Introduction to Dask

PARALLEL PROGRAMMING WITH DASK IN PYTHON

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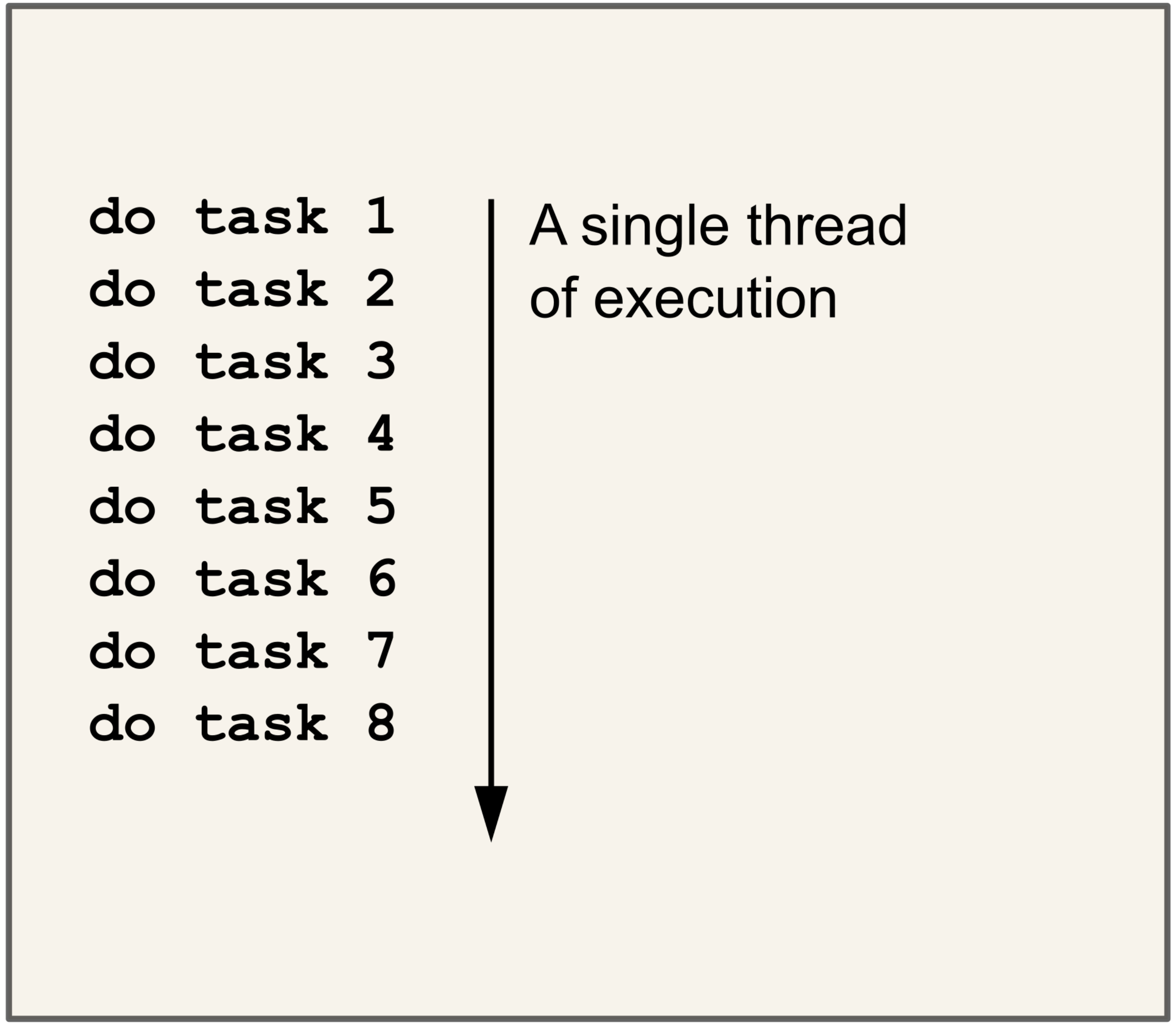
datacamp

Speeding up computations using multiple cores

- Computers have multiple cores
- Code needs to be written to use them
- The Dask package can be used to do this
- Complete our computations faster

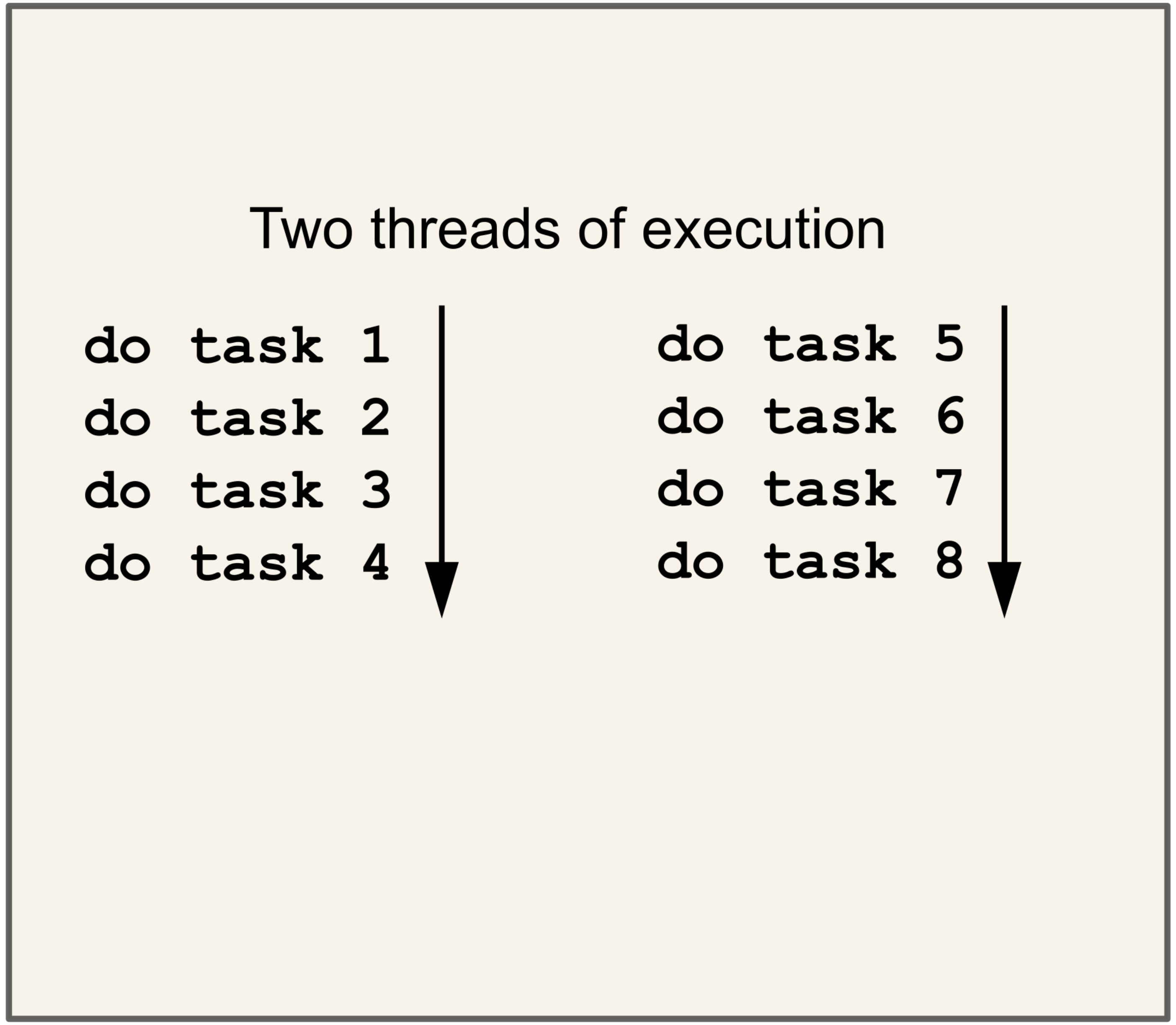
Concurrent programming



```
do task 1
do task 2
do task 3
do task 4
do task 5
do task 6
do task 7
do task 8
```

