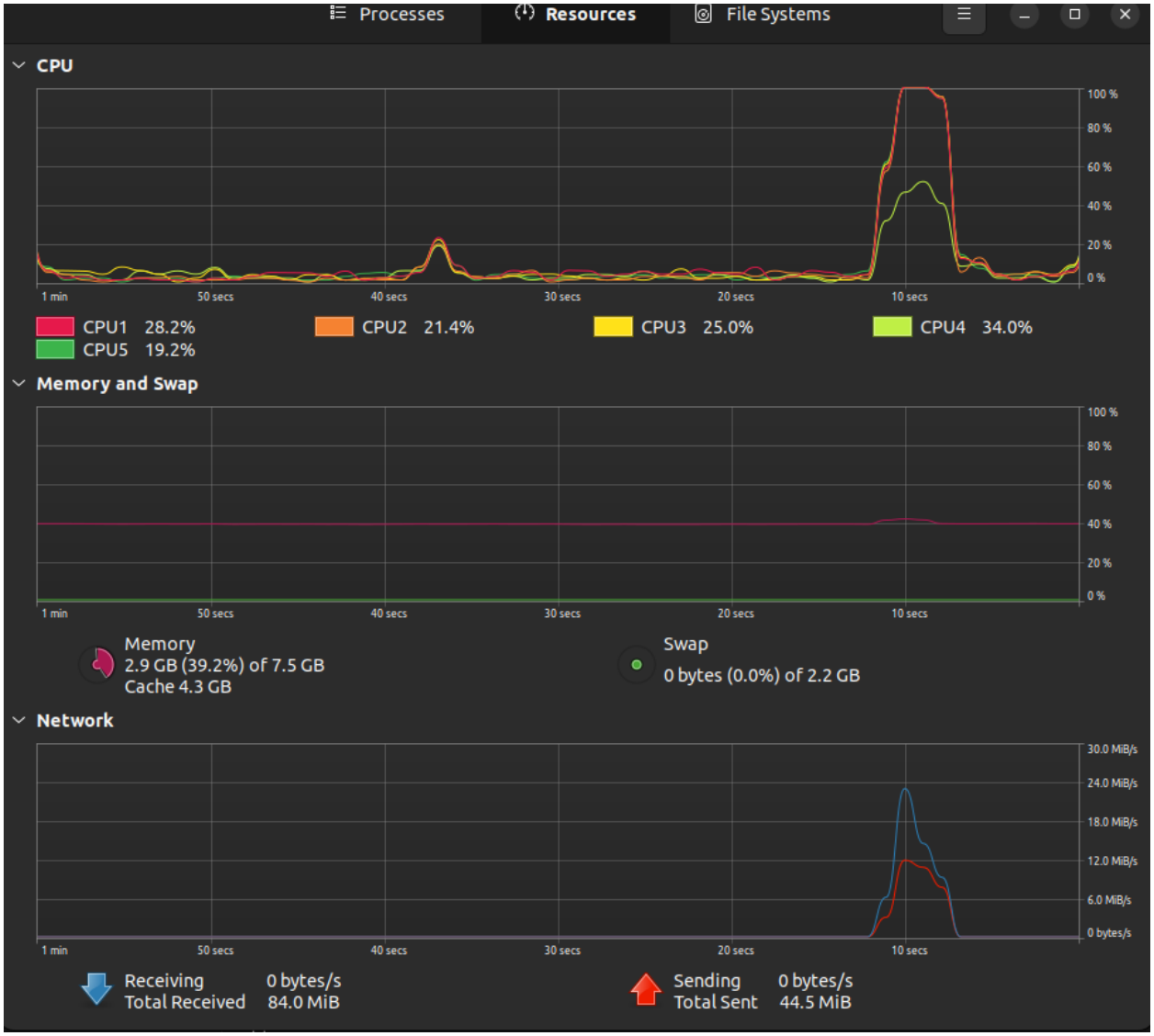
Graphs and htop results

Fork
500

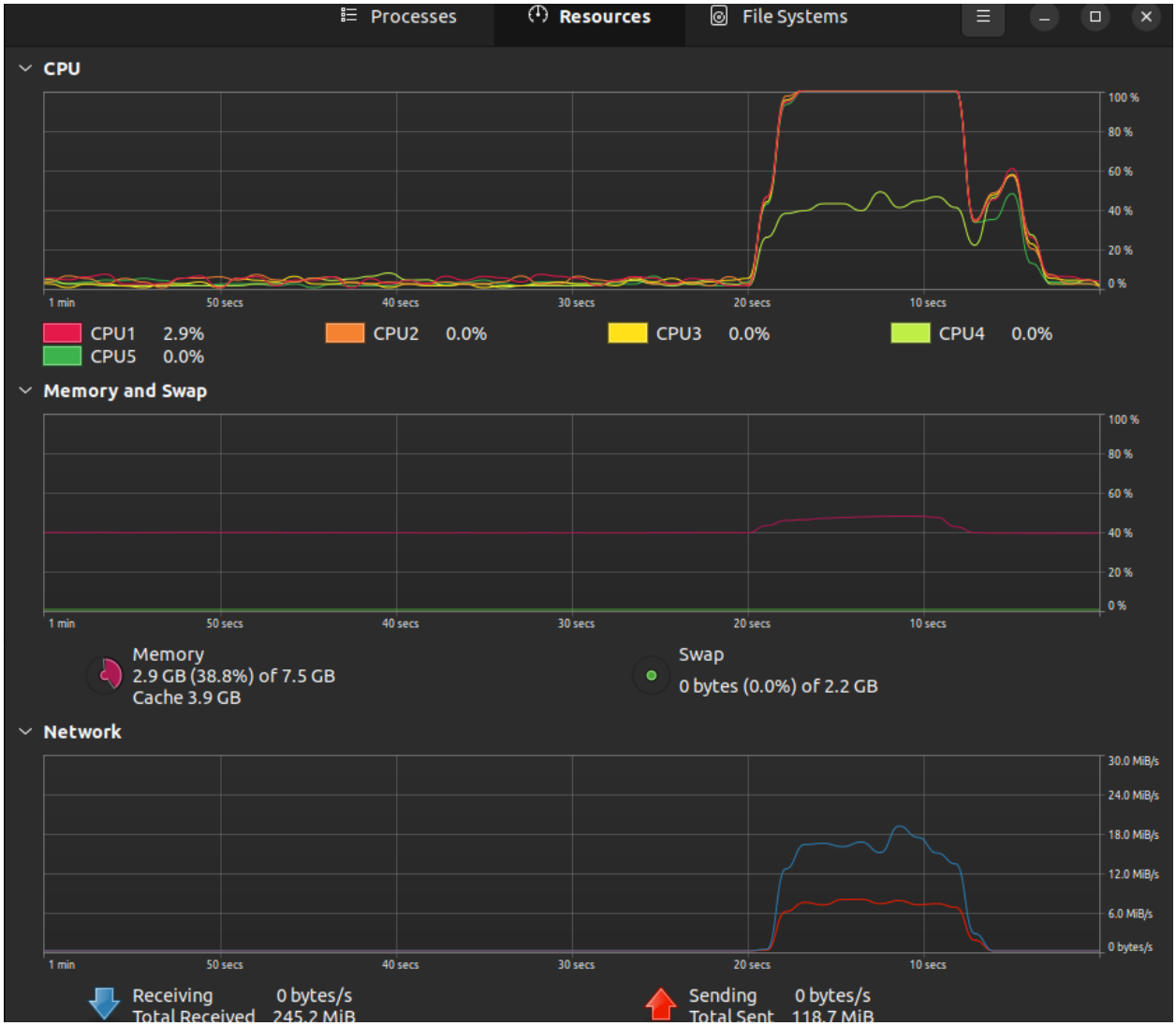

```
kitkat2@ubuntuchhota:~/Desktop/final_rev2$ time -v ./client_x86_64 10.0.2.15:808
1 50 500
-v: command not found

real    0m0.592s
user    0m0.055s
sys     0m0.417s
```

