KAIROS PROJECT PRESENTATION

Data Analysis and Visualization

TEAM

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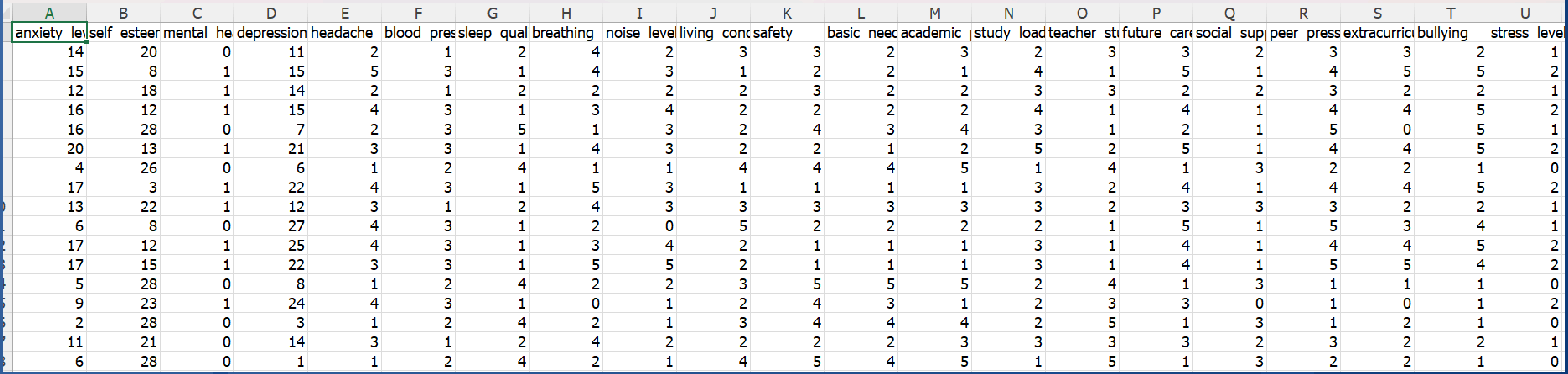
OUR OBJECTIVE

To optimize the process of analysis and visualization of data and create a better system for such task.

RECORD EXAMPLE OF OUR DATASET

This is raw data we will process and there are 20 column records to manage



A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
anxiety_lev	self_esteer	mental_hea	depression	headache	blood_pres	sleep_qual	breathing_	noise_level	living_conc	safety	basic_neec	academic_	study_load	teacher_st	future_care	social_sup	peer_press	extracurric	bullying	stress_level
14	20	0	11	2	1	2	4	2	3	3	2	3	2	3	3	2	3	3	2	1
15	8	1	15	5	3	1	4	3	1	2	2	1	4	1	5	1	4	5	5	2
12	18	1	14	2	1	2	2	2	2	3	2	2	3	3	2	2	3	2	2	1
16	12	1	15	4	3	1	3	4	2	2	2	2	4	1	4	1	4	4	5	2
16	28	0	7	2	3	5	1	3	2	4	3	4	3	1	2	1	5	0	5	1
20	13	1	21	3	3	1	4	3	2	2	1	2	5	2	5	1	4	4	5	2
4	26	0	6	1	2	4	1	1	4	4	4	5	1	4	1	3	2	2	1	0
17	3	1	22	4	3	1	5	3	1	1	1	1	3	2	4	1	4	4	5	2
13	22	1	12	3	1	2	4	3	3	3	3	3	3	2	3	3	3	2	2	1
6	8	0	27	4	3	1	2	0	5	2	2	2	2	1	5	1	5	3	4	1
17	12	1	25	4	3	1	3	4	2	1	1	1	3	1	4	1	4	4	5	2
17	15	1	22	3	3	1	5	5	2	1	1	1	3	1	4	1	5	5	4	2
5	28	0	8	1	2	4	2	2	3	5	5	5	2	4	1	3	1	1	1	0
9	23	1	24	4	3	1	0	1	2	4	3	1	2	3	3	0	1	0	1	2
2	28	0	3	1	2	4	2	1	3	4	4	4	2	5	1	3	1	2	1	0
11	21	0	14	3	1	2	4	2	2	2	2	3	3	3	3	2	3	2	2	1
6	28	0	1	1	2	4	2	1	4	5	4	5	1	5	1	3	2	2	1	0

DATA READING

OS CONCEPT WE APPLIED

1. Simulate Process Scheduling

   Break tasks into separate multiprocessing jobs

2.Optimize File I/O

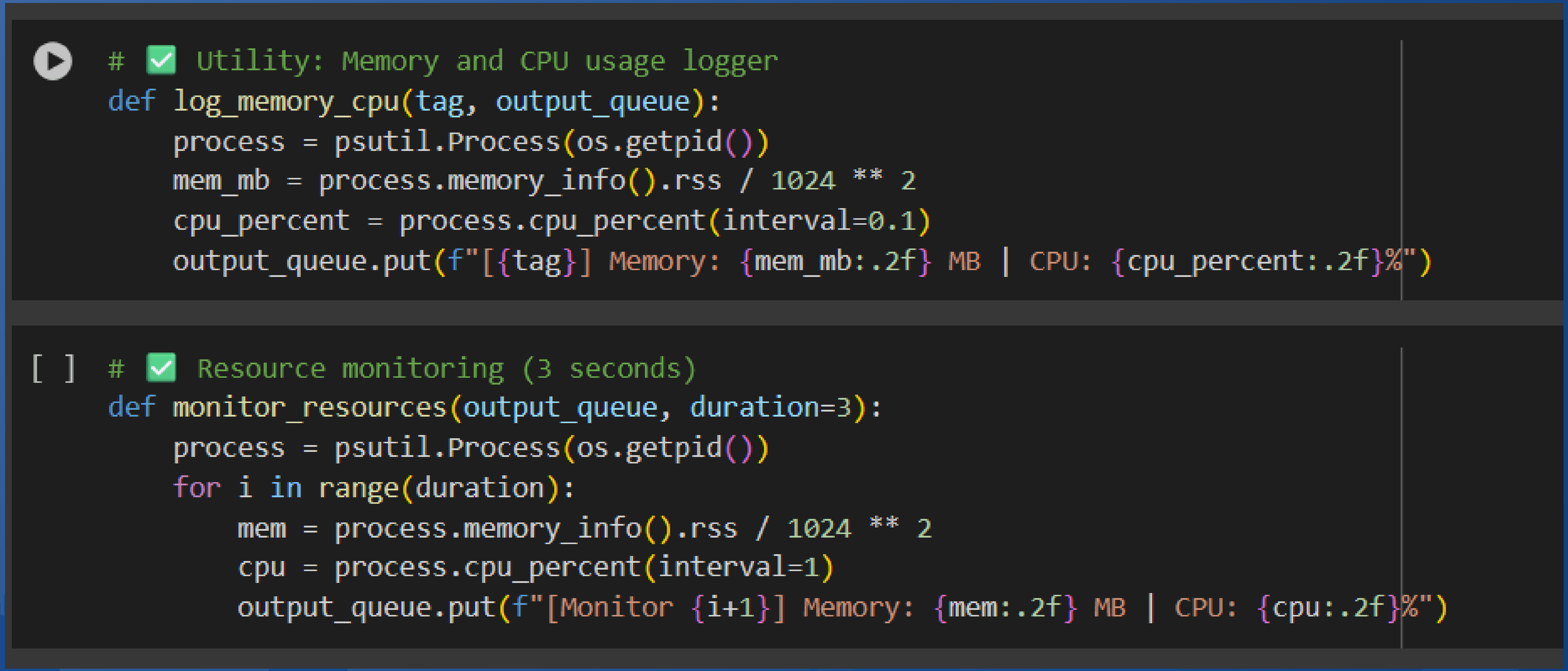
   Test and compare file reading speeds to simulate OS-level file handling.

3.Improve Memory Management

   Track how much memory each step uses — simulate what an OS does.

MEMORY MANAGEMENT

We use psutil to monitor the memory and CPU usage.