A single thread of execution

Multi-threading

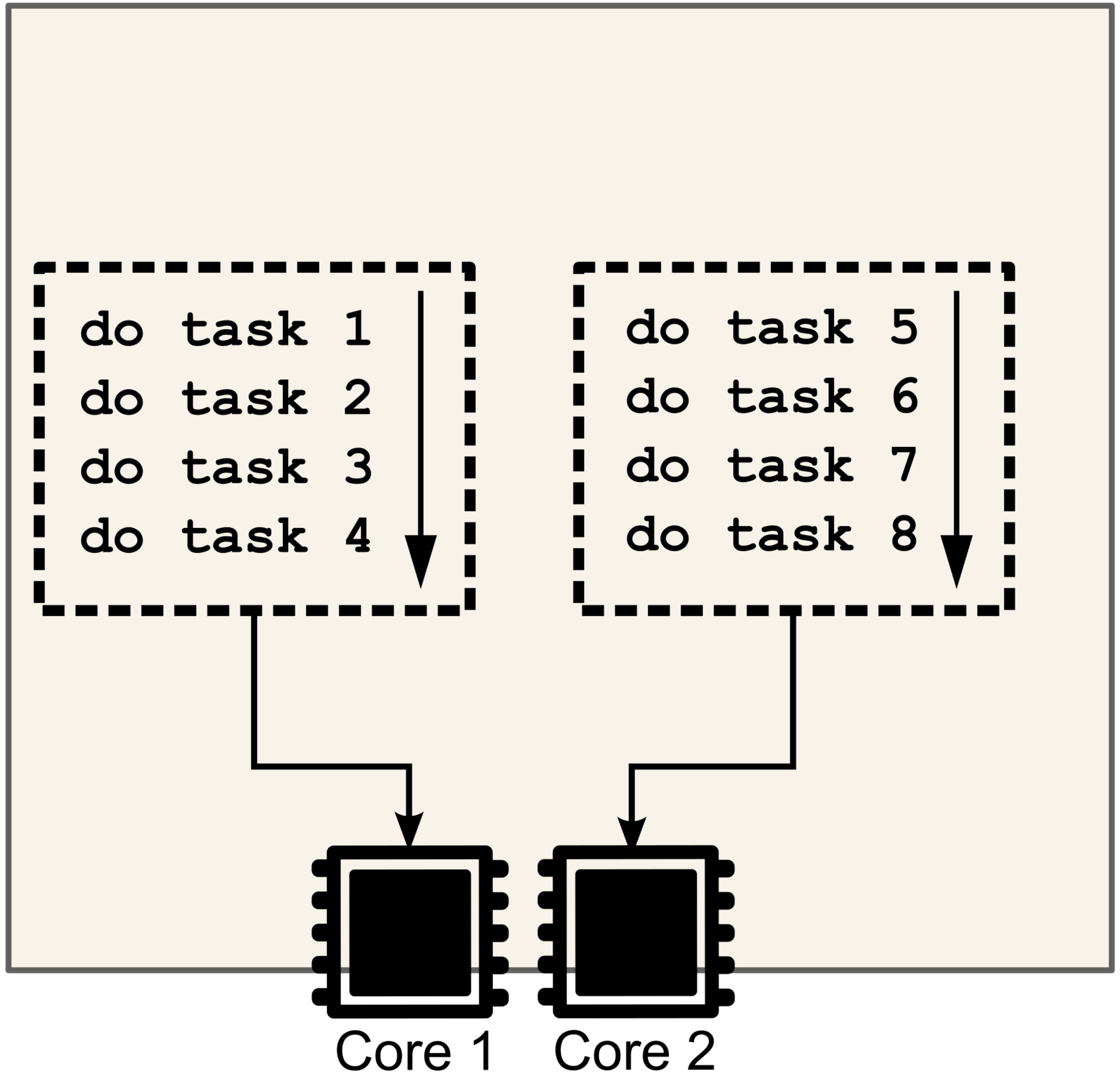


Two threads of execution

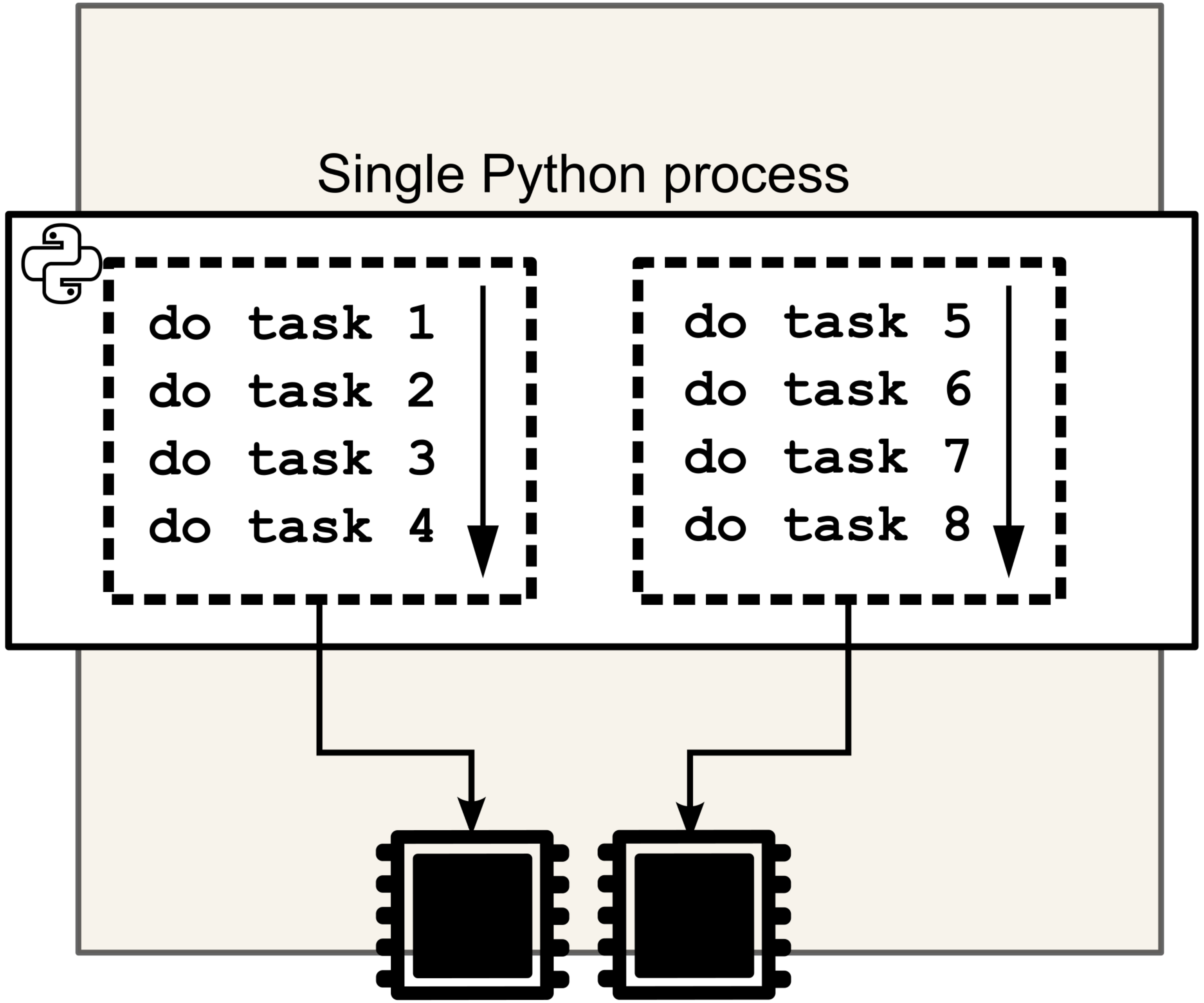
```
do task 1
do task 2
do task 3
do task 4
```

```
do task 5
do task 6
do task 7
do task 8
```

