|| & .py

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Basic Interface

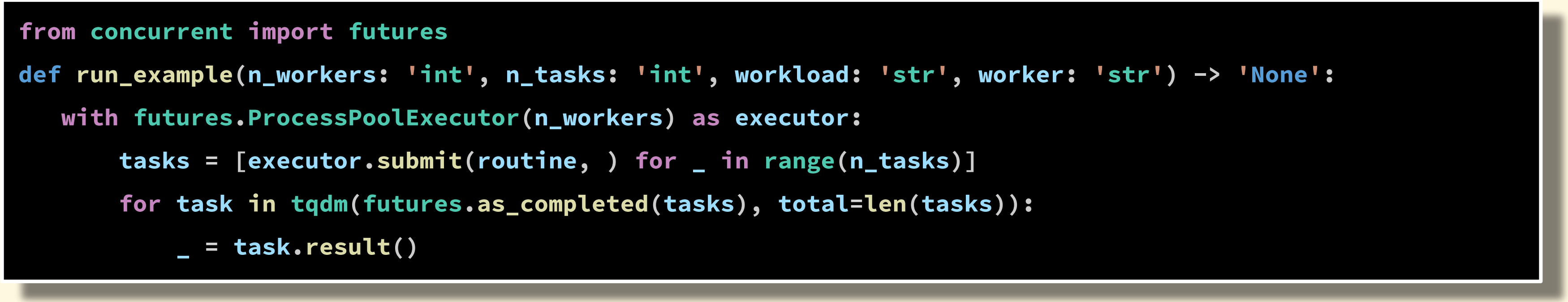
how to create process / thread in python?

- interface of processes
- interface of threads

Processes

If the task is simple, all process management can be left to special packages.

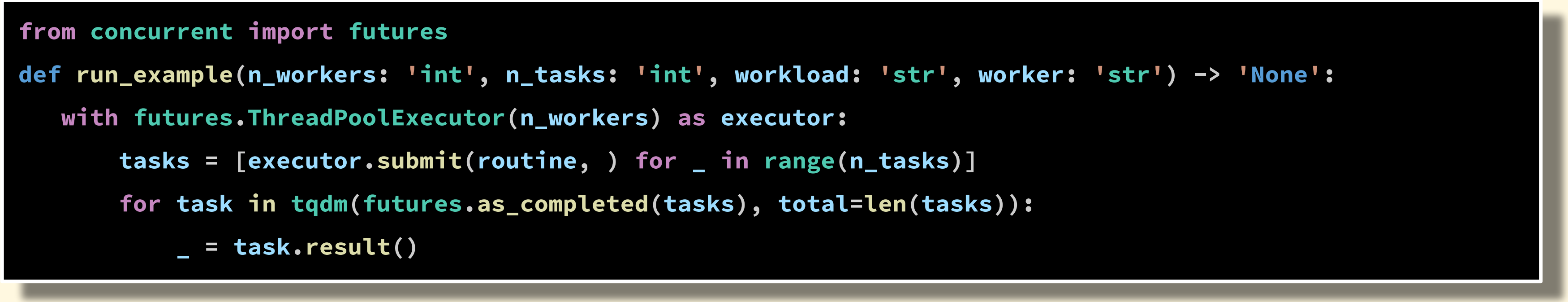
Mechanisms of synchronization between processes will be omitted :(



```python
from concurrent import futures
def run_example(n_workers: 'int', n_tasks: 'int', workload: 'str', worker: 'str') -> 'None':
   with futures.ProcessPoolExecutor(n_workers) as executor:
       tasks = [executor.submit(routine, ) for _ in range(n_tasks)]
       for task in tqdm(futures.as_completed(tasks), total=len(tasks)):
           _ = task.result()
```

Threads

If the task is simple, all process management can be left to special packages.