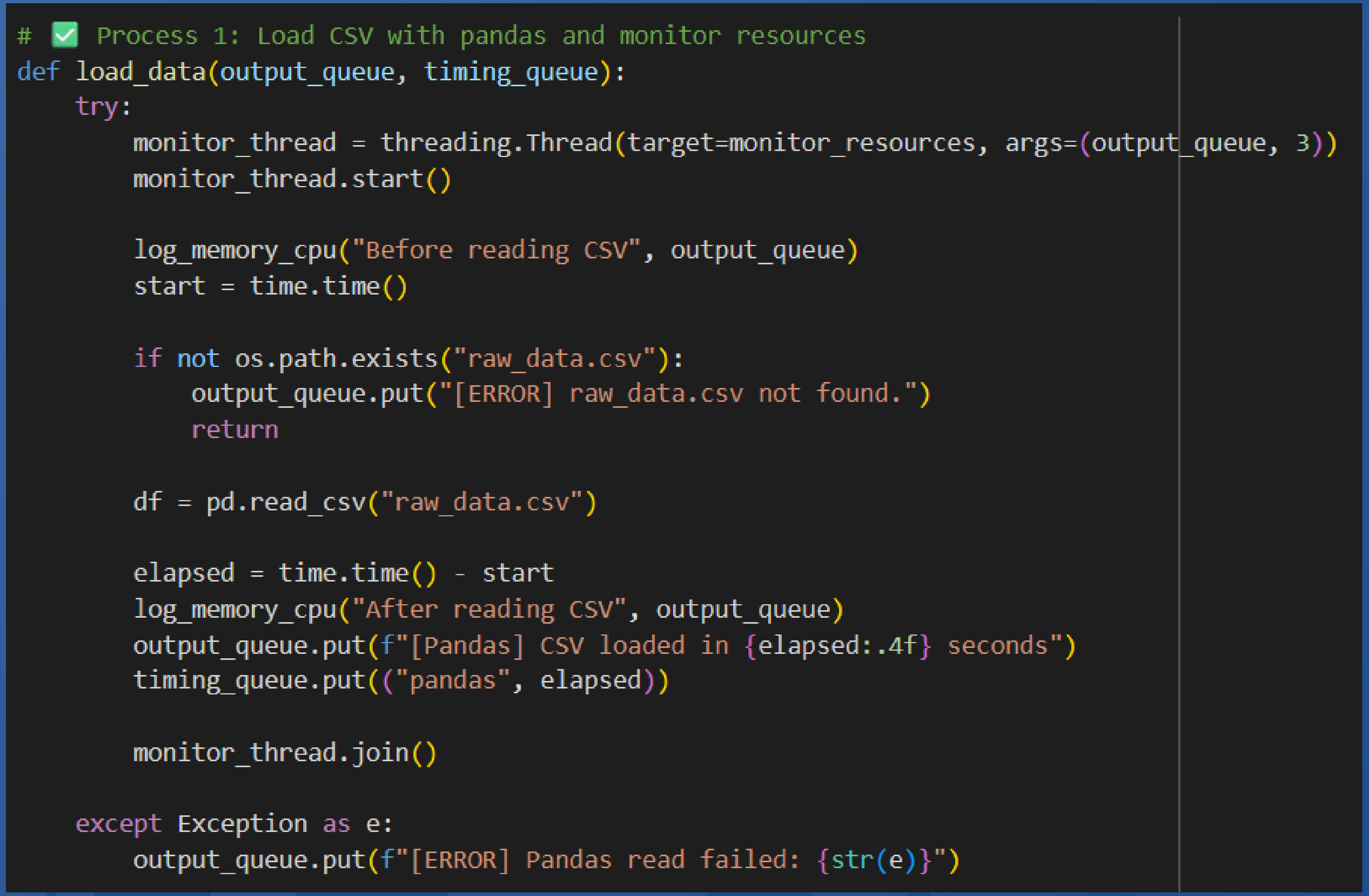


```
# ✅ Utility: Memory and CPU usage logger
def log_memory_cpu(tag, output_queue):
    process = psutil.Process(os.getpid())
    mem_mb = process.memory_info().rss / 1024 ** 2
    cpu_percent = process.cpu_percent(interval=0.1)
    output_queue.put(f"[{tag}] Memory: {mem_mb:.2f} MB | CPU: {cpu_percent:.2f}%")
```

```
# ✅ Resource monitoring (3 seconds)
def monitor_resources(output_queue, duration=3):
    process = psutil.Process(os.getpid())
    for i in range(duration):
        mem = process.memory_info().rss / 1024 ** 2
        cpu = process.cpu_percent(interval=1)
        output_queue.put(f"[Monitor {i+1}] Memory: {mem:.2f} MB | CPU: {cpu:.2f}%")
```

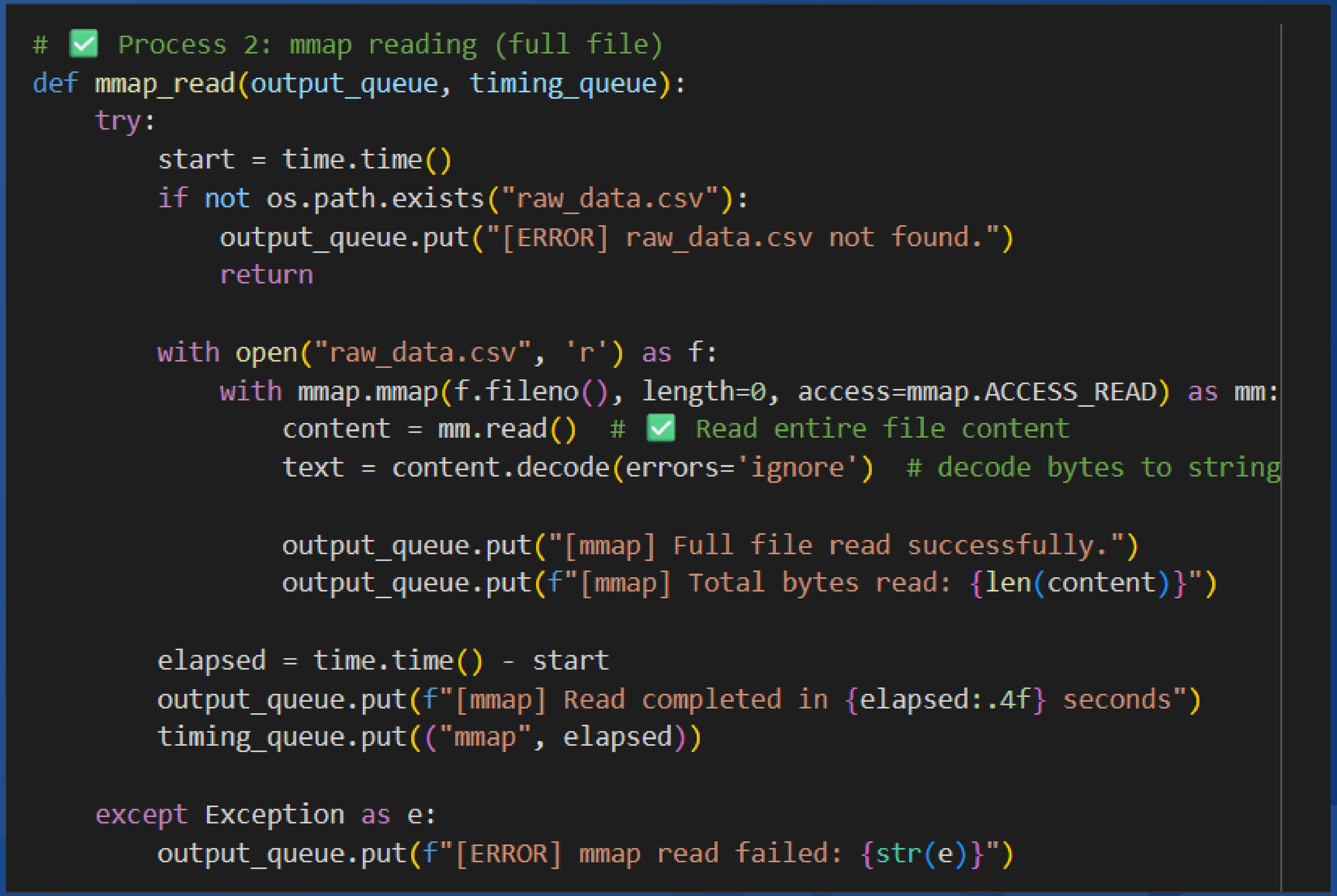
FILES I/O

Instead of downloading our file with panda, we use mmap instead. We also track the time it takes.



```python
# ✅ Process 1: Load CSV with pandas and monitor resources
def load_data(output_queue, timing_queue):
    try:
        monitor_thread = threading.Thread(target=monitor_resources, args=(output_queue, 3))
        monitor_thread.start()

        log_memory_cpu("Before reading CSV", output_queue)
        start = time.time()

        if not os.path.exists("raw_data.csv"):
            output_queue.put("[ERROR] raw_data.csv not found.")
            return

        df = pd.read_csv("raw_data.csv")

        elapsed = time.time() - start
        log_memory_cpu("After reading CSV", output_queue)
        output_queue.put(f"[Pandas] CSV loaded in {elapsed:.4f} seconds")
        timing_queue.put(("pandas", elapsed))

        monitor_thread.join()

    except Exception as e:
        output_queue.put(f"[ERROR] Pandas read failed: {str(e)}")
```

Load CSV file with panda

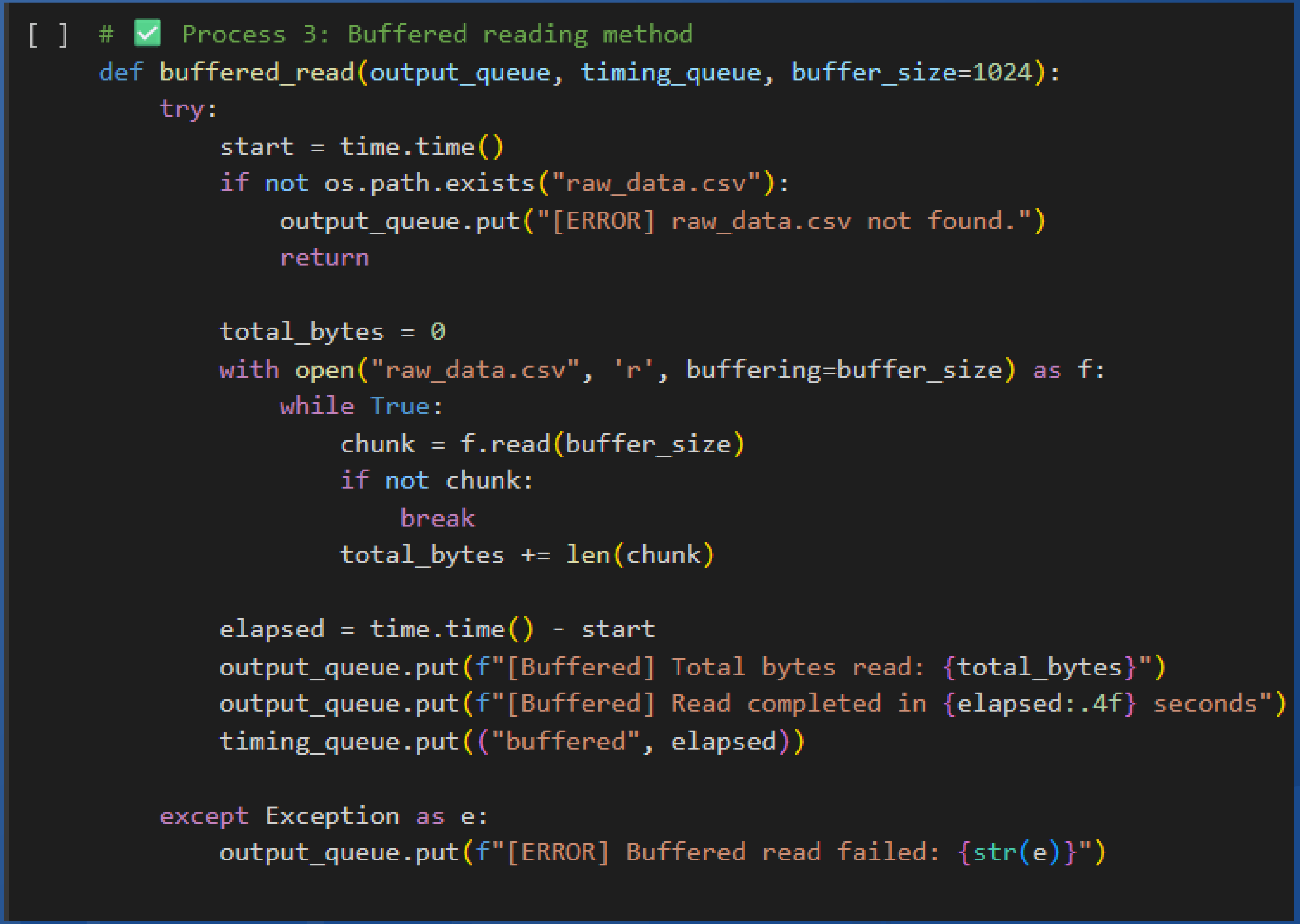


```python
# ✅ Process 2: mmap reading (full file)
def mmap_read(output_queue, timing_queue):
    try:
        start = time.time()
        if not os.path.exists("raw_data.csv"):
            output_queue.put("[ERROR] raw_data.csv not found.")
            return

        with open("raw_data.csv", 'r') as f:
            with mmap.mmap(f.fileno(), length=0, access=mmap.ACCESS_READ) as mm:
                content = mm.read()  # ✅ Read entire file content
                text = content.decode(errors='ignore')  # decode bytes to string

                output_queue.put("[mmap] Full file read successfully.")
                output_queue.put(f"[mmap] Total bytes read: {len(content)}")

        elapsed = time.time() - start
        output_queue.put(f"[mmap] Read completed in {elapsed:.4f} seconds")
        timing_queue.put(("mmap", elapsed))

    except Exception as e:
        output_queue.put(f"[ERROR] mmap read failed: {str(e)}")
```