Multi-threading



Multi-threading

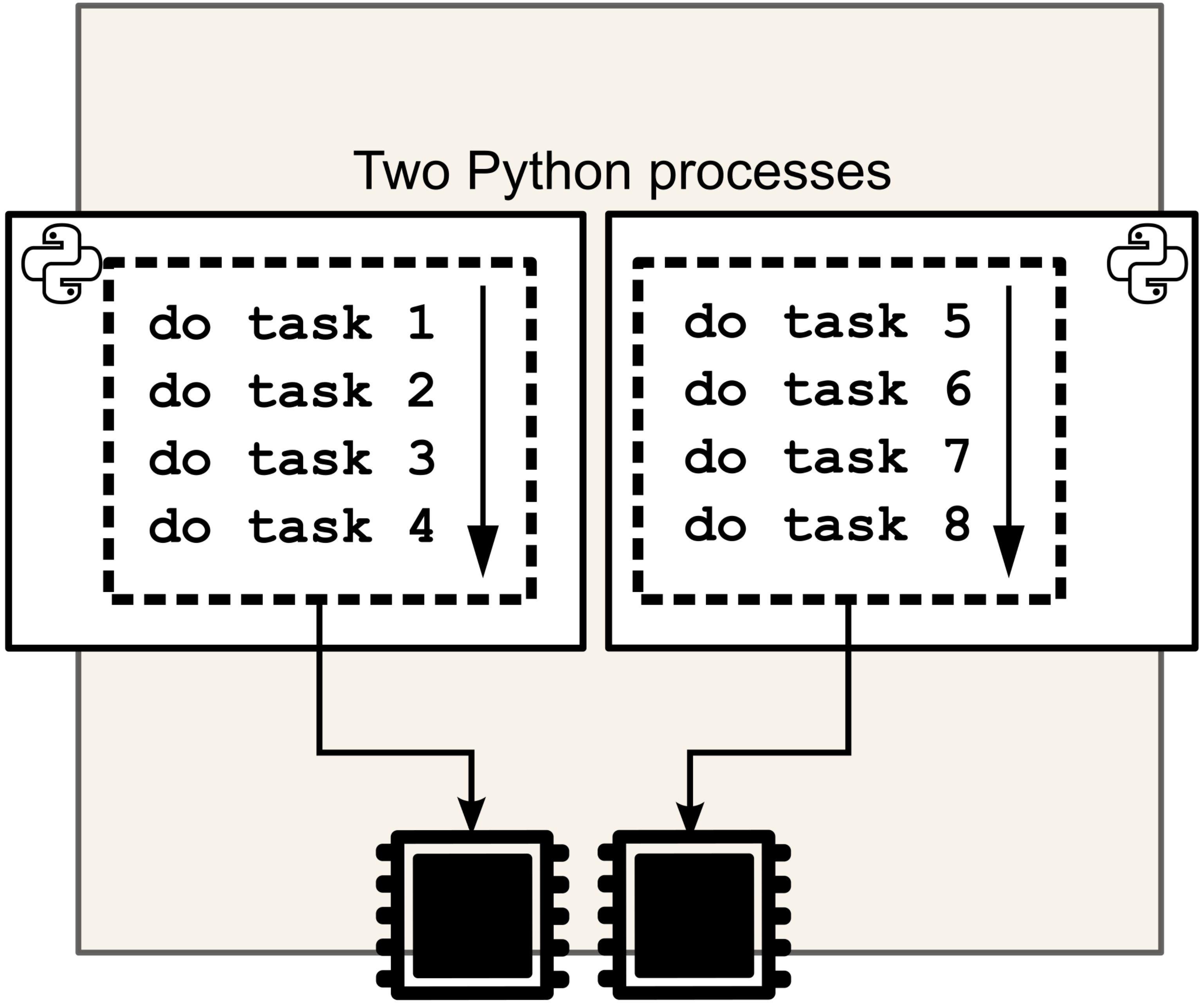


Single Python process

```
do task 1
do task 2
do task 3
do task 4
```

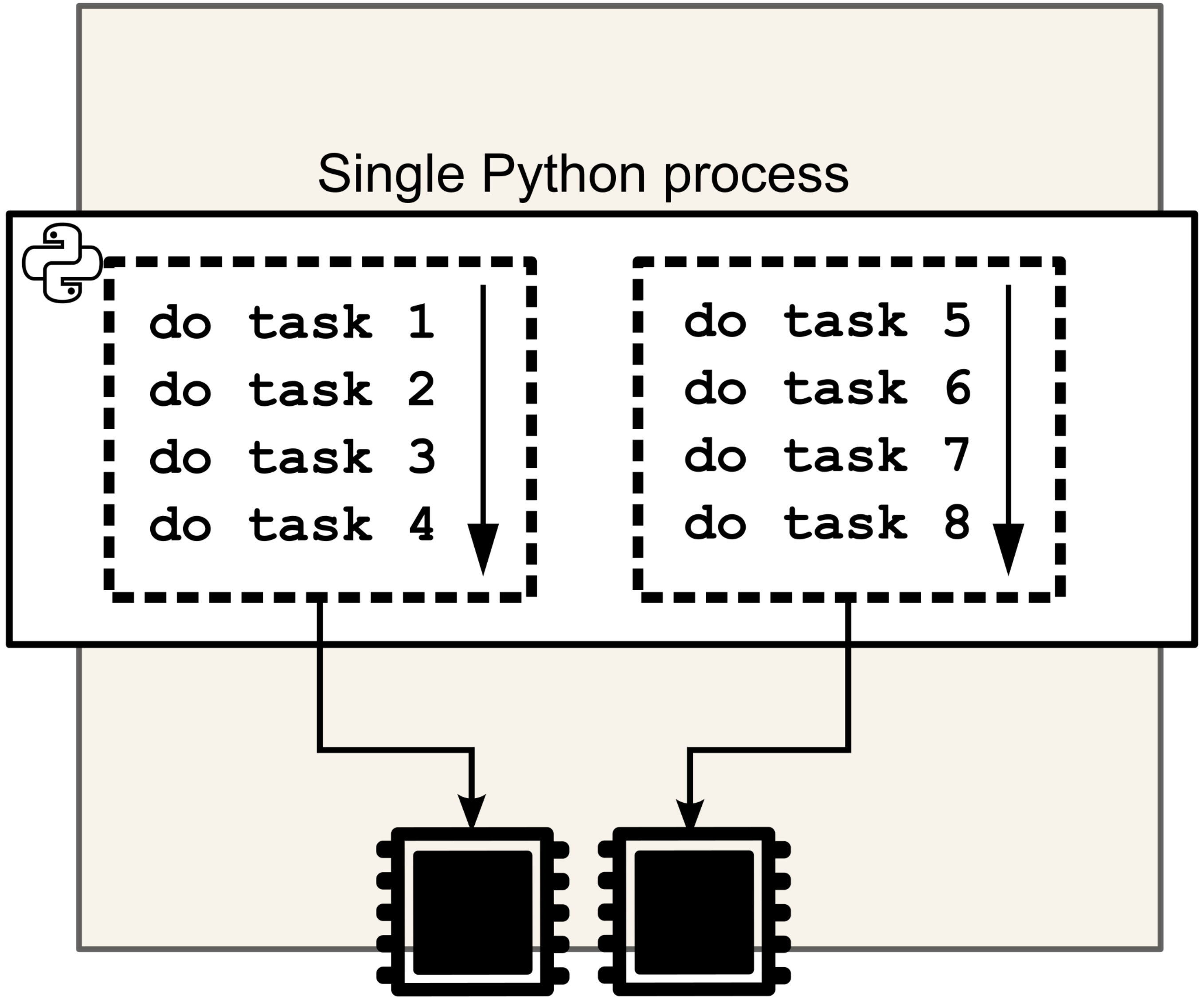
```
do task 5
do task 6
do task 7
do task 8
```