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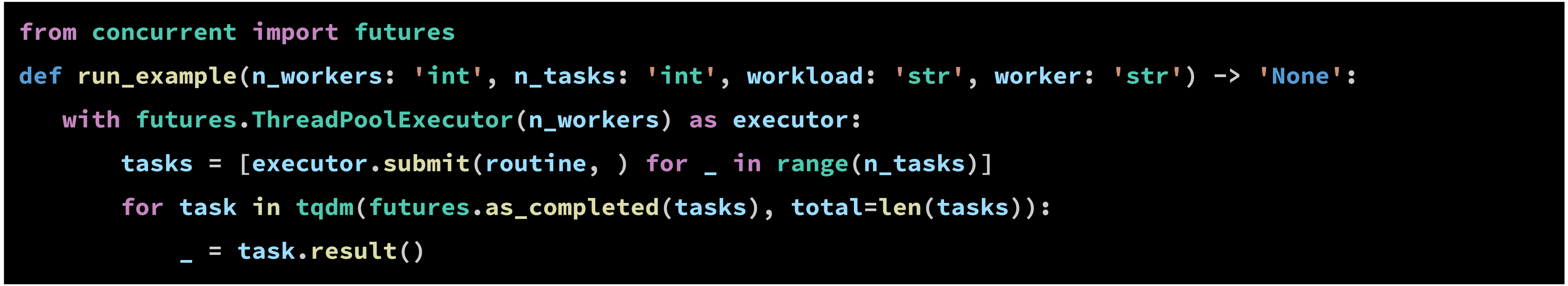
from concurrent import futures
def run_example(n_workers: 'int', n_tasks: 'int', workload: 'str', worker: 'str') -> 'None':
   with futures.ThreadPoolExecutor(n_workers) as executor:
       tasks = [executor.submit(routine, ) for _ in range(n_tasks)]
       for task in tqdm(futures.as_completed(tasks), total=len(tasks)):
           _ = task.result()
```

Threads

If the task is simple, all process management can be left to special packages.

Mechanisms of synchronization will be discussed. But later.



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```

Process
vs
Thread

which one should be used?

- cpu tasks & processes
- io tasks & processes
- etc.
- …
- comparison

?

- Is there true thread parallelism in .py?
- Is there true processes parallelism in .py?

Threads & True ||

```
100%|██████████| 24/24 [01:08<00:00,  2.87s/it]
[# threads = 1, # tasks = 24, workload = io]
Total time 68.7927 s

100%|██████████| 24/24 [00:45<00:00,  1.89s/it]
[# threads = 2, # tasks = 24, workload = io]
Total time 45.3669 s

100%|██████████| 24/24 [00:43<00:00,  1.79s/it]
[# threads = 4, # tasks = 24, workload = io]
Total time 43.0095 s
```

for io bound tasks threads are **useful**

Threads & True ||

```
100%|██████████| 24/24 [00:00<00:00, 45.88it/s]
[# threads = 1, # tasks = 24, workload = cpu]
Total time 0.6458 s


100%|██████████| 24/24 [00:00<00:00, 114.38it/s]
[# threads = 2, # tasks = 24, workload = cpu]
Total time 0.6140 s


100%|██████████| 24/24 [00:00<00:00, 77612.41it/s]
[# threads = 4, # tasks = 24, workload = cpu]
Total time 0.6088 s
```

for cpu bound tasks threads are **useless**

Threads & True ||

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Total time 0.6088 s
```

for cpu bound tasks threads are useless*

Processes & True ||

```
100%|██████████| 24/24 [01:10<00:00,  2.92s/it]
[# processes = 1, workload = io]
Total time 70.1880 s

100%|██████████| 24/24 [00:49<00:00,  2.05s/it]
[# processes = 2, workload = io]
Total time 49.3300 s

100%|██████████| 24/24 [00:32<00:00,  1.35s/it]
[# processes = 4, workload = io]
Total time 32.4546 s
```

for cpu bound tasks threads are **useful**

Processes & True ||

```
100%|██████████| 24/24 [00:00<00:00, 35.59it/s]
[# processes = 1, workload = cpu]
Total time 0.6933 s

100%|██████████| 24/24 [00:00<00:00, 67.80it/s]
[# processes = 2, workload = cpu]
Total time 0.3709 s

100%|██████████| 24/24 [00:00<00:00, 109.61it/s]
[# processes = 4, workload = cpu]
Total time 0.2443 s
```

for cpu bound tasks processes are **useful**

```
100%|██████████| 24/24 [00:00<00:00, 77612.41it/s]
[# threads = 4, # tasks = 24, workload = cpu]
Total time 0.6088 s
```

```
100%|██████████| 24/24 [00:43<00:00,  1.79s/it]
[# threads = 4, # tasks = 24, workload = io]
Total time 43.0095 s
```

```
100%|██████████| 24/24 [00:00<00:00, 109.61it/s]
[# processes = 4, workload = cpu]
Total time 0.2443 s
```

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And why do we need threads?

```
100%|██████████| 24/24 [00:00<00:00, 77612.41it/s]
[# threads = 4, # tasks = 24, workload = cpu]
Total time 0.6088 s

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Total time 43.0095 s
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And why do we need threads?

