:

$$\texttt{timeout} = \begin{cases} 0, & \text{if Handle queue is not empty} \\ \text{minimal timeout}, & \text{if scheduled heap is not empty} \\ \text{None}, & \text{otherwise} \end{cases}$$

```
// block if timeout is None
ev_list = self._selector.select(timeout)
self._process_events(ev_list)
```

Handle queue += handles from scheduled heap which the time is up

`handles` = pop all from Handle queue

for `handle: handles` **do**
  `handle._run()` // runs `task.__step`

Task.__step(exc)

```
1  def __step(exc):
2      coro = self._coro
3      try:
4          result = coro.send(None)
5      except StopIteration as exc:
6          self.set_result(exc.value)
7      except BaseException as exc:
8          self.set_exception(exc)
9      else:
10         if result <<is a blocking future>>:
11             result.add_done_callback(self.__wakeup)
12         elif result is None:  # bare yield used
13             self._loop.call_soon(self.__step)
14
15 def __wakeup(self, future):
16     # check if cancelled or errored
17     ...
18     self.__step()
```

- `await` ≡ `yield from`

demo

- `run_once_demo.py`
- `timeout_zero_future.py`

References

Talk by Saúl Ibarra Corretgé in PyGrunn 2014
https://www.youtube.com/watch?v=HppNu0-ANYw

Code based on Python 3.8.2