1000




```
Command being timed: "./client_x86_64 10.0.2.15:8081 50 1000"
User time (seconds): 0.11
System time (seconds): 1.47
Percent of CPU this job got: 43%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:03.67
```

3000

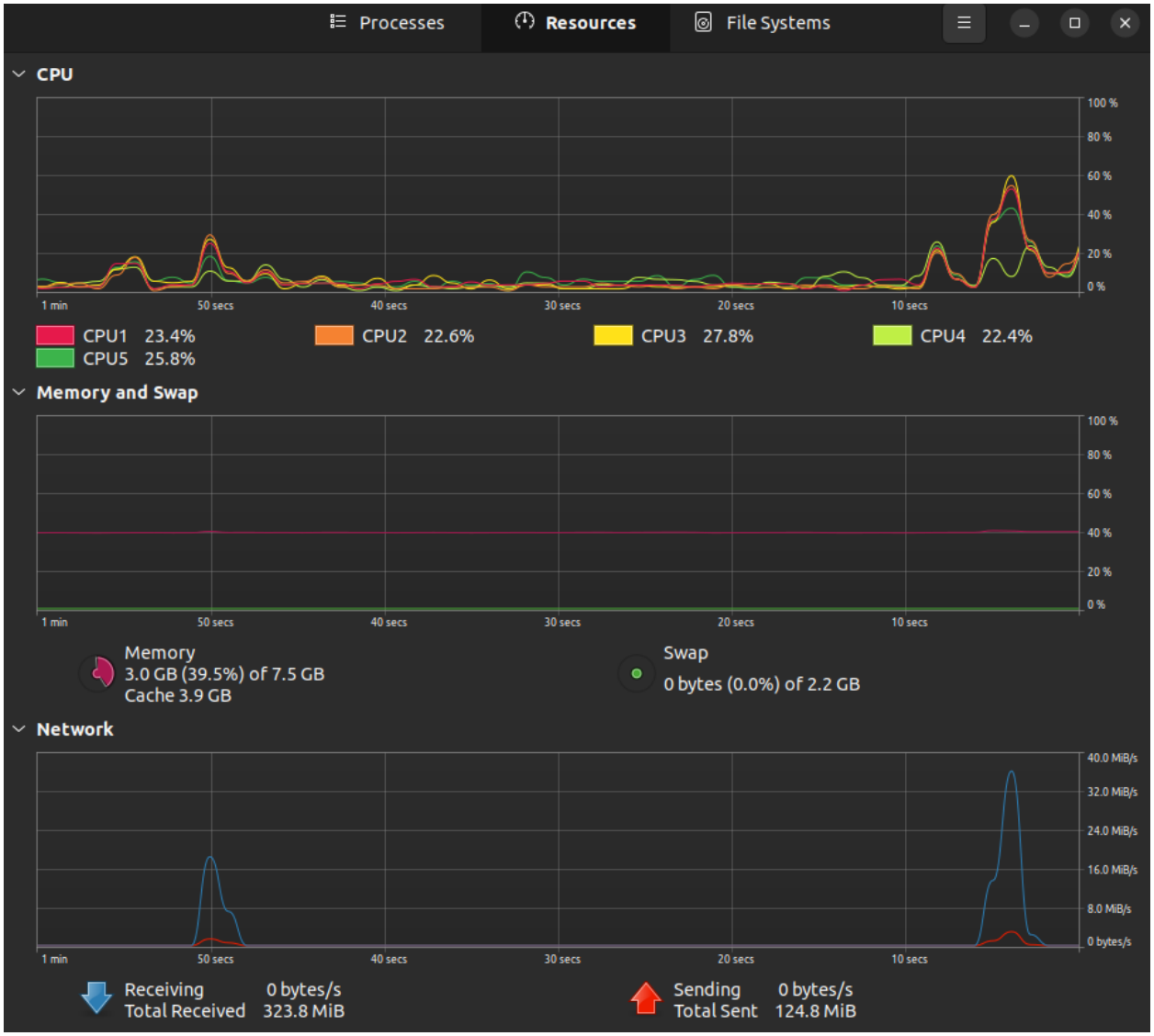



```
Command being timed: "./client_x86_64 10.0.2.15:8081 50 3000"
User time (seconds): 0.67
System time (seconds): 4.35
Percent of CPU this job got: 45%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:10.96
Average shared text size (kbytes): 0
```