```
Total Python's memory: 144.84375 MB
100%|██████████| 10/10
```

i.e. ~ 14mB/process

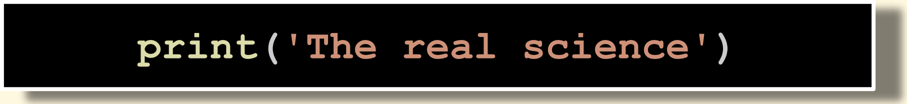
threads and cpu bound tasks

what is the problem?

- execution workflow
- garbage collector
- GIL
- workflow with GIL

Execution workflow

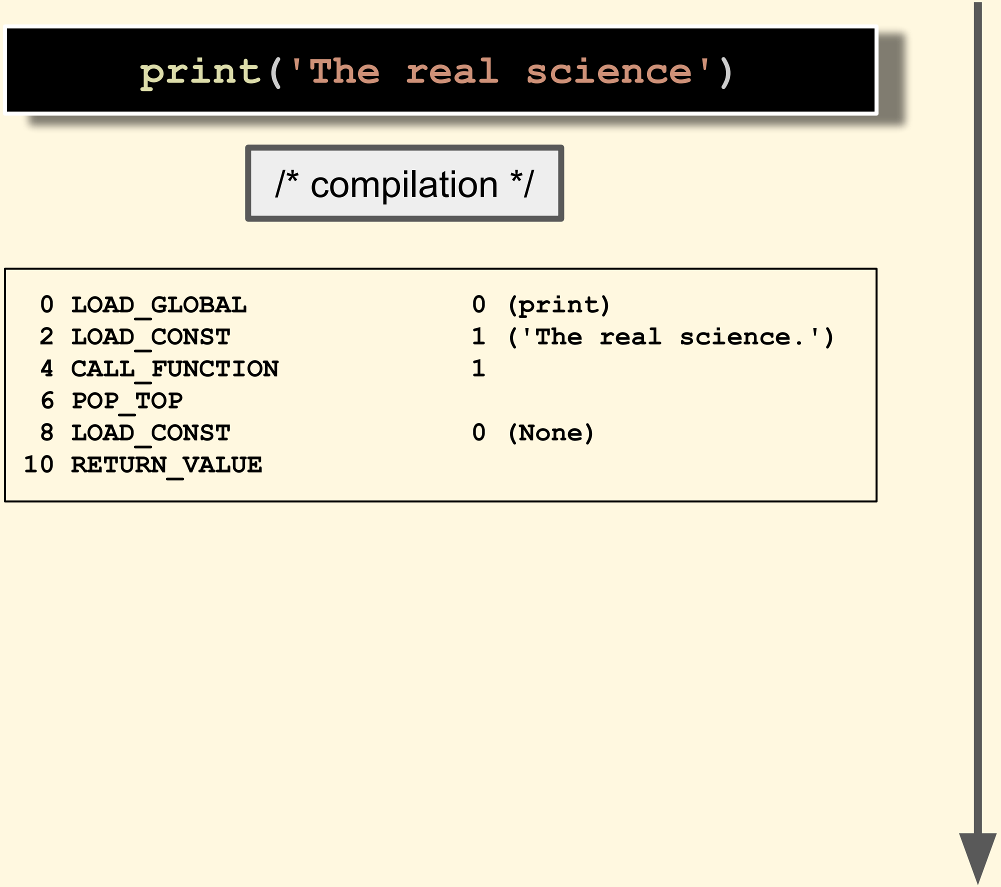
file.py *(source code)*



```
print('The real science')
```

Execution workflow

file.py *(source code)*



```
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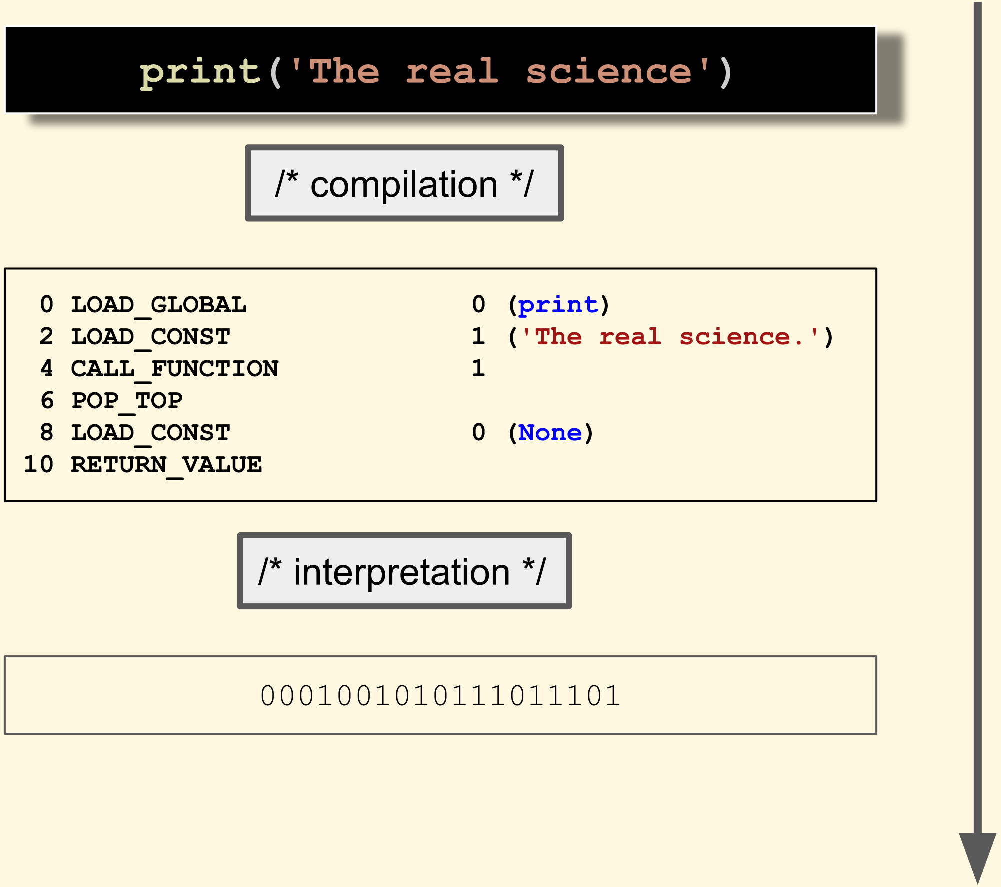
```

/* compilation */

file.pyc *(byte code)*