Parallel processing

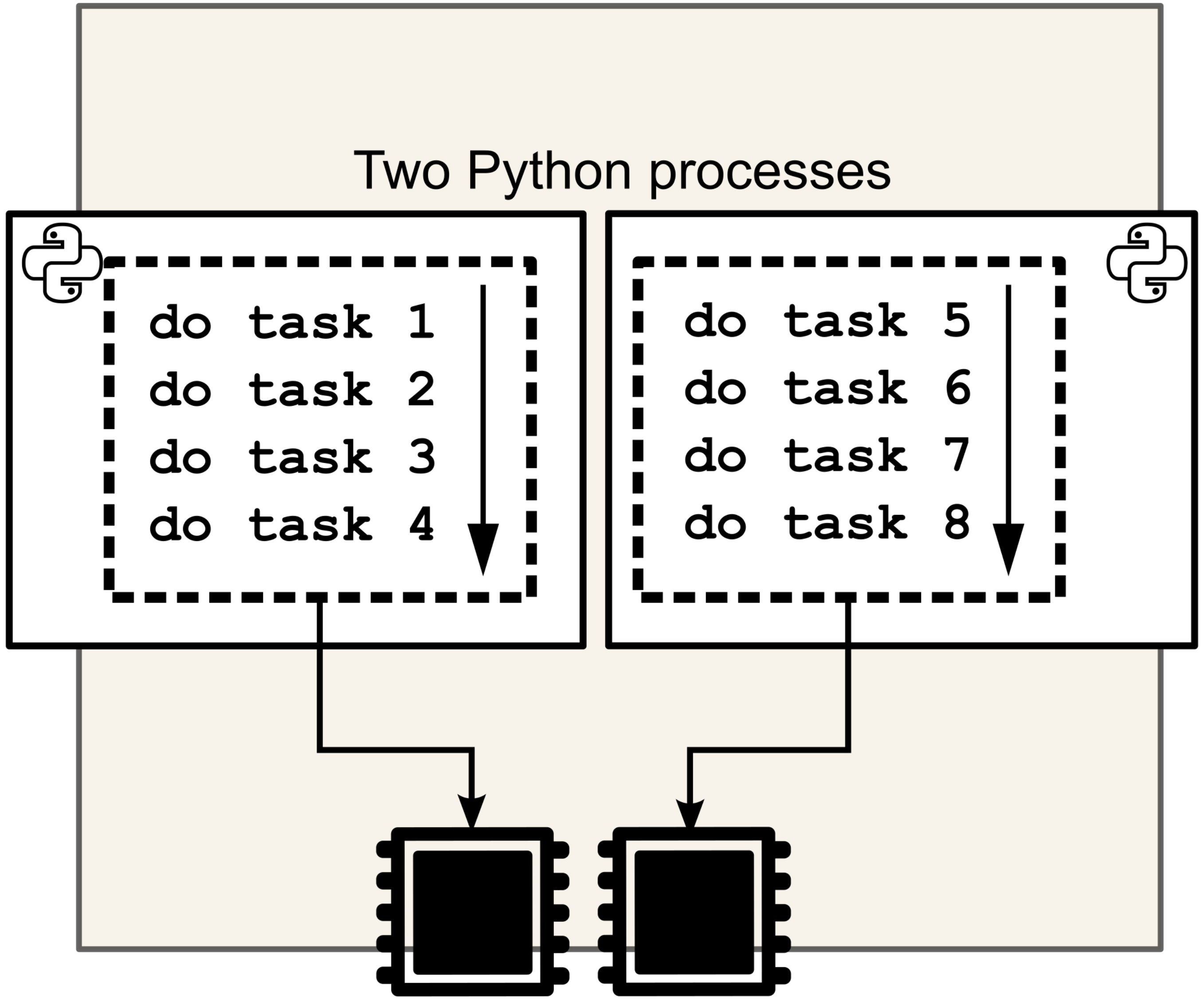


Parallel programming

Multi-threading



Parallel processing



Lazy evaluation

- Computations are not run until the moment the result is needed
- The steps required to compute the result are stored for later
- Dask splits the tasks between threads or processes

Dask delayed

```python
from dask import delayed

def my_square_function(x):
    return x**2

# Create delayed version of above function
delayed_square_function = delayed(my_square_function)
```

Dask delayed

```python
from dask import delayed

def my_square_function(x):
    return x**2

# Create delayed version of above function
delayed_square_function = delayed(my_square_function)

# Use the delayed function with input 4
delayed_result = delayed_square_function(4)

# Print the delayed answer
print(delayed_result)
```

```
Delayed('my_square_function-7f71b132-70a9-457a-aa52-604e8c34f8a7')
```

Dask delayed

```python
from dask import delayed

def my_square_function(x):
    return x**2

# Delay and use function
delayed_result = delayed(my_square_function)(4)

print(delayed_result)
```

```
Delayed('my_square_function-7f71b132-70a9-457a-aa52-604e8c34f8a7')
```

Computing the answer

```python
from dask import delayed

def my_square_function(x):
    return x**2

delayed_result = delayed(my_square_function)(4)

real_result = delayed_result.compute() # <- This line is where the calculation happens

# Print the answer
print(real_result)
```

```
16
```

Using operations on delayed objects

```
delayed_result1 = delayed(my_square_function)(4)

# Math operations return delayed object
delayed_result2 = (4 + delayed_result1) * 5

print(delayed_result2.compute())
```

```
100
```

Lazy evaluation

```
x_list = [30, 85, 14, 12, 27, 62, 89, 15, 78,  0]

sum_of_squares = 0

for x in x_list:
    # Square and add numbers
    sum_of_squares += delayed(my_square_function)(x)
```

Lazy evaluation

```python
x_list = [30, 85, 14, 12, 27, 62, 89, 15, 78,  0]

sum_of_squares = 0

for x in x_list:
    # Square and add numbers
    sum_of_squares += delayed(my_square_function)(x)

result = sum_of_squares.compute()

# Print the answer
print(result)
```

```
27268
```

Sharing computation

```
delayed_intermediate = delayed(my_square_function)(3)

# These two results both use delayed_intermediate
delayed_result1 = delayed_intermediate - 5
delayed_result2 = delayed_intermediate + 4

# delayed_3_squared will be computed twice
print('delayed_result1:', delayed_result1.compute())
print('delayed_result2:', delayed_result2.compute())
```

```
delayed_result1: 4
delayed_result2: 13
```

Sharing computation

```
import dask

# delayed_intermediate will be computed once
comp_result1, comp_result2 = dask.compute(delayed_result1, delayed_result2)

print('comp_result1:', comp_result1)
print('comp_result2:', comp_result2)
```

```
delayed_result1: 4
delayed_result2: 13
```

Let's practice!

Task graphs and scheduling methods

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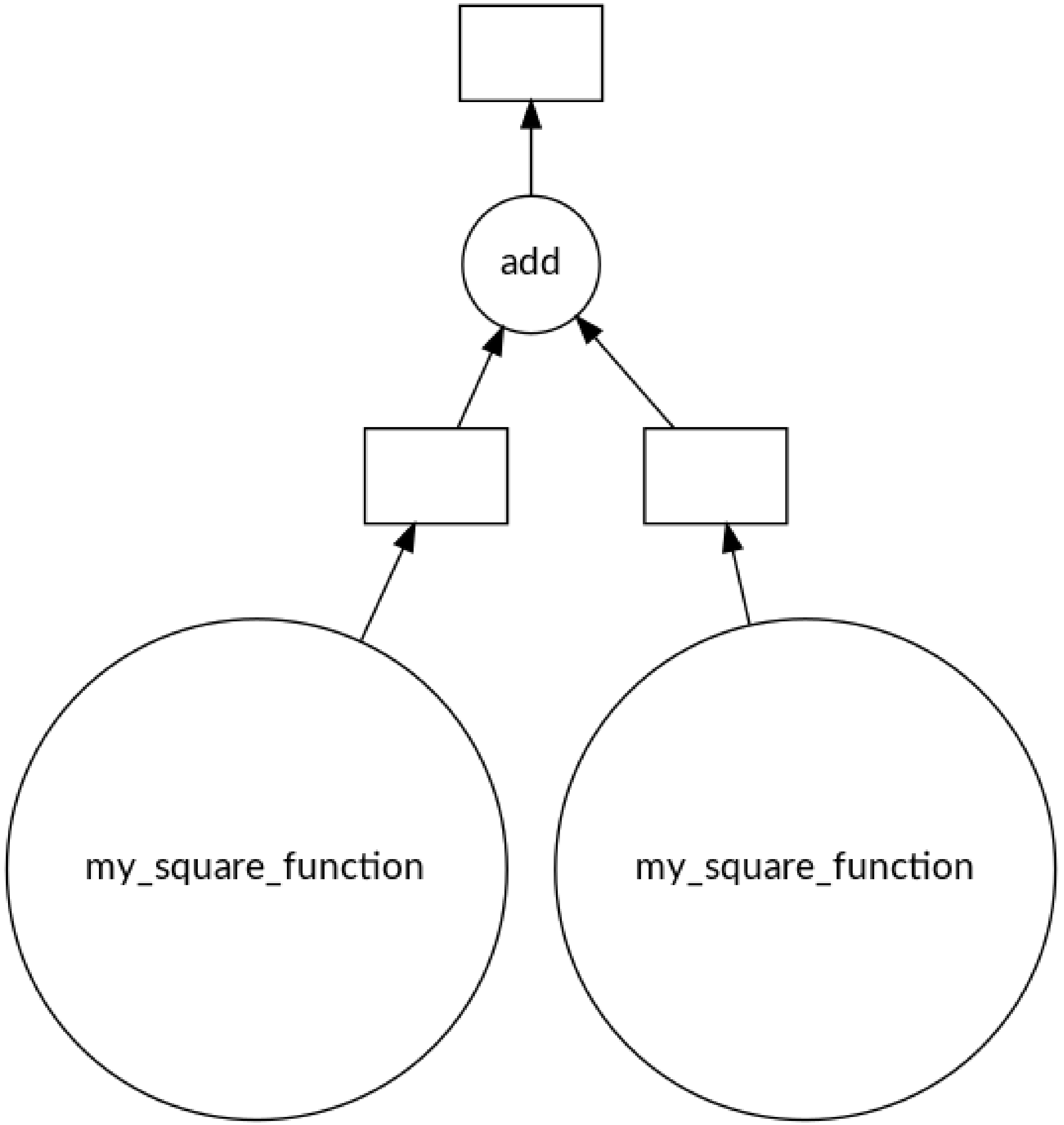
Visualizing a task graph

```python
# Create 2 delayed objects
delayed_num1 = delayed(my_square_function)(3)
delayed_num2 = delayed(my_square_function)(4)

# Add them
result = delayed_num1 + delayed_num2

# Plot the task graph
result.visualize()
```