Load CSV file with mmap

FILES I/O

Additionally, we try another method called ‘Buffer’

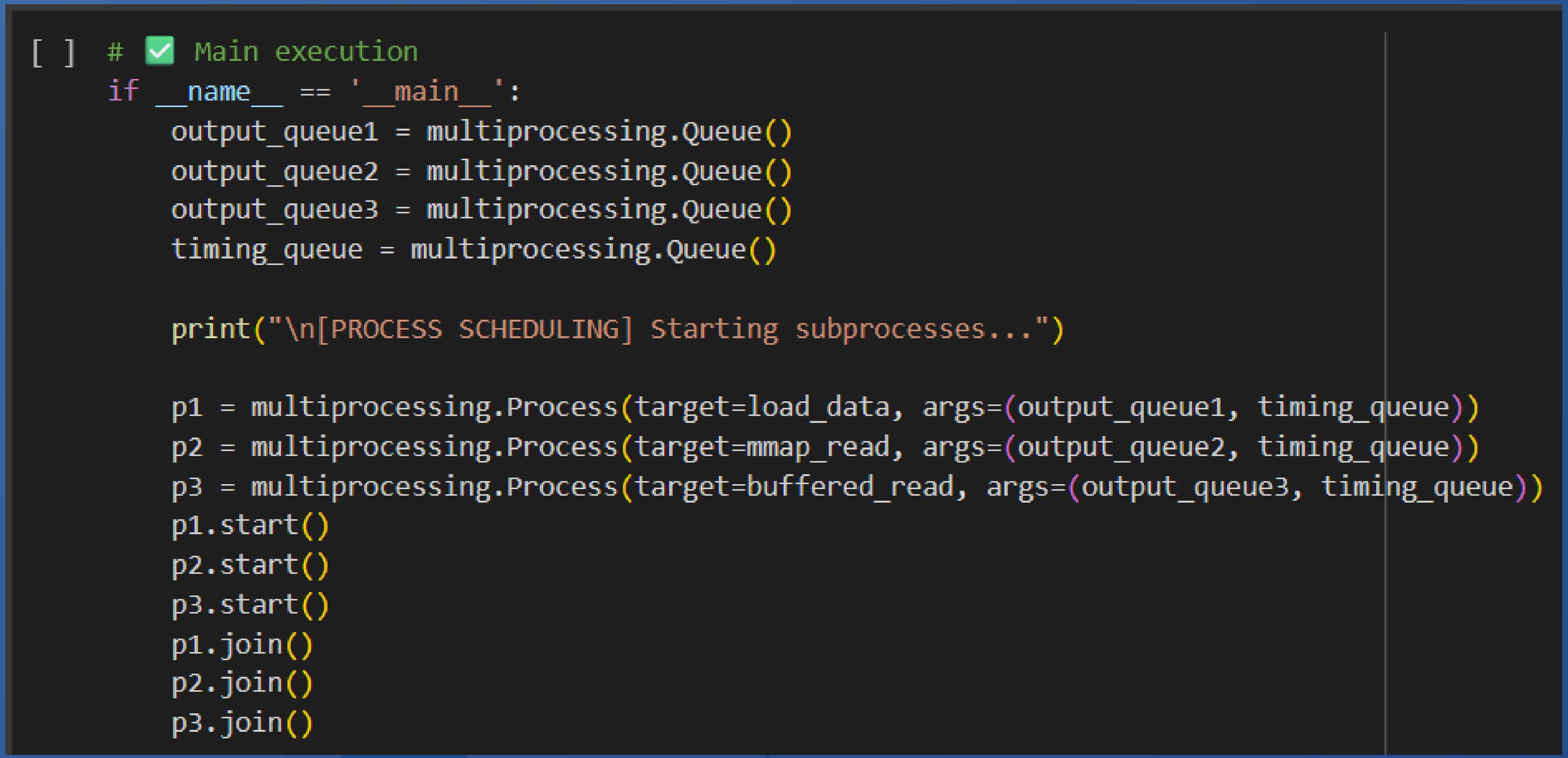


```python
# ✅ Process 3: Buffered reading method
def buffered_read(output_queue, timing_queue, buffer_size=1024):
    try:
        start = time.time()
        if not os.path.exists("raw_data.csv"):
            output_queue.put("[ERROR] raw_data.csv not found.")
            return

        total_bytes = 0
        with open("raw_data.csv", 'r', buffering=buffer_size) as f:
            while True:
                chunk = f.read(buffer_size)
                if not chunk:
                    break
                total_bytes += len(chunk)

        elapsed = time.time() - start
        output_queue.put(f"[Buffered] Total bytes read: {total_bytes}")
        output_queue.put(f"[Buffered] Read completed in {elapsed:.4f} seconds")
        timing_queue.put(("buffered", elapsed))

    except Exception as e:
        output_queue.put(f"[ERROR] Buffered read failed: {str(e)}")
```