Thread
500

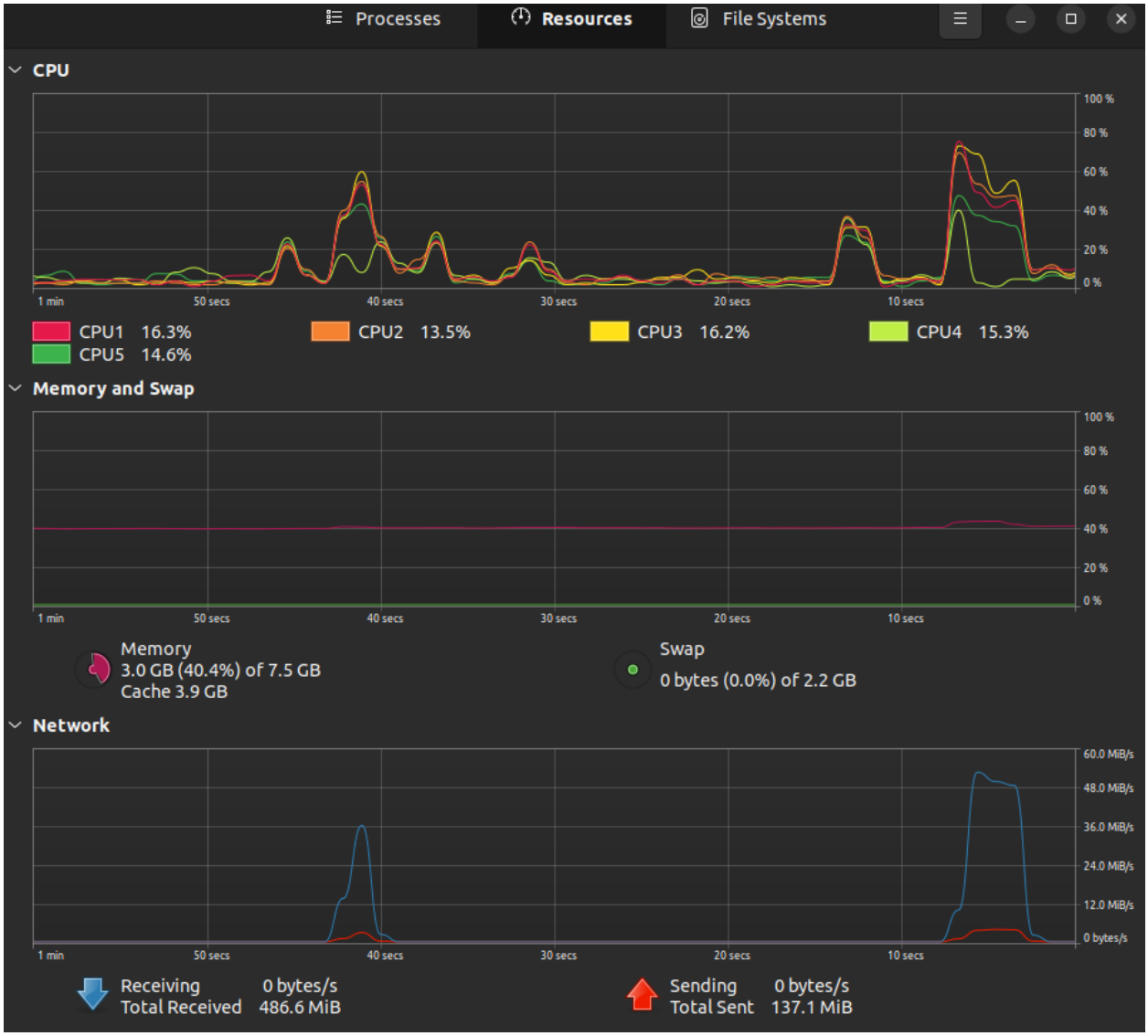

```
Command being timed: "./client_x86_64 10.0.2.15:8081 50 500"
User time (seconds): 0.02
System time (seconds): 0.49
Percent of CPU this job got: 61%
```