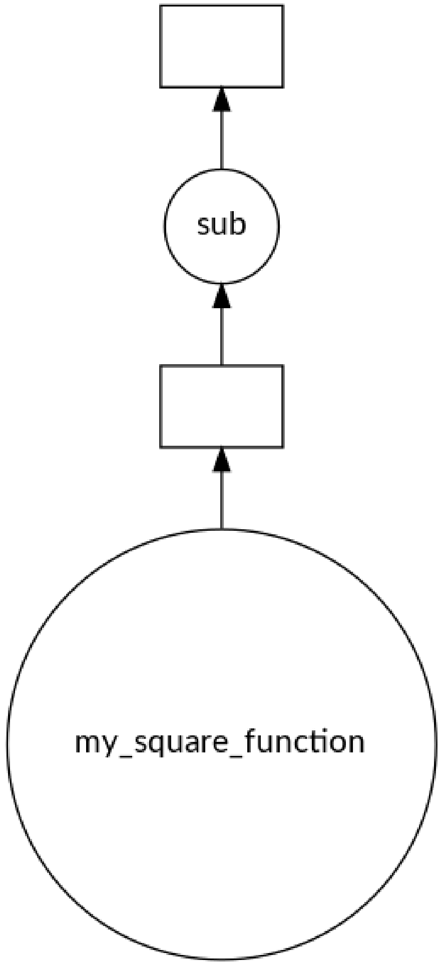


Overlapping task graph

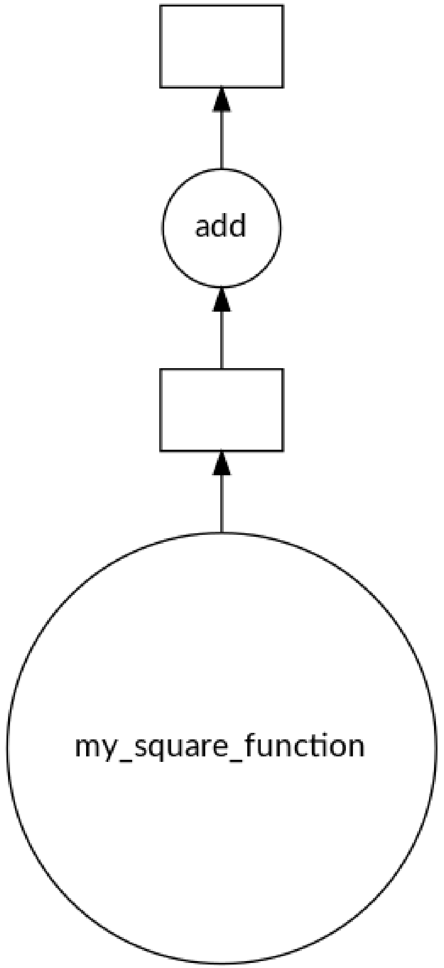
```
delayed_intermediate = delayed(my_square_function)(3)


# These two results both use delayed_intermediate_result
delayed_result1 = delayed_intermediate - 5
delayed_result2 = delayed_intermediate + 4
```

Overlapping task graph

```
delayed_result1.visualize()
```

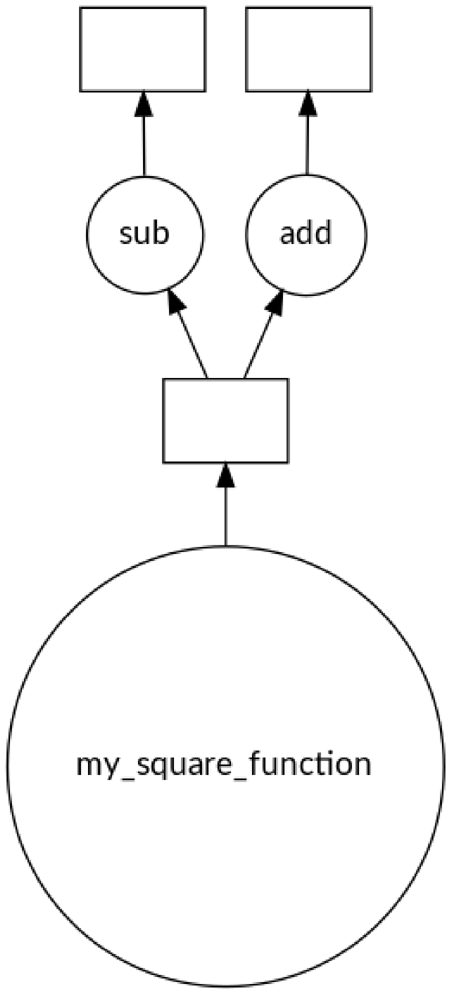


```
delayed_result2.visualize()
```



Overlapping task graph

```
# Plot the task graph
dask.visualize(delayed_result1, delayed_result2)
```