```
 0 LOAD_GLOBAL              0 (print)
 2 LOAD_CONST               1 ('The real science.')
 4 CALL_FUNCTION            1
 6 POP_TOP
 8 LOAD_CONST               0 (None)
10 RETURN_VALUE
```

Execution workflow



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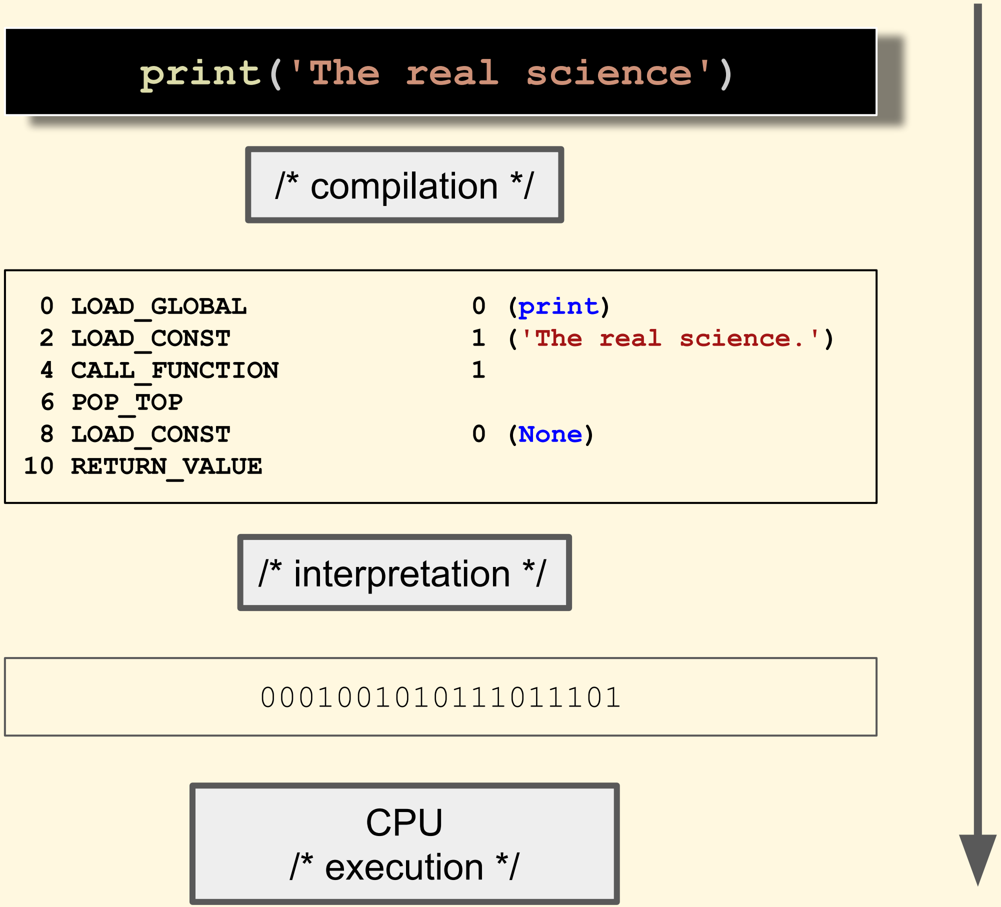
```