1000



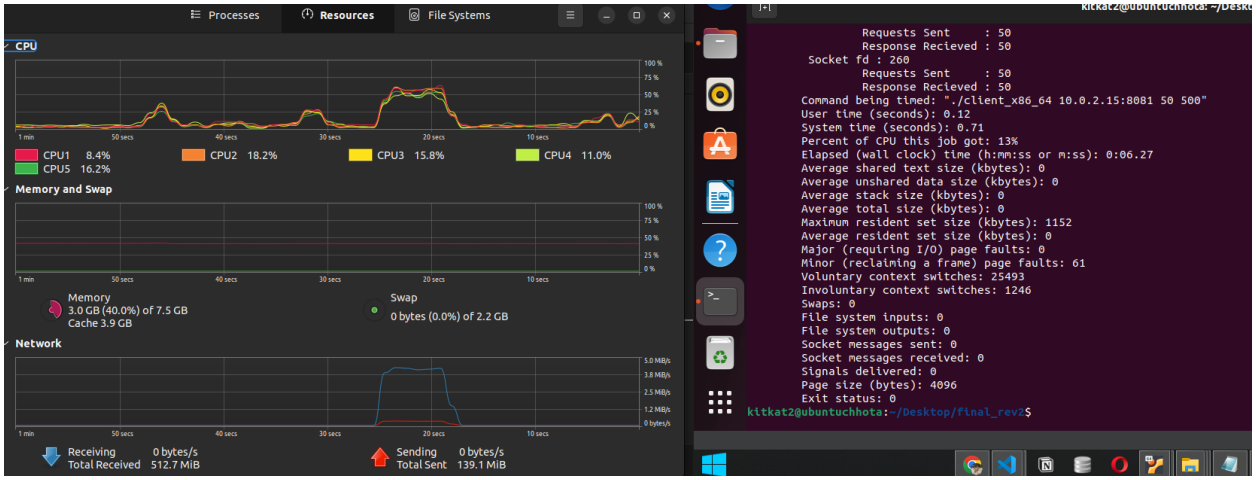

```
Command being timed: "./client_x86_64 10.0.2.15:8081 50 1000"
User time (seconds): 0.10
System time (seconds): 1.18
Percent of CPU this job got: 74%
```