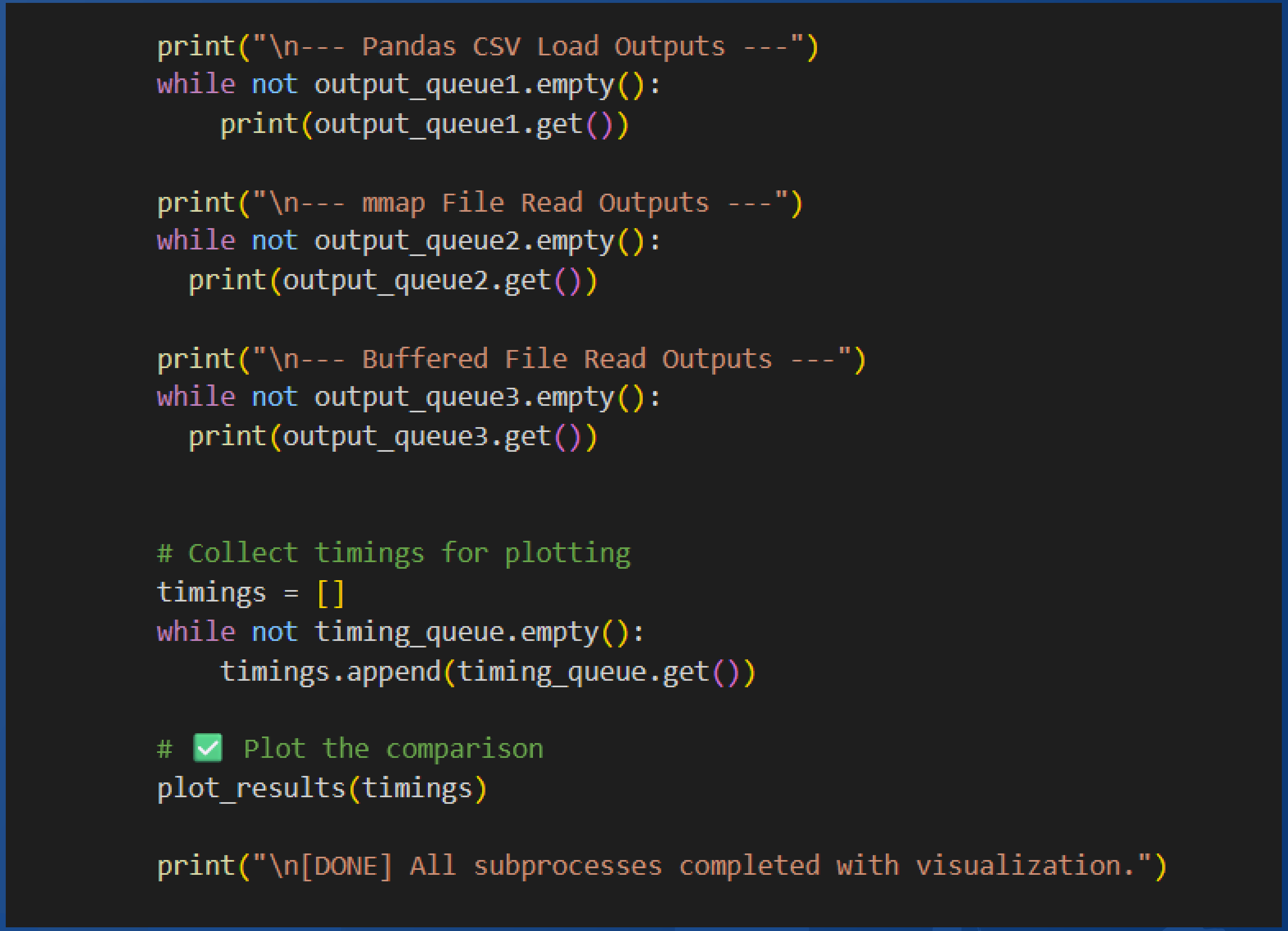
Load CSV with Buffer

PROCESS SCHEDULING

We also updated our scheduling to handle the additional process



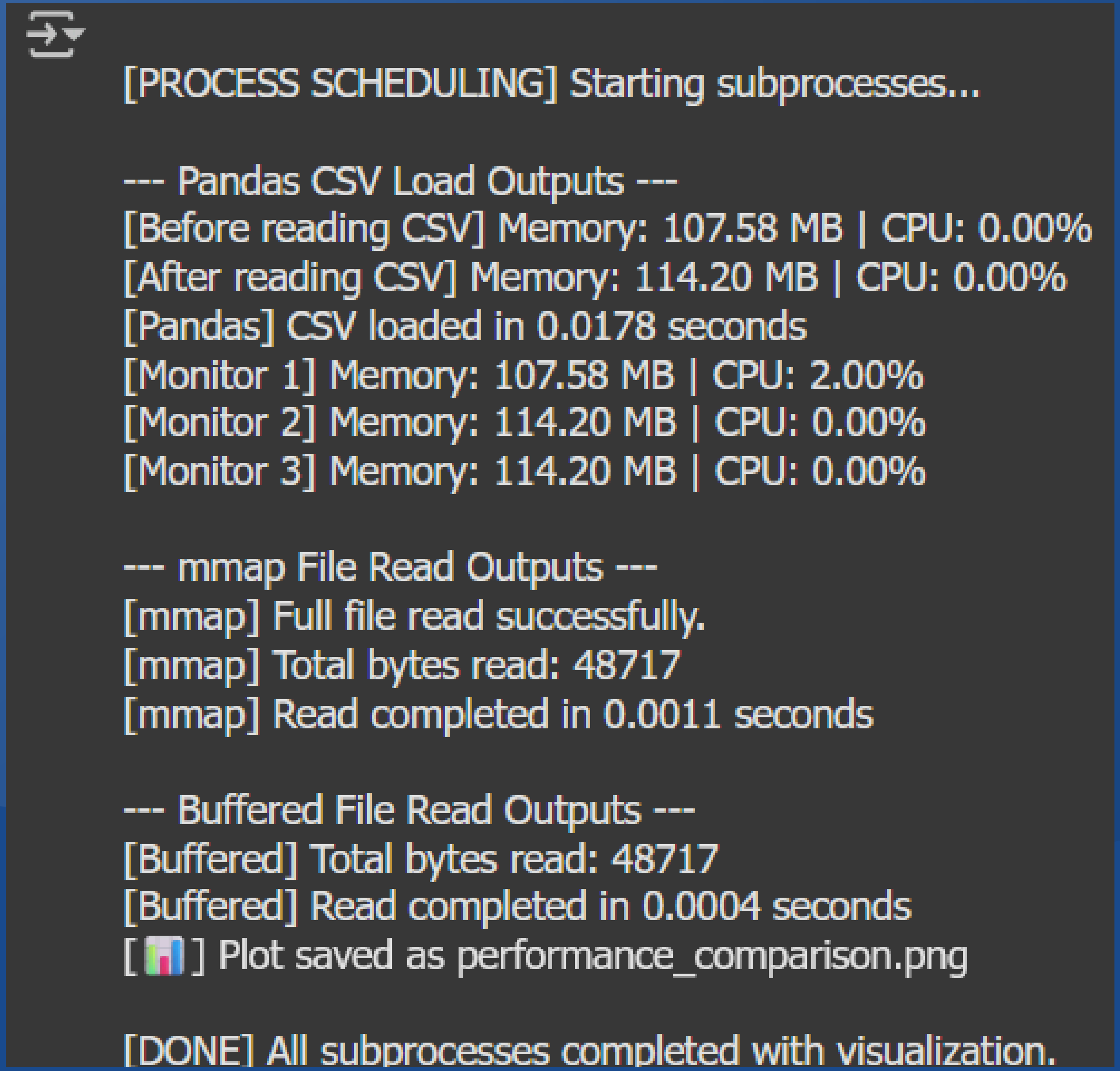
```
[ ]  # ✅ Main execution
     if __name__ == '__main__':
         output_queue1 = multiprocessing.Queue()
         output_queue2 = multiprocessing.Queue()
         output_queue3 = multiprocessing.Queue()
         timing_queue = multiprocessing.Queue()

         print("\n[PROCESS SCHEDULING] Starting subprocesses...")

         p1 = multiprocessing.Process(target=load_data, args=(output_queue1, timing_queue))
         p2 = multiprocessing.Process(target=mmap_read, args=(output_queue2, timing_queue))
         p3 = multiprocessing.Process(target=buffered_read, args=(output_queue3, timing_queue))
         p1.start()
         p2.start()
         p3.start()
         p1.join()
         p2.join()
         p3.join()
```



```
print("\n--- Pandas CSV Load Outputs ---")
while not output_queue1.empty():
    print(output_queue1.get())

print("\n--- mmap File Read Outputs ---")
while not output_queue2.empty():
  print(output_queue2.get())

print("\n--- Buffered File Read Outputs ---")
while not output_queue3.empty():
  print(output_queue3.get())


# Collect timings for plotting
timings = []
while not timing_queue.empty():
    timings.append(timing_queue.get())

# ✅ Plot the comparison
plot_results(timings)

print("\n[DONE] All subprocesses completed with visualization.")
```

PROCESS SCHEDULING

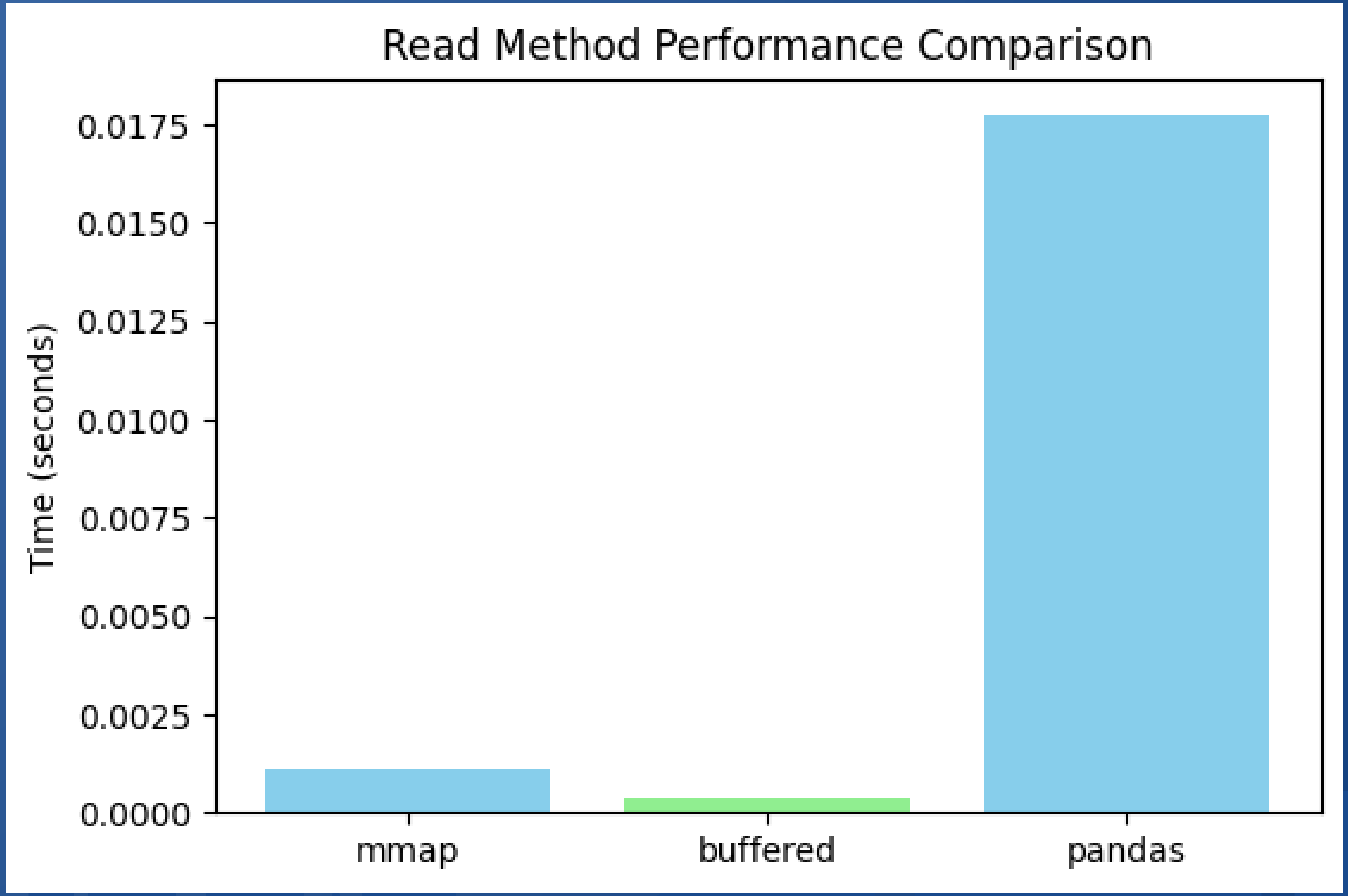
The result of the run, including the memory usage and the time used for each process



```
[PROCESS SCHEDULING] Starting subprocesses...

--- Pandas CSV Load Outputs ---
[Before reading CSV] Memory: 107.58 MB | CPU: 0.00%
[After reading CSV] Memory: 114.20 MB | CPU: 0.00%
[Pandas] CSV loaded in 0.0178 seconds
[Monitor 1] Memory: 107.58 MB | CPU: 2.00%
[Monitor 2] Memory: 114.20 MB | CPU: 0.00%
[Monitor 3] Memory: 114.20 MB | CPU: 0.00%

--- mmap File Read Outputs ---
[mmap] Full file read successfully.
[mmap] Total bytes read: 48717
[mmap] Read completed in 0.0011 seconds

--- Buffered File Read Outputs ---
[Buffered] Total bytes read: 48717
[Buffered] Read completed in 0.0004 seconds
[📊] Plot saved as performance_comparison.png

[DONE] All subprocesses completed with visualization.
```