/* interpretation */

/ ? */ (binary code)*

```
0001001010111011101
```

Execution workflow



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/* interpretation */

/ ? */ (binary code)*

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0001001010111011101
```

CPU
/* execution */

Garbage collection

Garbage is bad

Garbage collection

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It’s hard to manage it by ourselves

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We'll prevent multiple threads from touching this counter.
How?
GIL - Global Interpreter Lock, i.e. mutex on the interpreter

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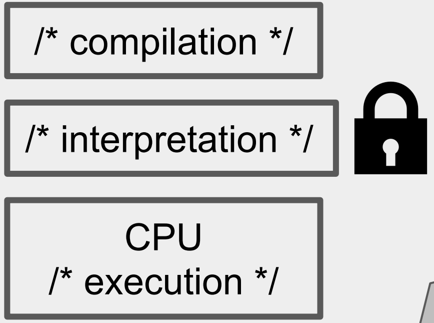
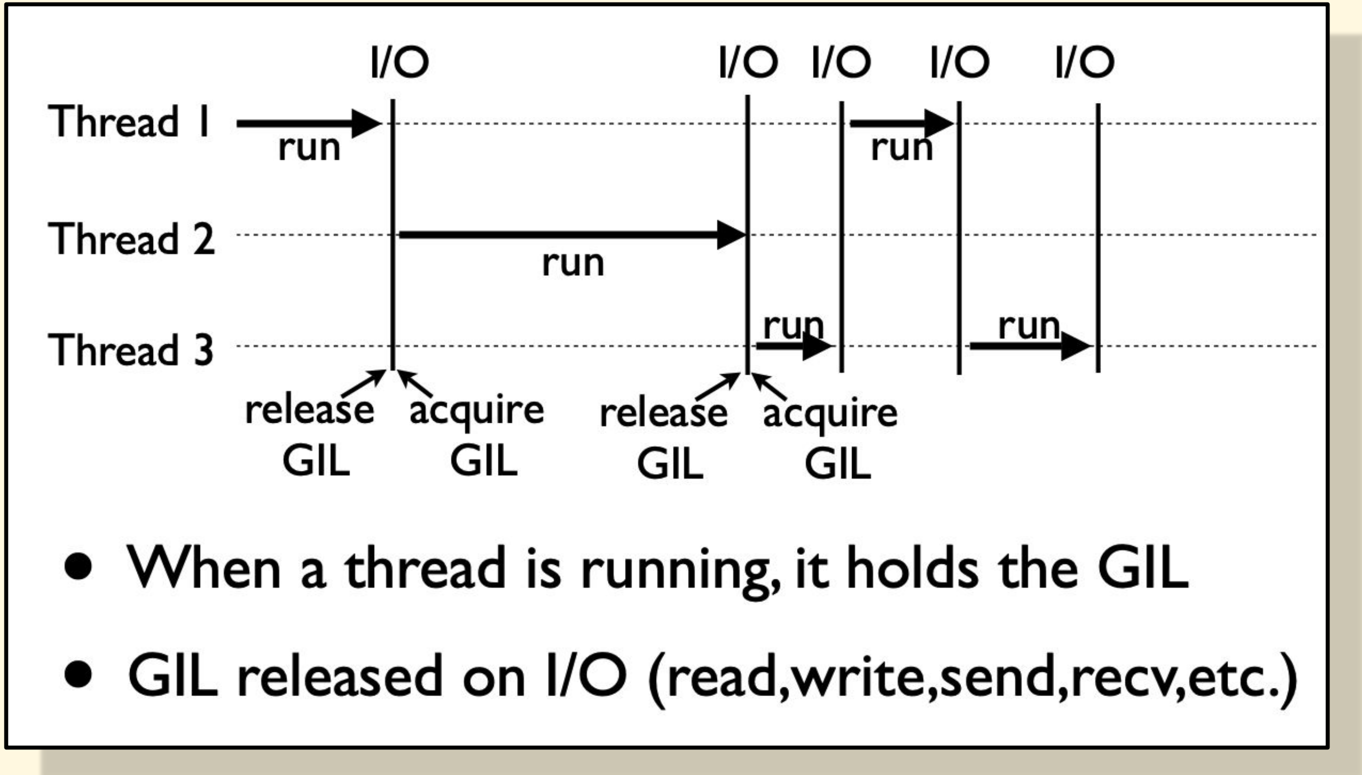


/* compilation */

/* interpretation */

CPU
/* execution */

Workflow with GIL



- When a thread is running, it holds the GIL
- GIL released on I/O (read,write,send,recv,etc.)

That’s why cpu bound tasks are not accelerated by adding threads.

https://www.fatalerrors.org/a/python-concurrent-programming.html

Okay;
Threads are friends with io bound tasks;
Processes are friends with everything;
Thanks for your attention.

Cython

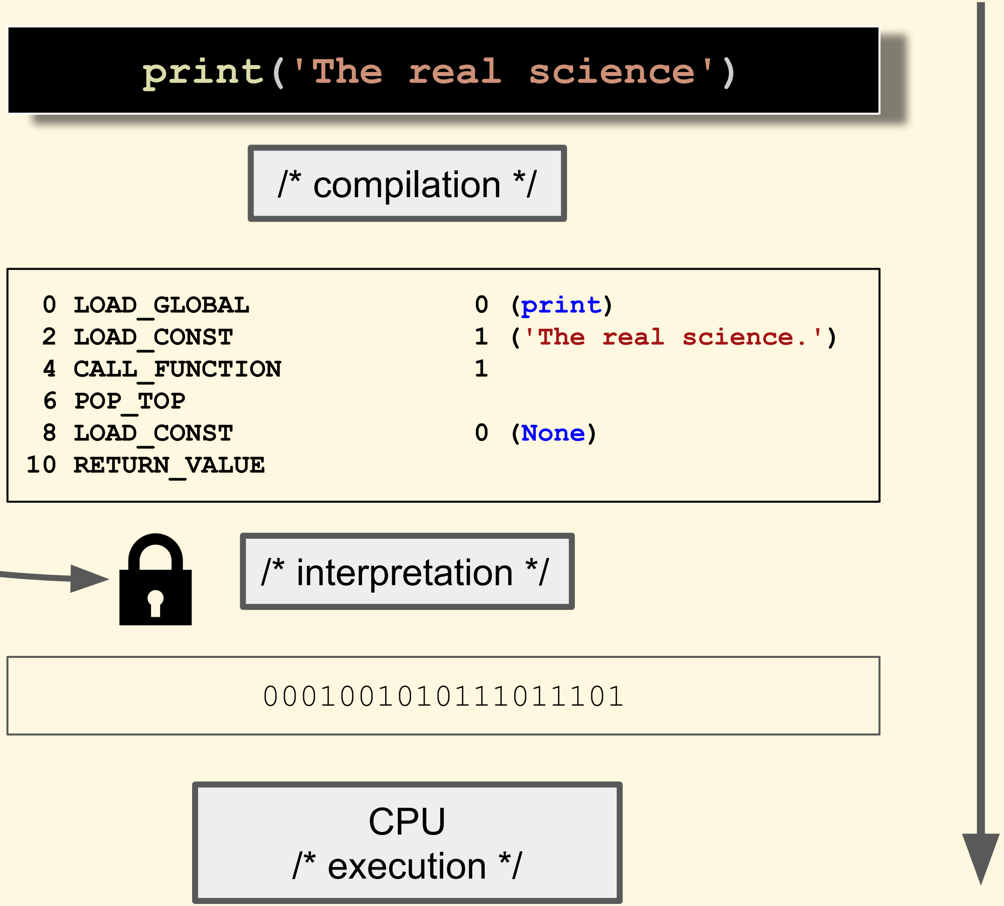
… or freeing ourselves from the shackles

- avoiding GIL
- threads & true parallelism
- fun

Avoiding GIL

We can avoid blocking the interpreter if we promise to keep track of memory ourselves. Then we get true || even with threads.