Multi-threading vs. parallel processing

Moving data

Parallel processing

- Processes have their own RAM space

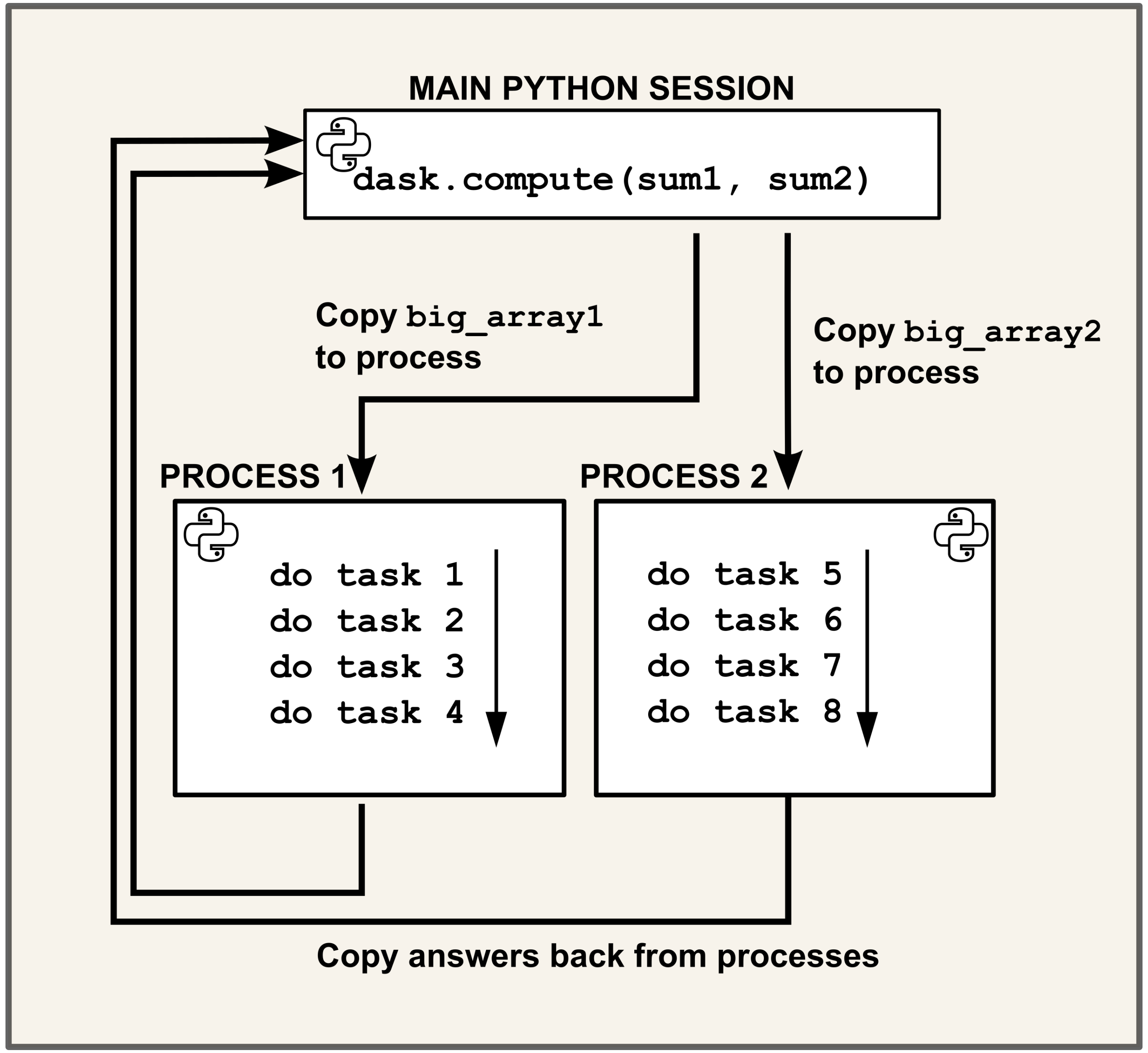
Multi-threading

- Threads use the same RAM space

Multi-threading vs. parallel processing

```
# Run a sum on two big arrays
sum1 = delayed(np.sum)(big_array1)
sum2 = delayed(np.sum)(big_array2)

# Compute using processes
dask.compute(sum1, sum2)
```

- Slow using parallel processing



MAIN PYTHON SESSION

```
dask.compute(sum1, sum2)
```

Copy `big_array1` to process

Copy `big_array2` to process

PROCESS 1

```
do task 1
do task 2
do task 3
do task 4
```

PROCESS 2

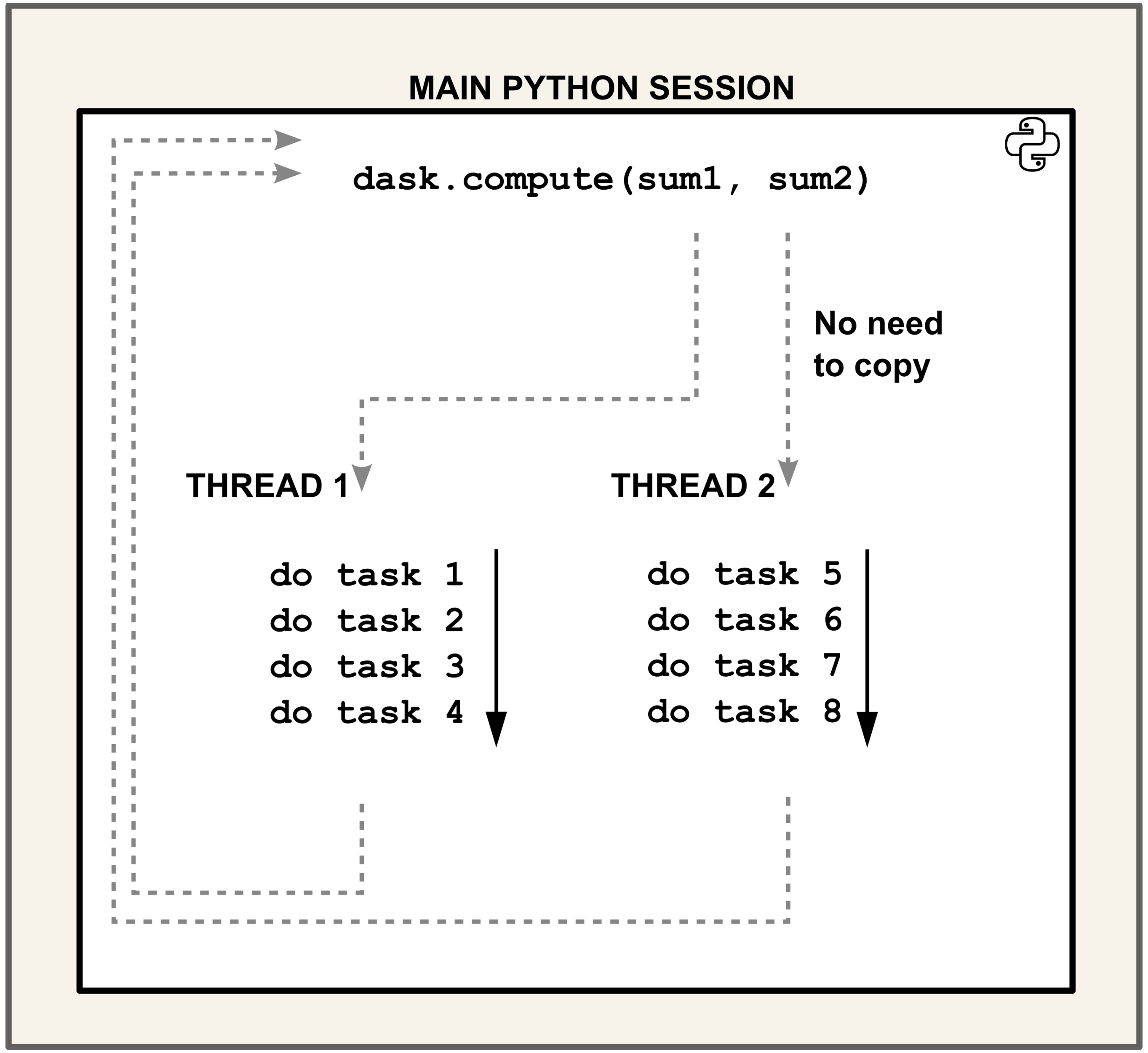
```
do task 5
do task 6
do task 7
do task 8
```

Copy answers back from processes

Multi-threading vs. parallel processing

```
# Run a sum on two big arrays
sum1 = delayed(np.sum)(big_array1)
sum2 = delayed(np.sum)(big_array2)

# Compute using threads
dask.compute(sum1, sum2)
```

- Fast using multi-threading



```
dask.compute(sum1, sum2)
```

```
do task 1
do task 2
do task 3
do task 4
```

```
do task 5
do task 6
do task 7
do task 8
```

