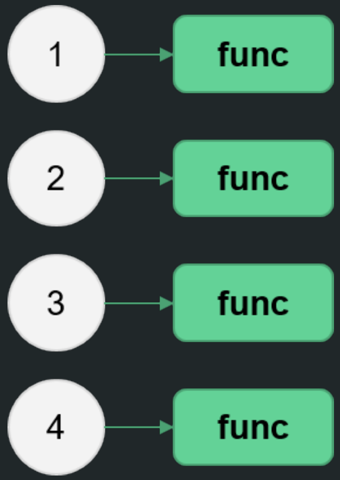
Parallel Python



Aitor Morales-Gregorio
Zbigniew Jędrzejewski-Szmek

ASPP 2025, Plovdiv

Fork/clone the repo now!

Outline

- Processes, threads and THE GIL
- Hands-on investigations of embarrassingly parallel problems
    A. Multithreading with NumPy
    B. The `multiprocessing` package
    C. Blending processes and threads
- Going further
- Wrap-up

Exercise: brainstorm

Why do we parallelize?

Talk to your partner and come up with three practical examples of where parallelization could be beneficial (in your work or another application).

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In short, two reasons why:

- Speed up computations.
- Process “big” things.

As for the “how”...we’ll come back to that later.

Processes, threads and the *GIL*

Kitchen-2-Computer analogy

Customer
Gives orders

Large Pantry
across the street

Workstation
Includes chef, tiny countertop and tools

Transport servants
Carry stuff

Big Countertop
temporarily holds things

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Talk to your partner:
What is what?

The шопска салата program

We need to make a single dish:
<u>шопска салата</u>.

This requires:

1. Fetch vegetables from pantry
2. Wash vegetables
3. Fetch cheese from pantry
4. Grate cheese
5. Chop vegetables
6. Combine veggies and cheese
7. Place salad in the pantry

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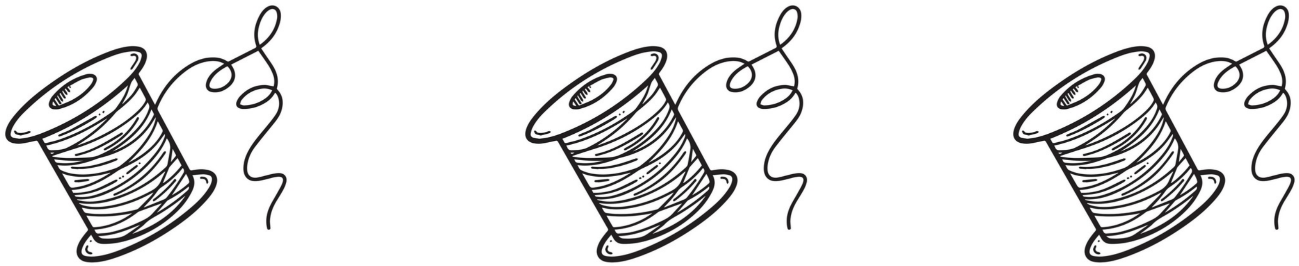
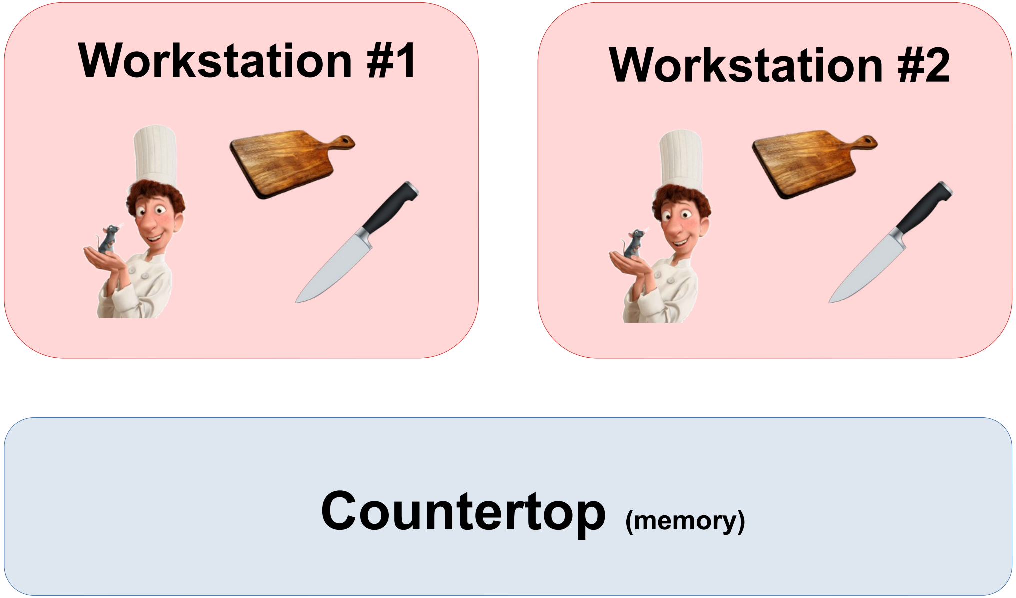
Talk to your partner:
How can we make шопска салата faster?
Without kitchen renovations