```
with nogil:
    ...
```



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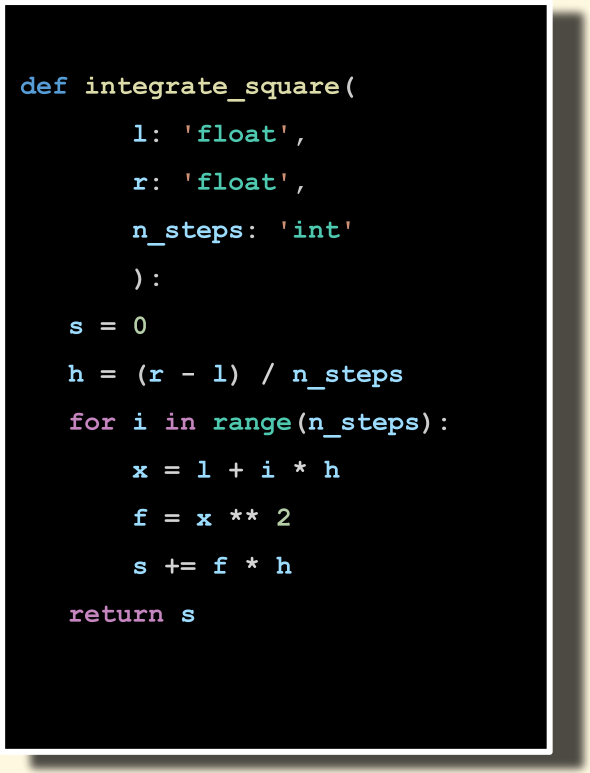
```
0001001010111011101
```

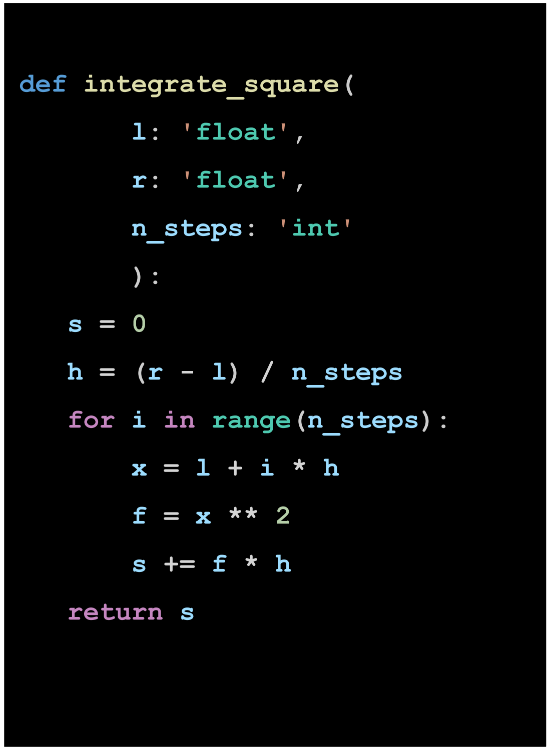
CPU
/* execution */

Ex. `with nogil`