RESULT BENCHMARK

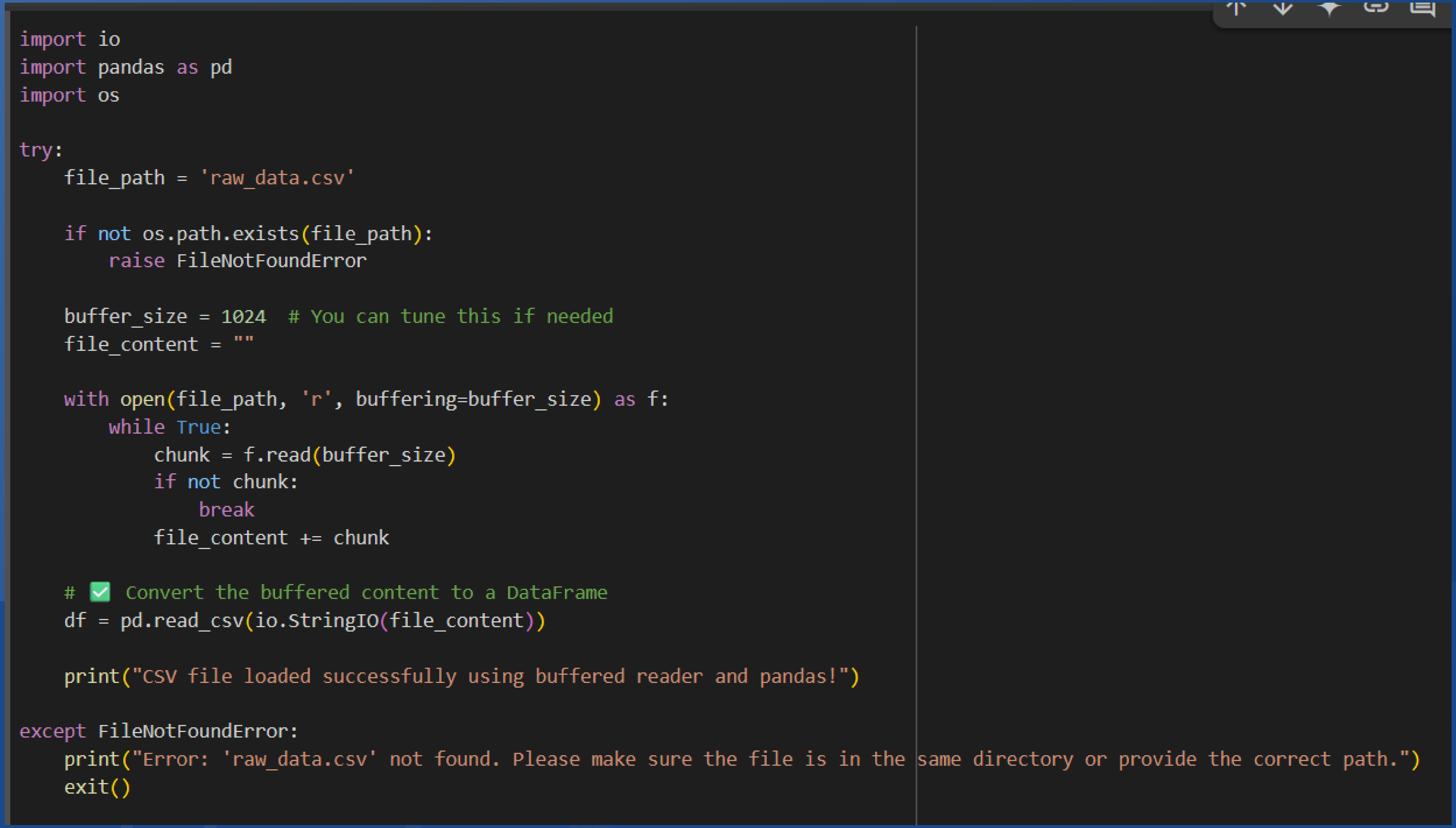
Performance different between these three methods.



DATA PROCESSING

READ THE DATA

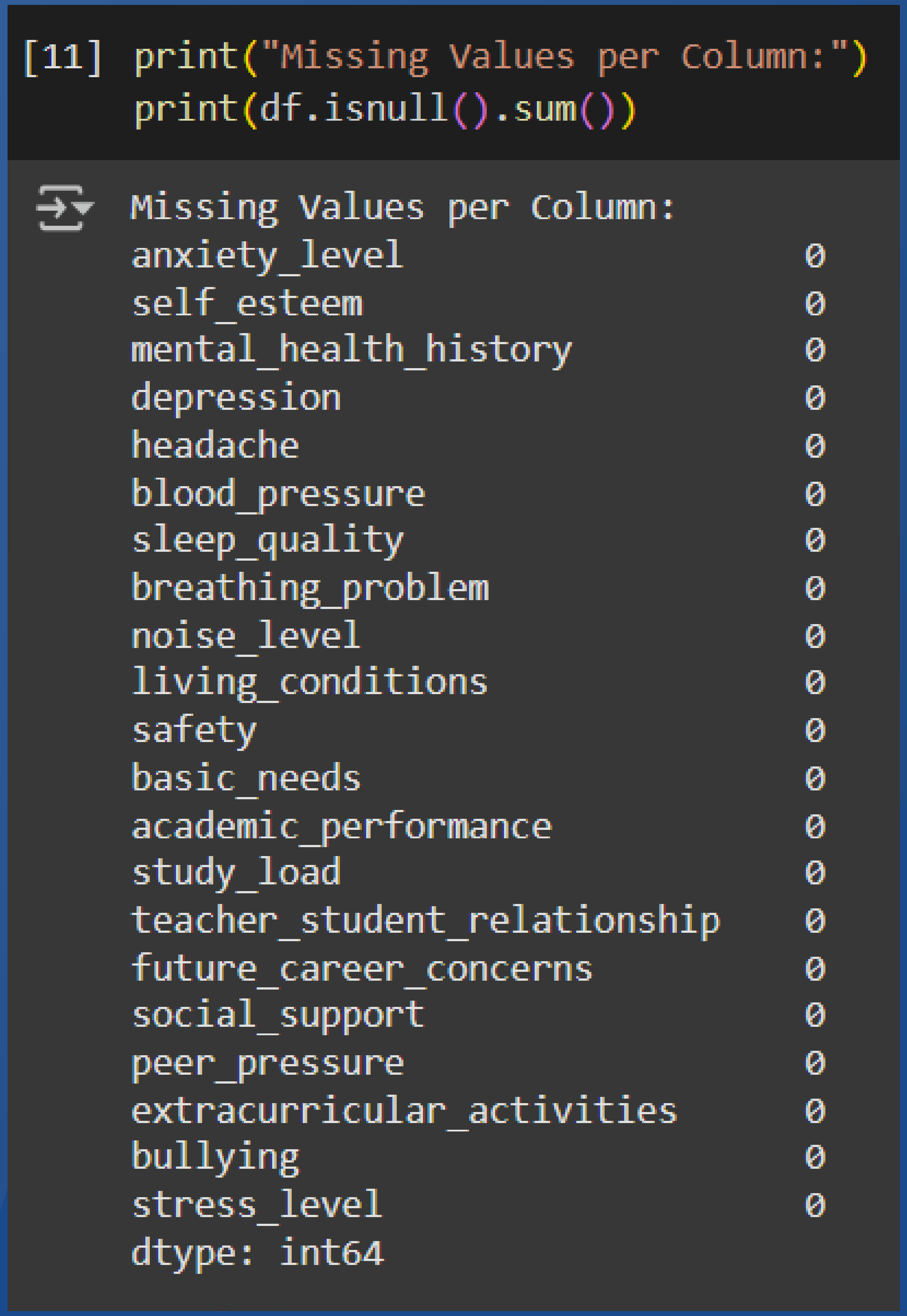
Using the best methods we discovered (Panda and Buffer)



```python
import io
import pandas as pd
import os

try:
    file_path = 'raw_data.csv'

    if not os.path.exists(file_path):
        raise FileNotFoundError

    buffer_size = 1024  # You can tune this if needed
    file_content = ""

    with open(file_path, 'r', buffering=buffer_size) as f:
        while True:
            chunk = f.read(buffer_size)
            if not chunk:
                break
            file_content += chunk

    # ✅ Convert the buffered content to a DataFrame
    df = pd.read_csv(io.StringIO(file_content))

    print("CSV file loaded successfully using buffered reader and pandas!")

except FileNotFoundError:
    print("Error: 'raw_data.csv' not found. Please make sure the file is in the same directory or provide the correct path.")
    exit()
```

IDENTIFY NULL VALUE

There is none.