The GIL

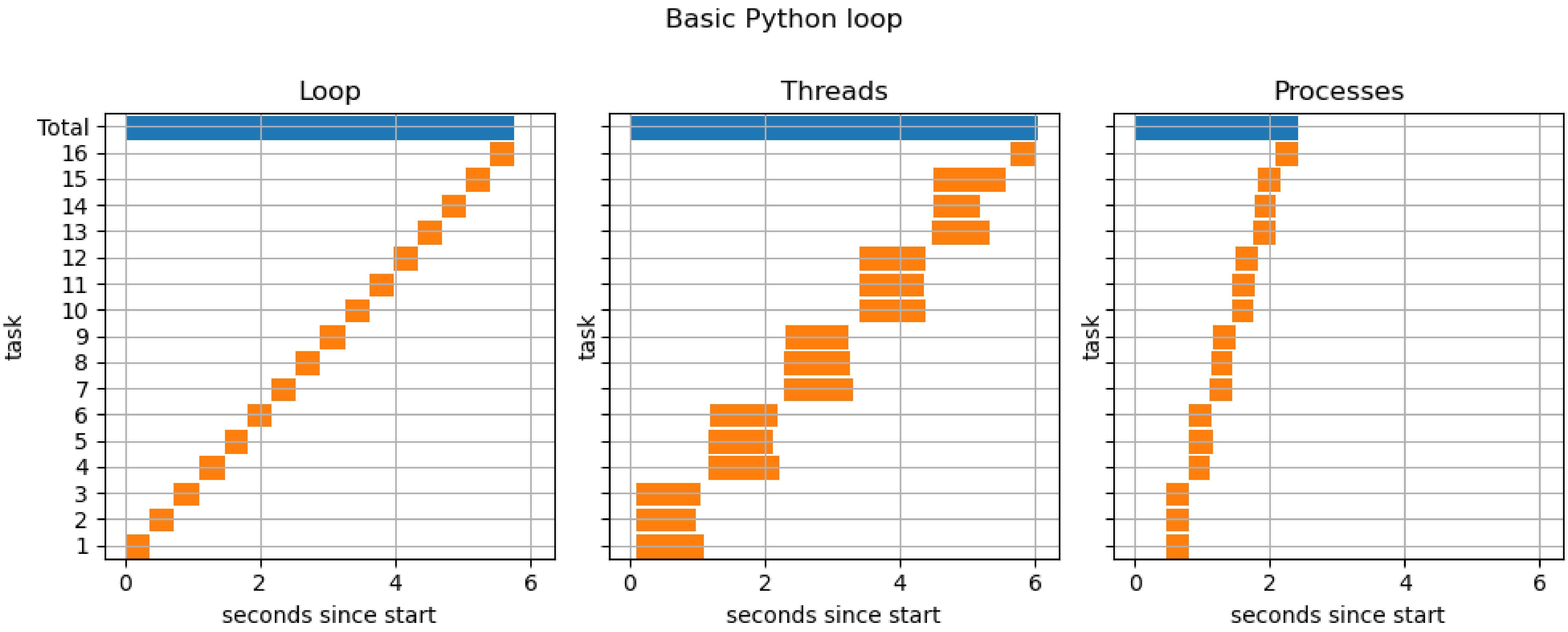
Global interpreter lock - only one thread can read the Python script at a time

```python
def sum_to_n(n):
    """Sums numbers from 0 to n"""
    total = 0
    for i in range(n+1):
        total += i
    return total
```

- Multi-threading won't help here
- Parallel processing will

```python
sum1 = delayed(sum_to_n)(1000)
sum2 = delayed(sum_to_n)(1000)
```

Example timings - GIL

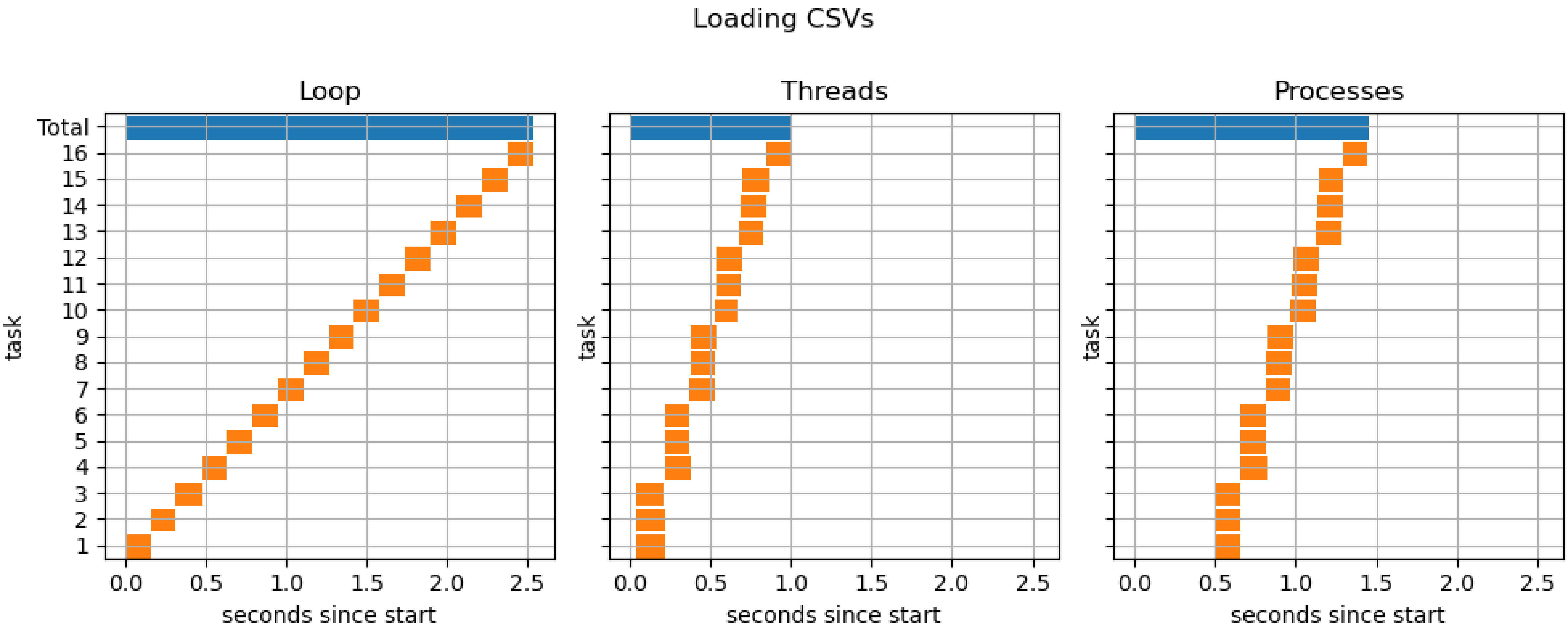


Functions which release the GIL

- E.g. the `pd.read_csv()` function releases the GIL

```
df1 = delayed(pd.read_csv)('file1.csv')
df2 = delayed(pd.read_csv)('file2.csv')
```

Example timings - Loading data



Summary

Threads

- Are very fast to initiate
- Share memory space with main session
- No memory transfer needed
- Limited by the GIL, which allows one thread to read the code at once

Processes

- Take time and memory to set up
- Have separate memory pools
- Very slow to transfer data between themselves and to the main Python session
- Each have their own GIL and so don't need to take turns reading the code

Let's practice!

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Building delayed pipelines

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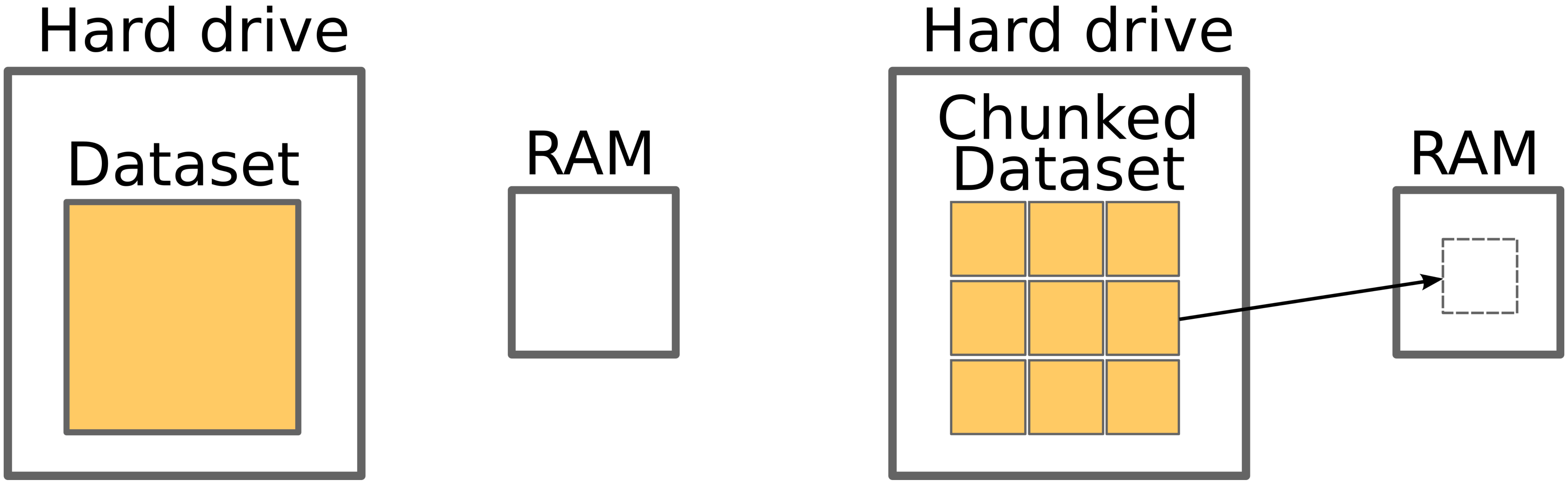
Chunks of data