```
def integrate_square(
       l: 'float',
       r: 'float',
       n_steps: 'int'
       ):
   s = 0
   h = (r - l) / n_steps
   for i in range(n_steps):
       x = l + i * h
       f = x ** 2
       s += f * h
   return s
```

Ex. `with nogil`



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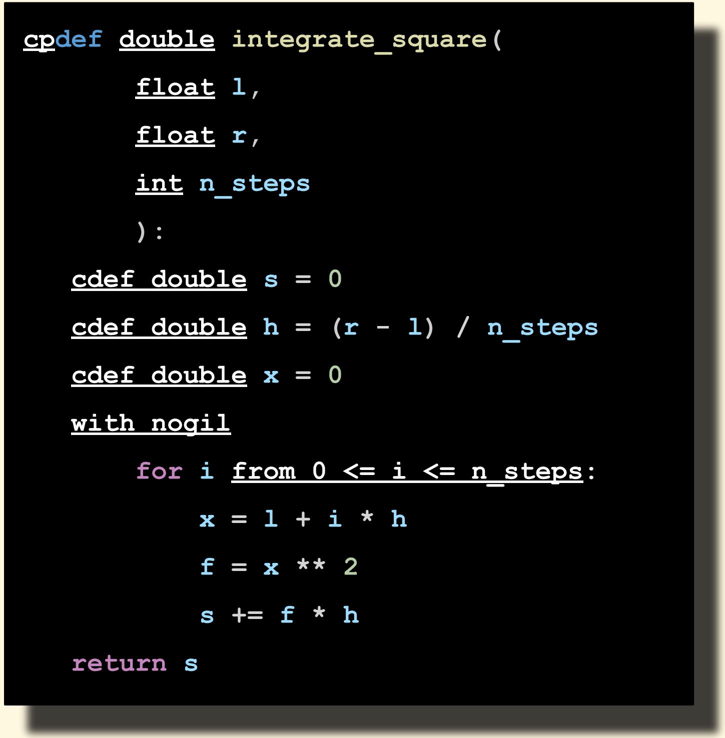
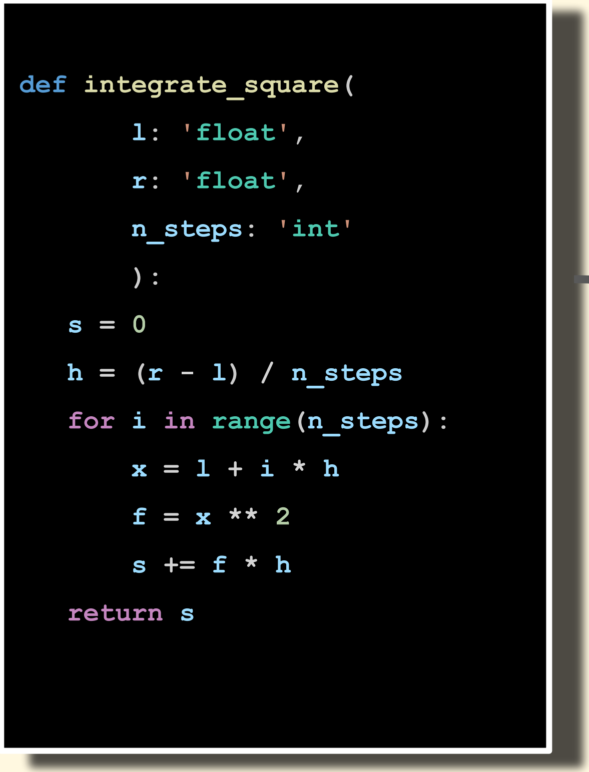
```

/* C-fication */



```cython
cpdef double integrate_square(
        float l,
        float r,
        int n_steps
        ):
    cdef double s = 0
    cdef double h = (r - l) / n_steps
    cdef double x = 0
    with nogil
        for i from 0 <= i <= n_steps:
            x = l + i * h
            f = x ** 2
            s += f * h
    return s
```