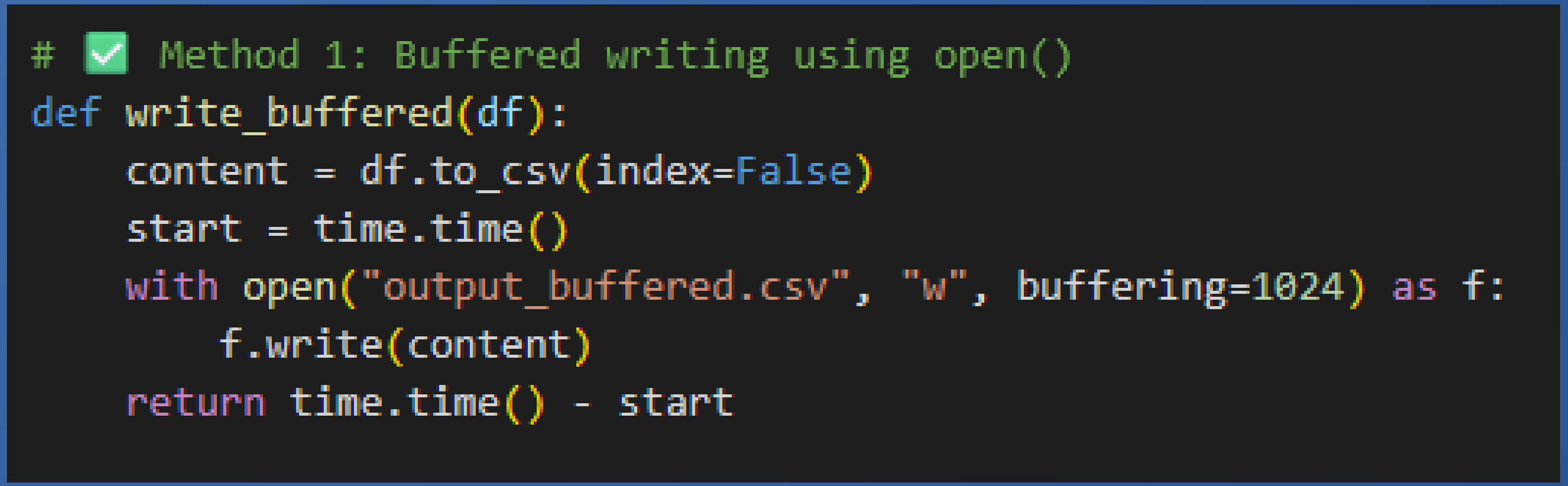


```
[11] print("Missing Values per Column:")
     print(df.isnull().sum())
```

```
Missing Values per Column:
anxiety_level                   0
self_esteem                     0
mental_health_history           0
depression                      0
headache                        0
blood_pressure                  0
sleep_quality                   0
breathing_problem               0
noise_level                     0
living_conditions               0
safety                          0
basic_needs                     0
academic_performance            0
study_load                      0
teacher_student_relationship    0
future_career_concerns          0
social_support                  0
peer_pressure                   0
extracurricular_activities      0
bullying                        0
stress_level                    0
dtype: int64
```

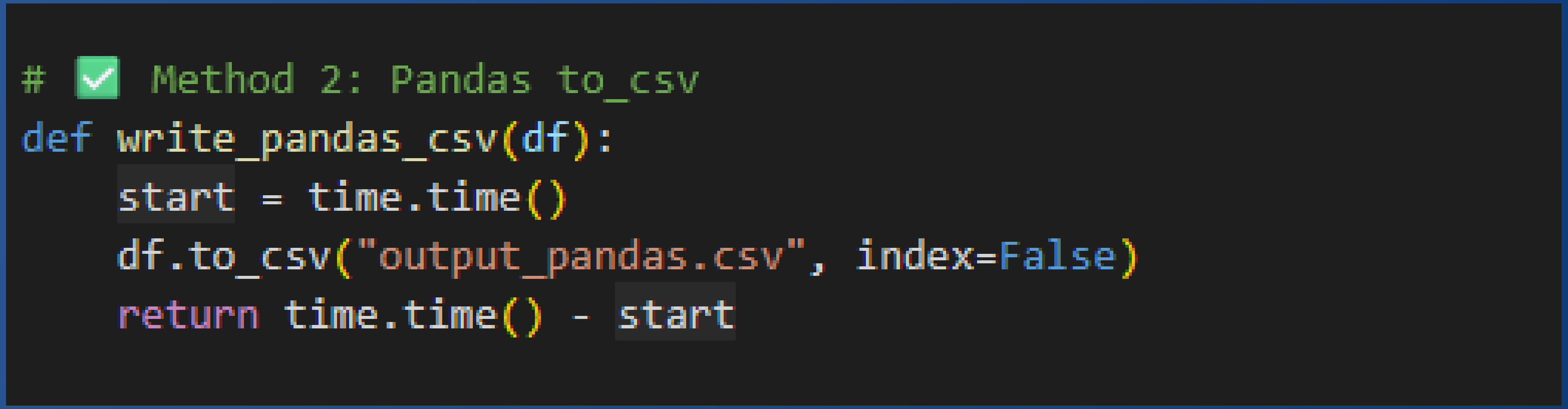
WRITE THE DATA

Save the data into processed file. We used and compared three methods for this task.



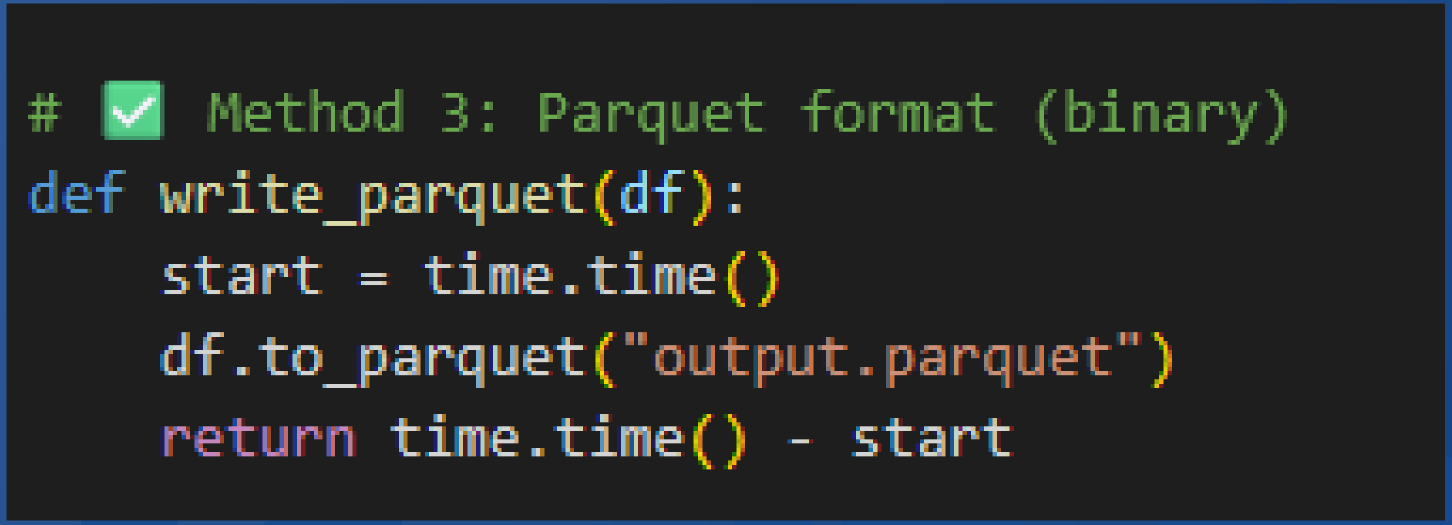
```python
# ✅ Method 1: Buffered writing using open()
def write_buffered(df):
    content = df.to_csv(index=False)
    start = time.time()
    with open("output_buffered.csv", "w", buffering=1024) as f:
        f.write(content)
    return time.time() - start
```

Buffer



```python
# ✅ Method 2: Pandas to_csv
def write_pandas_csv(df):
    start = time.time()
    df.to_csv("output_pandas.csv", index=False)
    return time.time() - start
```

Pandas

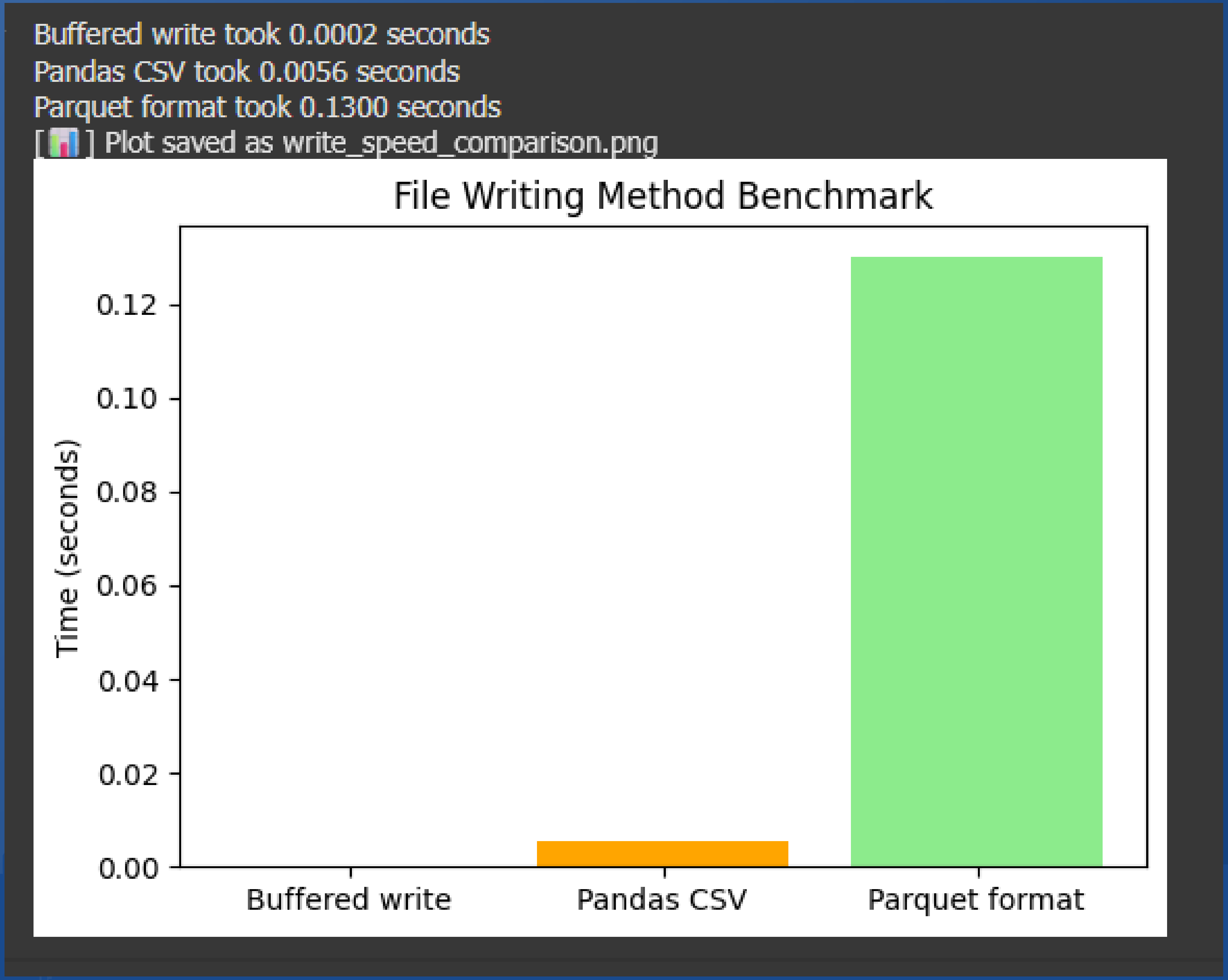


```python
# ✅ Method 3: Parquet format (binary)
def write_parquet(df):
    start = time.time()
    df.to_parquet("output.parquet")
    return time.time() - start
```