Yay! We have just designed a

multi-<u>thread</u>ed program



The restaurant owner made the kitchen larger!



So everything is twice as fast, **right?**

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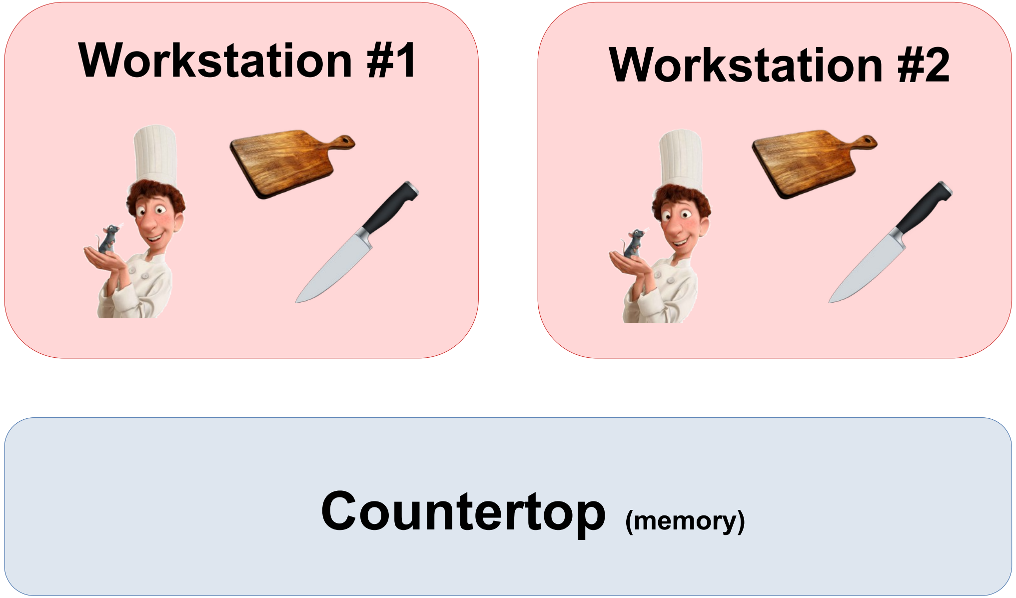


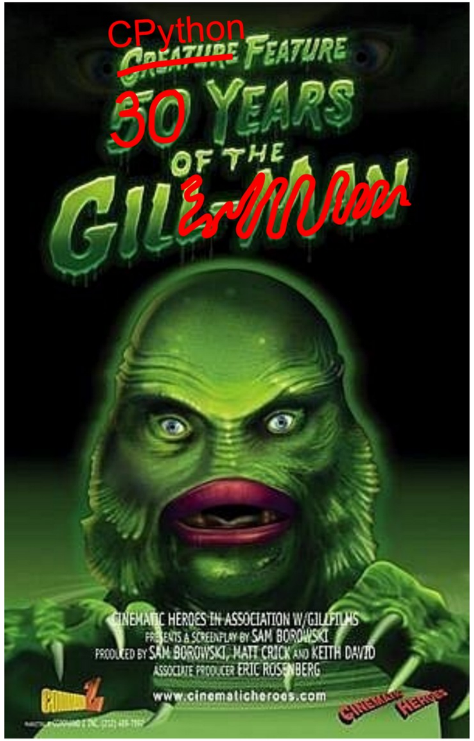
Problem #1:
Memory corruption

Problem #2:
Race conditions

Race conditions

(Live coding)

Python’s approach: The *Global Interpreter Lock* (GIL)



* A mutual exclusion (mutex) lock.

* Within the Python process, only 1 thread is allowed to execute pure-Python code in a given instance. Leading to **NO SPEED-UP** from multithreading.

