## **Multi-Processing in Python:**

Multiprocessing in Python is a module that allows you to run multiple processes simultaneously, taking advantage of multiple CPU cores to perform tasks concurrently. This is particularly useful for CPU-bound tasks where the Global Interpreter Lock (GIL) in Python would otherwise be a bottleneck.

Here's a basic overview of how to use the multiprocessing module:

**Key Concepts**

1. **Process**: An independent sequence of execution. Each process has its own memory space.
2. **Pool**: A convenient way to parallelize the execution of a function across multiple input values.
3. **Queue**: Allows safe exchange of information between processes.
4. **Pipe**: Another way to allow processes to communicate.
5. **Manager**: Helps in sharing state between processes.

**Basic Example**

Here’s a simple example of using the multiprocessing module to run a function in parallel using multiple processes.

import multiprocessing

def worker(num):

"""Thread worker function"""

print(f'Worker: {num}')

if \_\_name\_\_ == '\_\_main\_\_':

jobs = []

for i in range(5):

p = multiprocessing.Process(target=worker, args=(i,))

jobs.append(p)

p.start()

**Using Pool**

The Pool class provides a convenient means of parallelizing the execution of a function across multiple input values, distributing the input data across processes (data parallelism).

import multiprocessing

def square(x):

return x \* x

if \_\_name\_\_ == '\_\_main\_\_':

with multiprocessing.Pool(4) as pool:

result = pool.map(square, range(10))

print(result)

**Using Queue**

The Queue class provides a thread- and process-safe way to exchange information between processes.

import multiprocessing

import time

def worker(q):

"""Thread worker function"""

time.sleep(1)

q.put('Task done')

if \_\_name\_\_ == '\_\_main\_\_':

q = multiprocessing.Queue()

p = multiprocessing.Process(target=worker, args=(q,))

p.start()

print(q.get()) # Will print 'Task done'

p.join()

**Using Manager**

The Manager class allows you to share state between processes.

import multiprocessing

def worker(d, key, value):

d[key] = value

if \_\_name\_\_ == '\_\_main\_\_':

with multiprocessing.Manager() as manager:

d = manager.dict()

jobs = []

for i in range(5):

p = multiprocessing.Process(target=worker, args=(d, i, i\*i))

jobs.append(p)

p.start()

for job in jobs:

job.join()

print(d)

**Summary**

* **Process**: Use multiprocessing.Process for running a function in a new process.
* **Pool**: Use multiprocessing.Pool for simple parallel execution of a function over a list of arguments.
* **Queue**: Use multiprocessing.Queue for safe inter-process communication.
* **Manager**: Use multiprocessing.Manager for sharing state between processes.

By using these tools, you can effectively perform parallel computation in Python, making your programs more efficient, especially for CPU-bound tasks.

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## **What is Global Interpreter Lock (GIL)**

The Global Interpreter Lock (GIL) is a mutex that protects access to Python objects, preventing multiple native threads from executing Python bytecodes at once. This lock is necessary because Python’s memory management is not thread-safe.

**Key Points about the GIL**

1. **Purpose**: The GIL ensures that only one thread executes Python bytecode at a time. This makes the CPython interpreter (the most common implementation of Python) thread-safe.
2. **Impact on Multithreading**: The GIL can be a significant bottleneck in CPU-bound and multithreaded programs, as it forces threads to execute one at a time, rather than truly concurrently. This means that even on multi-core systems, Python programs that are CPU-bound do not gain performance benefits from using multiple threads.
3. **Impact on I/O-bound Programs**: The GIL is less of an issue for I/O-bound programs (e.g., those involving network communication or disk I/O), as threads often spend time waiting for I/O operations to complete. During these waits, the GIL is released, allowing other threads to run.
4. **Alternatives to Multithreading**: To bypass the GIL and achieve true parallelism, developers often use multiprocessing or other concurrency models (such as asyncio for asynchronous I/O operations).

**Example**

To illustrate the impact of the GIL, consider the following example of a CPU-bound task:

import threading

import time

def cpu\_bound\_task(n):

while n > 0:

n -= 1

if \_\_name\_\_ == '\_\_main\_\_':

start = time.time()

threads = []

for \_ in range(4): # Create 4 threads

t = threading.Thread(target=cpu\_bound\_task, args=(100000000,))

t.start()

threads.append(t)

for t in threads:

t.join()

print('Time taken:', time.time() - start)

This code creates four threads, each performing a CPU-bound task. However, due to the GIL, these threads do not run truly concurrently, leading to a longer total execution time.

**Using Multiprocessing to Bypass the GIL**

By using the multiprocessing module, each process runs in its own Python interpreter, effectively bypassing the GIL and allowing true parallelism.

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import multiprocessing

import time

def cpu\_bound\_task(n):

while n > 0:

n -= 1

if \_\_name\_\_ == '\_\_main\_\_':

start = time.time()

processes = []

for \_ in range(4): # Create 4 processes

p = multiprocessing.Process(target=cpu\_bound\_task, args=(100000000,))

p.start()

processes.append(p)

for p in processes:

p.join()

print('Time taken:', time.time() - start)

This code creates four processes, each running the CPU-bound task independently. Since each process has its own interpreter and memory space, the GIL does not impact their execution, leading to better utilization of multiple CPU cores and reduced total execution time.

**Conclusion**

* The GIL is a mechanism in CPython that ensures only one thread executes Python bytecode at a time, which simplifies memory management but limits the performance of multi-threaded, CPU-bound programs.
* For I/O-bound programs, the GIL's impact is minimal.
* To achieve true parallelism in CPU-bound programs, use the multiprocessing module, which spawns separate processes that are not subject to the GIL.