Parquet

WRITE THE DATA

Time used by each method

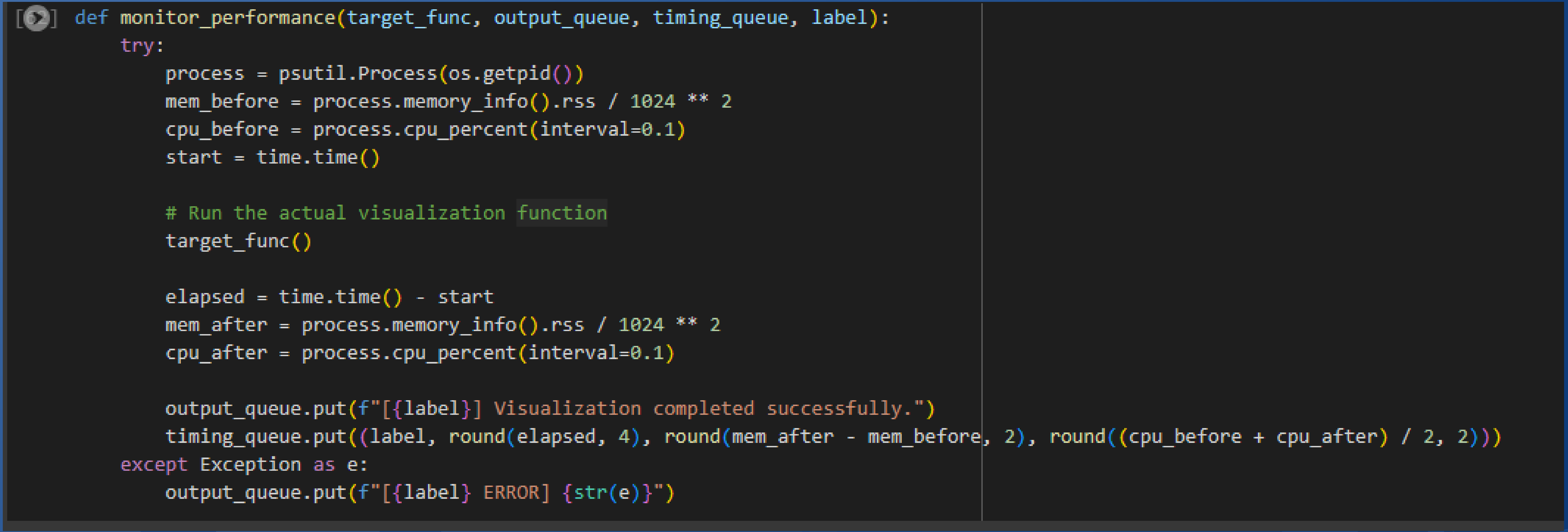


```
Buffered write took 0.0002 seconds
Pandas CSV took 0.0056 seconds
Parquet format took 0.1300 seconds
[📊] Plot saved as write_speed_comparison.png
```

VISUALIZATION

RESOURCE MANAGEMENT

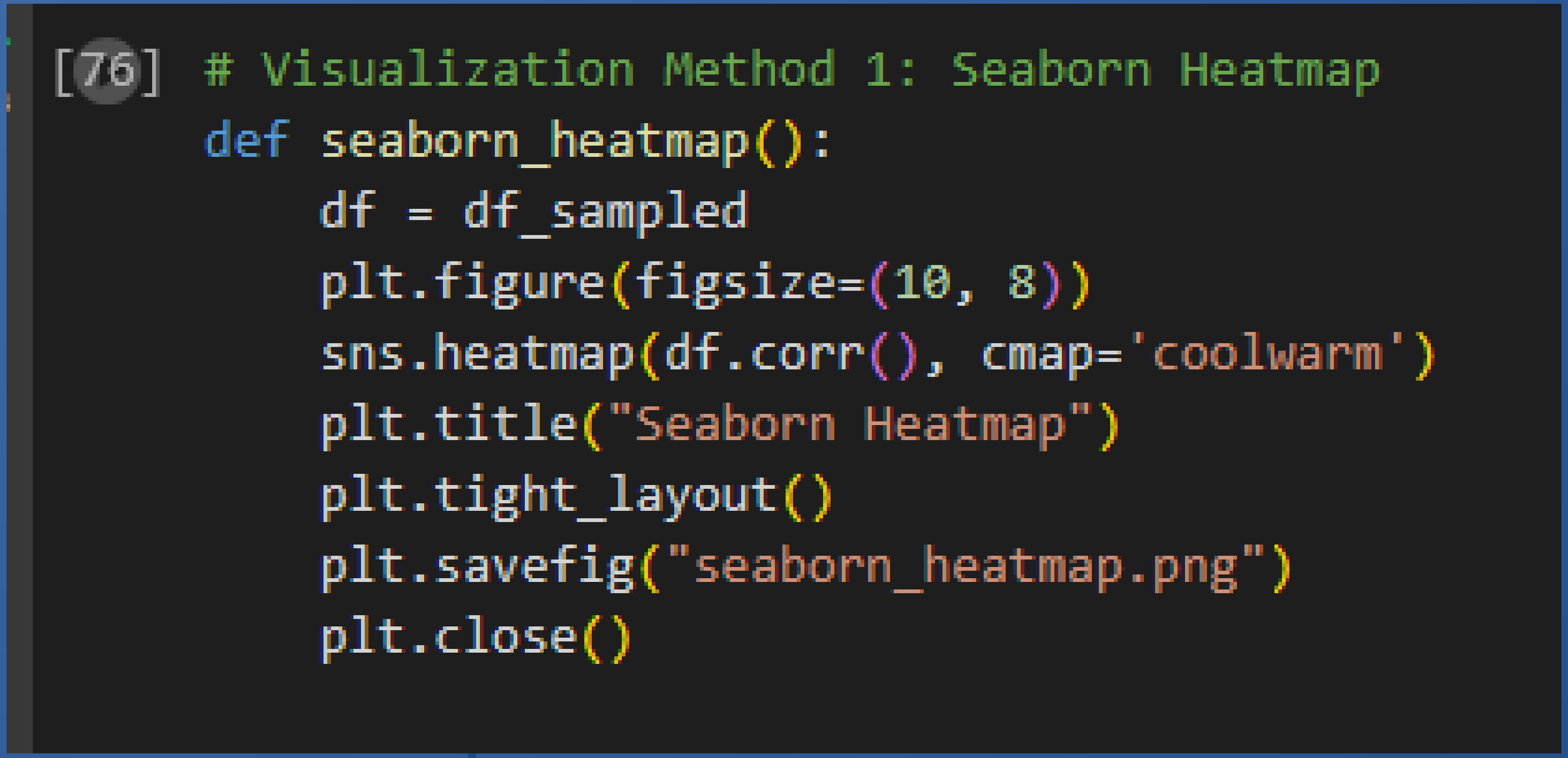
We used psuilt and process to monitor each method performance



```python
def monitor_performance(target_func, output_queue, timing_queue, label):
    try:
        process = psutil.Process(os.getpid())
        mem_before = process.memory_info().rss / 1024 ** 2
        cpu_before = process.cpu_percent(interval=0.1)
        start = time.time()

        # Run the actual visualization function
        target_func()

        elapsed = time.time() - start
        mem_after = process.memory_info().rss / 1024 ** 2
        cpu_after = process.cpu_percent(interval=0.1)

        output_queue.put(f"[{label}] Visualization completed successfully.")
        timing_queue.put((label, round(elapsed, 4), round(mem_after - mem_before, 2), round((cpu_before + cpu_after) / 2, 2)))
    except Exception as e:
        output_queue.put(f"[{label} ERROR] {str(e)}")
```