* The lock is acquired and released by threads, approximately every 100 bytecode instructions. Also released in other cases, e.g., I/O.

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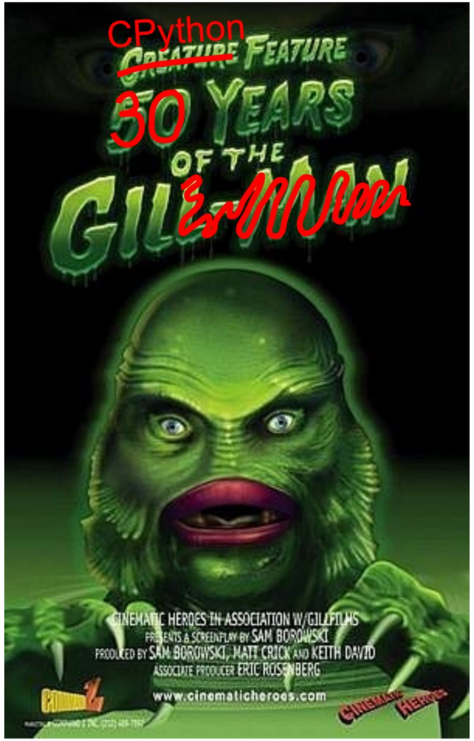

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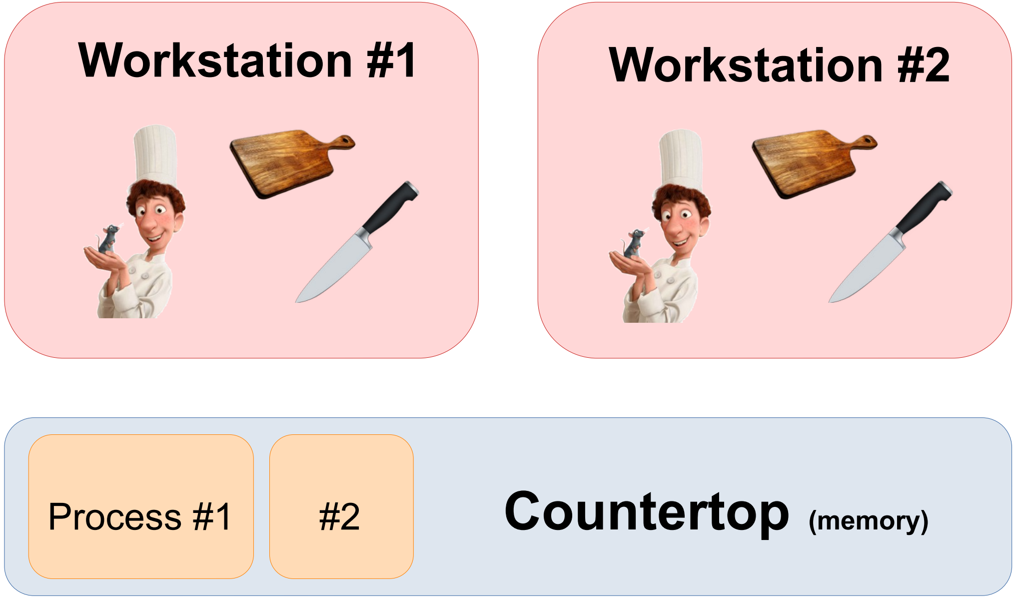
<u>Hypothesize with your partner:</u>
NumPy can achieve *massive speed-up* from multithreading. How is this possible?

NumPy's trick

NumPy runs compiled non-Python code, which operate free of the GIL

In other words, it is *many* threads disguised as one!

Faster solution: Protect the memory



<u>Multi-processing:</u>
Each process gets assigned <u>private memory</u>, other processes cannot read or write from it*, if they try there will be an error (*Segmentation Fault*)

*usually

Who does this?
The Operating System (OS)

Faster solution: Protect the memory

Great for embarrassingly parallel problems!

Workstation #1

Workstation #2

Process #1

#2

Countertop **(memory)**

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Who does this?
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Process
* List of instructions, i.e. an instance of some program
* Has private memory
* Can be made up of one or more threads
* Is not a physical part of the computer, it is defined by the rules of the OS

Thread
* Some instructions from the program (all instructions if single-threaded)
* Always part of a process
* Shares memory with other threads of the same process

Processes and threads do not run on a specific CPU,
the OS will allocate them and can move them mid-run

To wrap things up…a pop quiz!

On your pair computer, please navigate to **play.blooket.com** and enter game pin

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