Ex. `with nogil`



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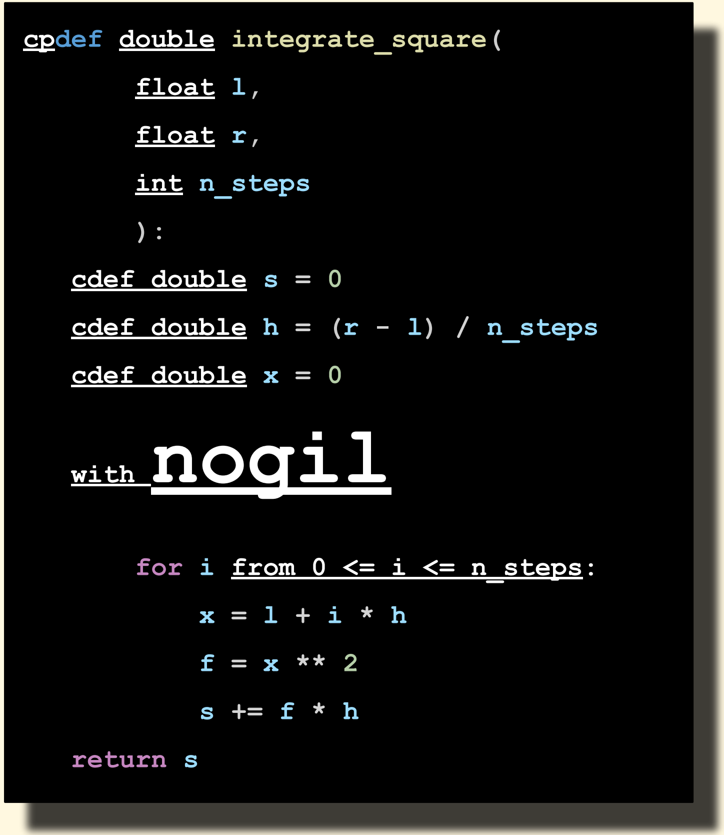

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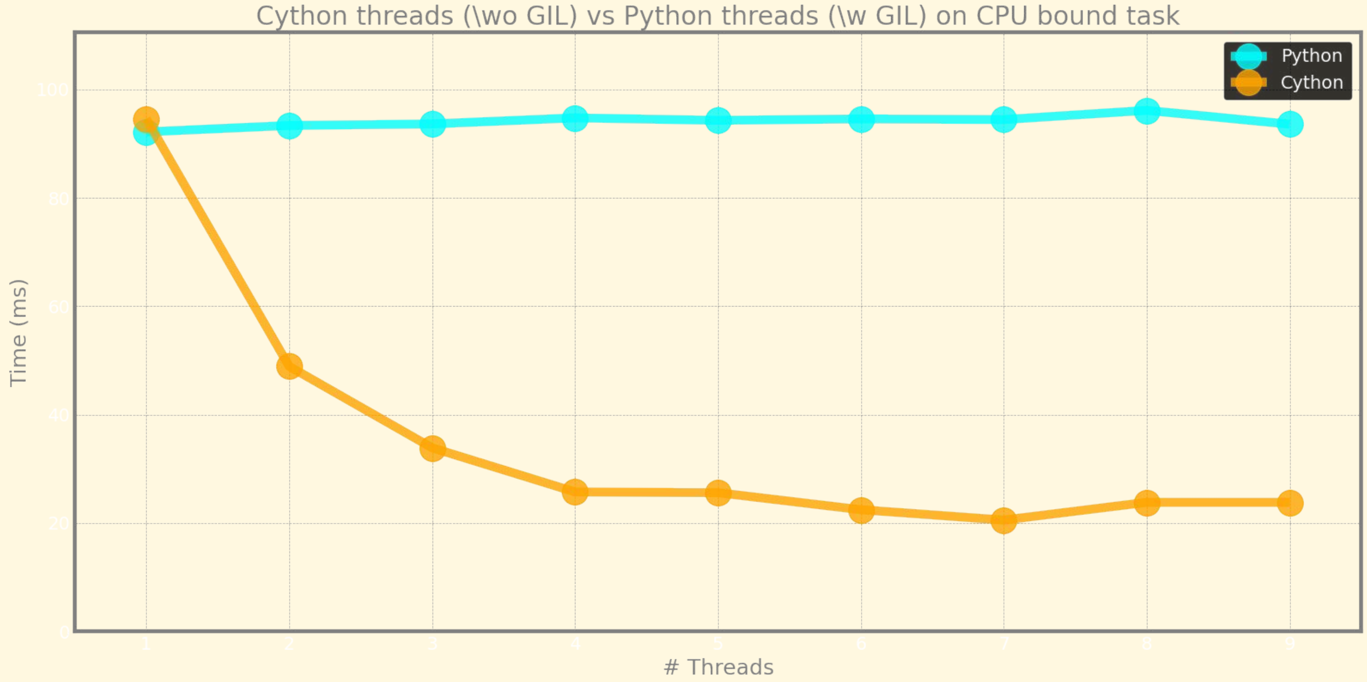

It really works!

Let's have some fun:

- *break python even with GIL,*
- *steal a little money,*
- *compile the python code,*
- *avoid the fucking GIL and*
- *break semaphore*

GitHub