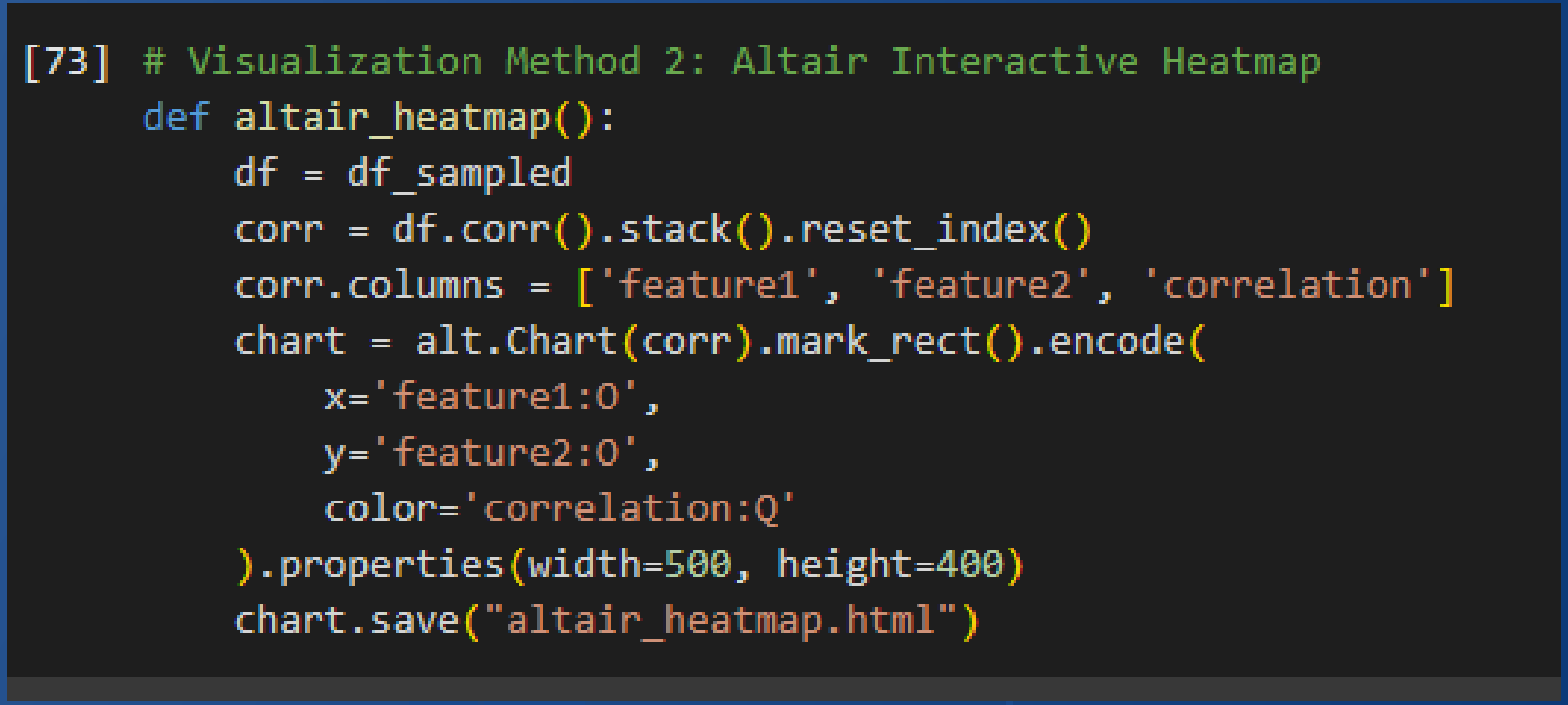
VISUALIZATION

We selected 2 methods; Seaborn and Altair



```
[76] # Visualization Method 1: Seaborn Heatmap
     def seaborn_heatmap():
         df = df_sampled
         plt.figure(figsize=(10, 8))
         sns.heatmap(df.corr(), cmap='coolwarm')
         plt.title("Seaborn Heatmap")
         plt.tight_layout()
         plt.savefig("seaborn_heatmap.png")
         plt.close()
```

Seaborn

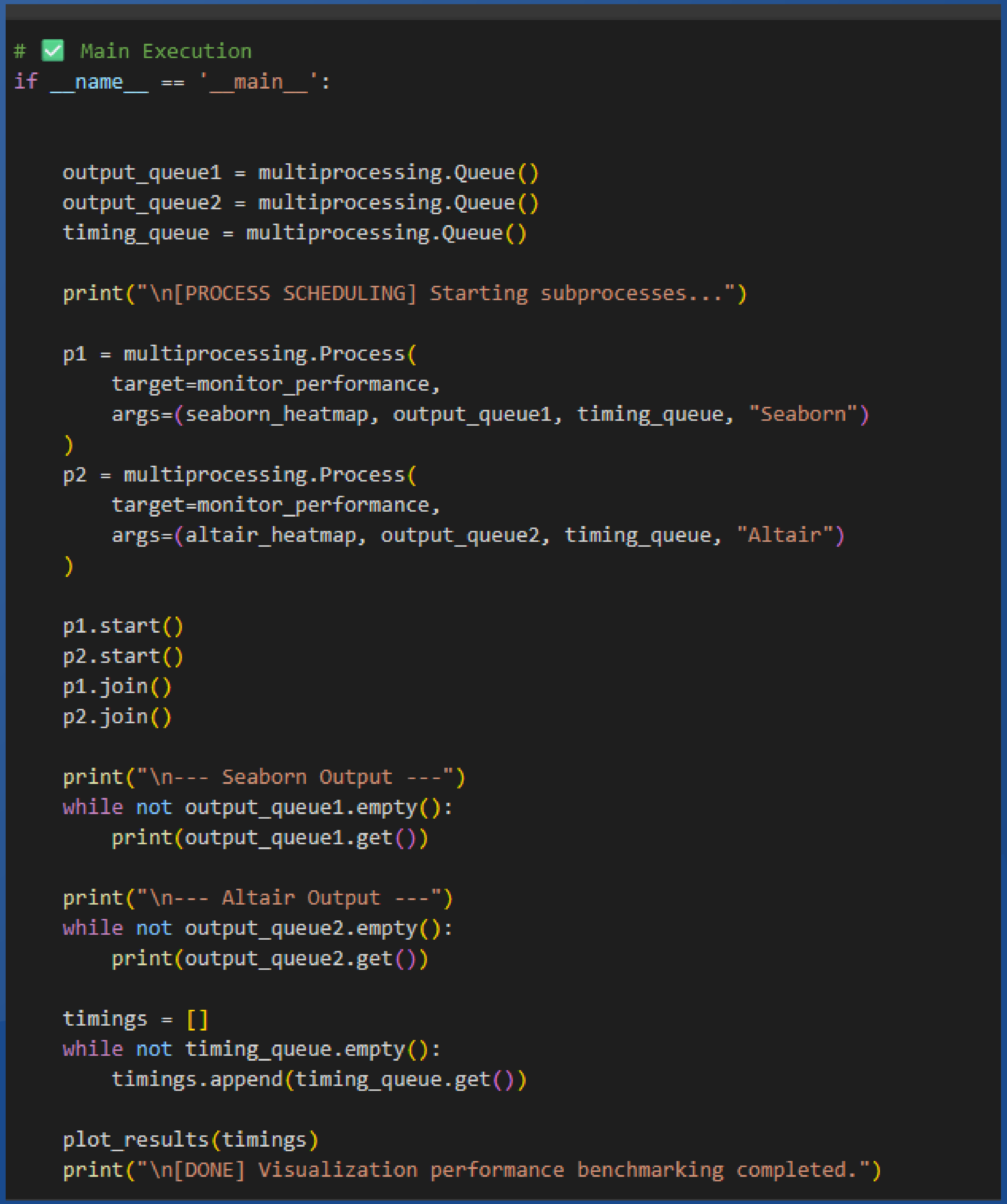


```
[73] # Visualization Method 2: Altair Interactive Heatmap
     def altair_heatmap():
         df = df_sampled
         corr = df.corr().stack().reset_index()
         corr.columns = ['feature1', 'feature2', 'correlation']
         chart = alt.Chart(corr).mark_rect().encode(
             x='feature1:O',
             y='feature2:O',
             color='correlation:Q'
         ).properties(width=500, height=400)
         chart.save("altair_heatmap.html")
```

Altair

MAIN EXECUTION

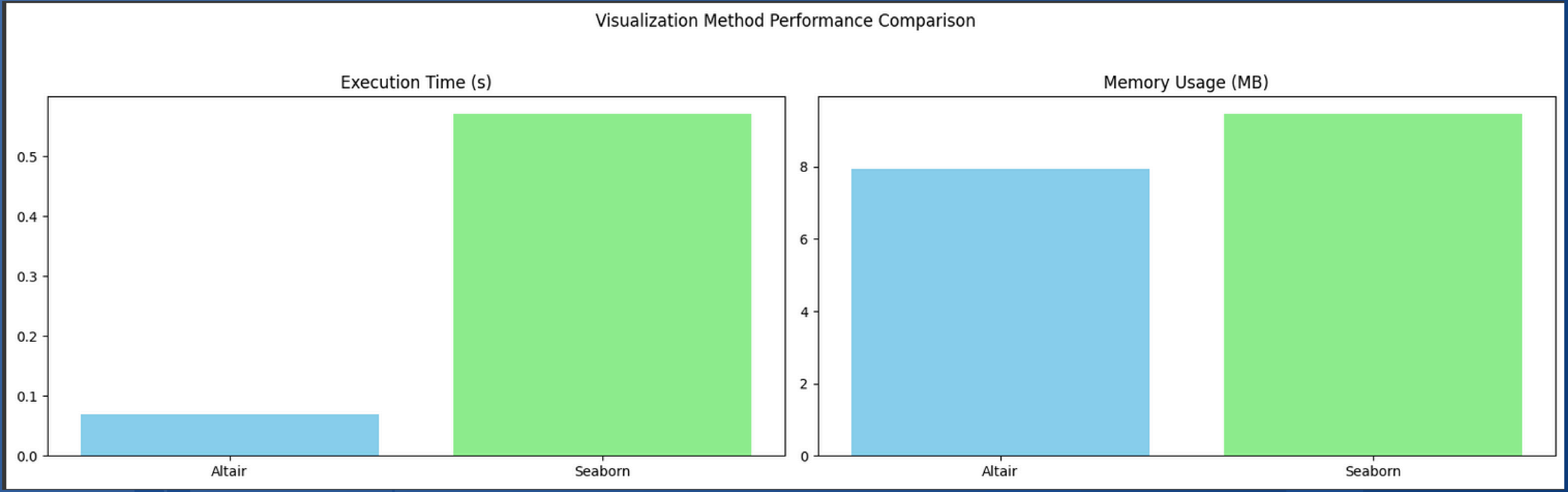
Also include the process scheduling from before



```
# ✅ Main Execution
if __name__ == '__main__':


    output_queue1 = multiprocessing.Queue()
    output_queue2 = multiprocessing.Queue()
    timing_queue = multiprocessing.Queue()

    print("\n[PROCESS SCHEDULING] Starting subprocesses...")

    p1 = multiprocessing.Process(
        target=monitor_performance,
        args=(seaborn_heatmap, output_queue1, timing_queue, "Seaborn")
    )
    p2 = multiprocessing.Process(
        target=monitor_performance,
        args=(altair_heatmap, output_queue2, timing_queue, "Altair")
    )

    p1.start()
    p2.start()
    p1.join()
    p2.join()

    print("\n--- Seaborn Output ---")
    while not output_queue1.empty():
        print(output_queue1.get())

    print("\n--- Altair Output ---")
    while not output_queue2.empty():
        print(output_queue2.get())

    timings = []
    while not timing_queue.empty():
        timings.append(timing_queue.get())

    plot_results(timings)
    print("\n[DONE] Visualization performance benchmarking completed.")
```

RESULT BENCHMARK

The execution time and memory usage of each method



THANK YOU