Spotify songs dataset

```
files = [
   '2005_tracks.csv',
   '2006_tracks.csv',
   '2007_tracks.csv',
   '2008_tracks.csv',
   '2009_tracks.csv',
   '2010_tracks.csv',
   ...
   '2020_tracks.csv',
]
```

Spotify songs dataset

```
                       name  duration_ms release_date  ...
0     Aldrig (feat. Carmon)       247869   2019-01-01  ...
2  2019 - The Year to Build       288105   2019-01-01  ...
3                 Na zawsze       186812   2019-01-01  ...
4         Humo en la Trampa       258354   2019-01-01  ...
5                     Au Au       176000   2019-01-01  ...
...                     ...          ...          ...  ...
```

Analyzing the data

```python
import pandas as pd

maximums = []

for file in files:
    # Load each file
    df = pd.read_csv(file)
    # Find maximum track length in each file
    max_length = df['duration_ms'].max()
    # Store this maximum
    maximums.append(max_length)

# Find the maximum of all the maximum lengths
absolute_maximum = max(maximums)
```

Analyzing the data

```python
import pandas as pd

maximums = []

for file in files:
    # Load each file
    df = delayed(pd.read_csv)(file) # <------- delay loading
    # Find maximum track length in each file
    max_length = df['duration_ms'].max()
    # Store this maximum
    maximums.append(max_length)

# Find the maximum of all the maximum lengths
absolute_maximum = max(maximums)
```

Analyzing the data

```python
import pandas as pd

maximums = []

for file in files:
    # Load each file
    df = delayed(pd.read_csv)(file) # <-------- delay loading
    # Find maximum track length in each file
    max_length = df['duration_ms'].max()
    # Store this maximum
    maximums.append(max_length)

# Find the maximum of all the maximum lengths
absolute_maximum = delayed(max)(maximums) # <-------- delay max() function
```

Using methods of a delayed object

```python
import pandas as pd

maximums = []

for file in files:
    df = delayed(pd.read_csv)(file)
    # Use the .max() method
    max_length = df['duration_ms'].max()

    maximums.append(max_length)


absolute_maximum = delayed(max)(maximums)
```

```python
print(max_length)
```

```
Delayed('max-0602855d-3ee6-4c43-a4d2-...')
```

- Delayed object methods and properties return new delayed objects

```python
print(df.shape)
print(df.shape.compute())
```

```
Delayed('getattr-bc1e8838ab...')
(11907, 12)
```

Using methods of a delayed object

```python
import pandas as pd

maximums = []

for file in files:
    df = delayed(pd.read_csv)(file)
    # Use a method which doesn't exist
    max_length = df['duration_ms'].fake()

    maximums.append(max_length)


absolute_maximum = delayed(max)(maximums)
```

```python
print(max_length)
```

```
Delayed('max-6c026036-5daf-4b2-...')
```

- Methods aren't run until after `.compute()` is used

```python
print(max_length.compute())
```

```
...
AttributeError: 'Series' object has no
attribute 'fake'
```

Using methods of a delayed object

```
import pandas as pd

maximums = []

for file in files:
    df = delayed(pd.read_csv)(file)

    max_length = df['duration_ms'].max()
    # Add delayed object to list
    maximums.append(max_length)

# Run delayed max on delayed objects list
absolute_maximum = delayed(max)(maximums)
```

`maximums` is a list of delayed objects

```
print(maximums)
```

```
[Delayed('max-80b...'),
Delayed('max-fa15d...',
...]
```

Computing lists of delayed objects

```python
import pandas as pd

maximums = []

for file in files:
    df = delayed(pd.read_csv)(file)

    max_length = df['duration_ms'].max()
    # Add dalayed object to list
    maximums.append(max_length)

# Compute all the maximums
all_maximums = dask.compute(maximums)
```

```python
print(all_maximums)
```

```
([2539418, 4368000, ...
... 4511716, 4864333],)
```

Computing lists of delayed objects

```python
import pandas as pd

maximums = []

for file in files:
    df = delayed(pd.read_csv)(file)

    max_length = df['duration_ms'].max()

    maximums.append(max_length)

# Compute all the maximums
all_maximums = dask.compute(maximums)[0]
```

```python
print(all_maximums)
```

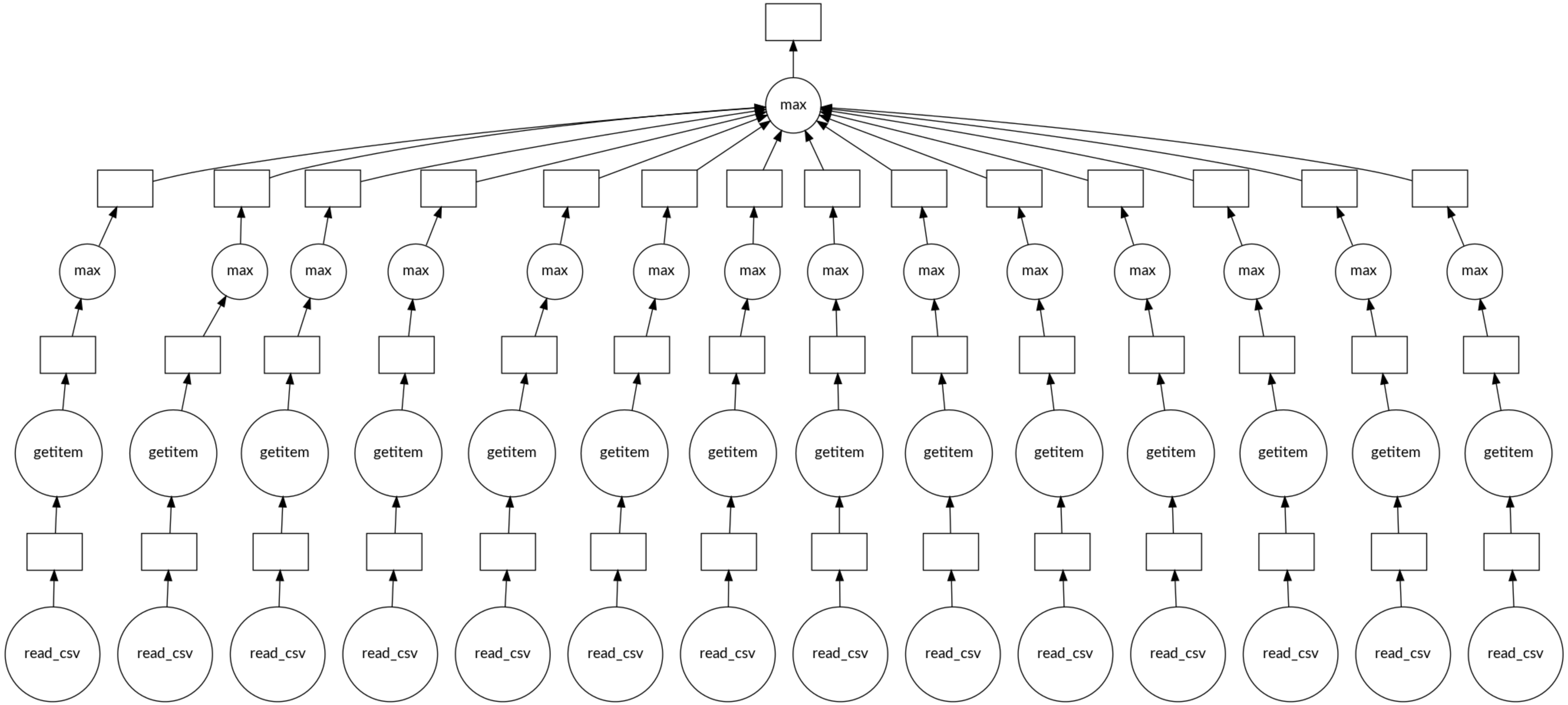
```
[2539418, 4368000, ...
... 4511716, 4864333]
```

To delay or not to delay

```python
def get_max_track(df):
    return df['duration_ms'].max()

for file in files:
    df = delayed(pd.read_csv)(file)
    # Use function to find max
    max_length = get_max_track(df)

    maximums.append(max_length)



absolute_maximum = delayed(max)(maximums)
```

Deeper task graph

```
absolute_maximum.visualize()
```



Let's practice!

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