3000

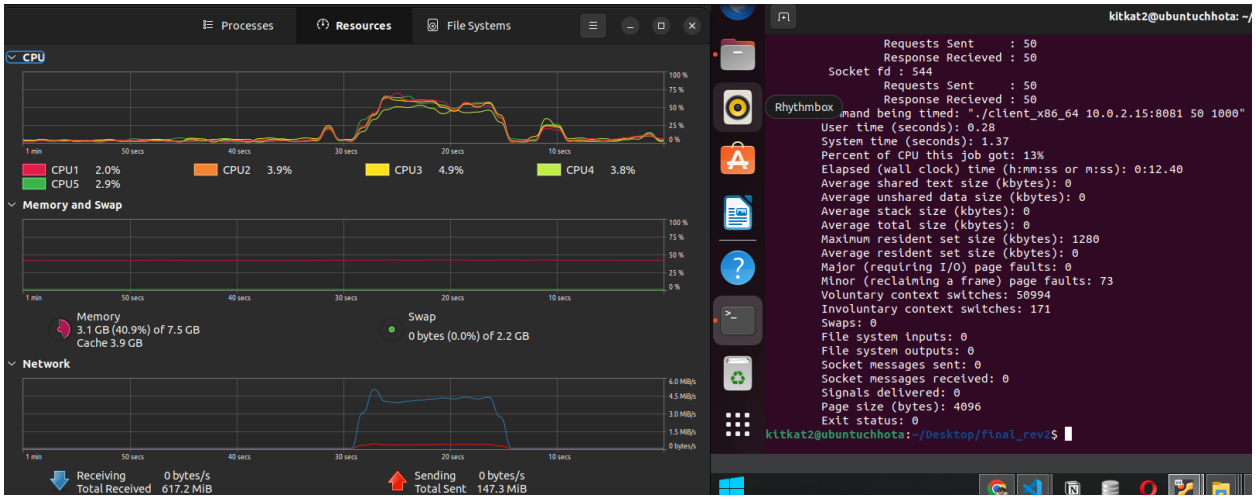



```
Command being timed: "./client_x86_64 10.0.2.15:8081 50 3000"
User time (seconds): 0.31
System time (seconds): 3.15
Percent of CPU this job got: 84%
```

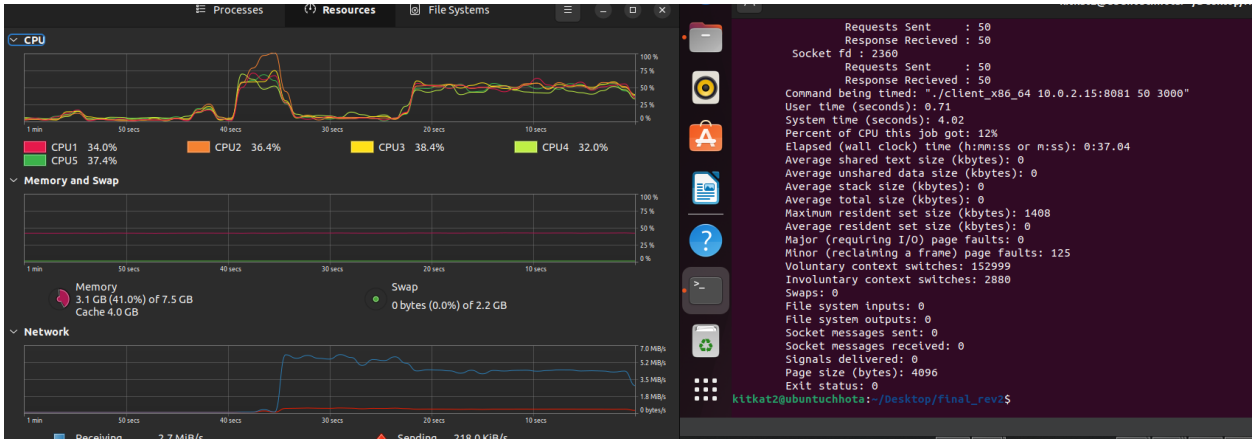
Epoll
500


Processes
Resources
File Systems
CPU
CPU1 8.4%
CPU2 18.2%
CPU3 15.8%
CPU4 11.0%
CPU5 16.2%
Memory and Swap
Memory
3.0 GB (40.0%) of 7.5 GB
Cache 3.9 GB
Swap
0 bytes (0.0%) of 2.2 GB
Network
Receiving 0 bytes/s
Total Received 512.7 MiB
Sending 0 bytes/s
Total Sent 139.1 MiB
Requests Sent : 50
Response Recieved : 50
Socket fd : 260
Requests Sent : 50
Response Recieved : 50
Command being timed: "./client_x86_64 10.0.2.15:8081 50 500"
User time (seconds): 0.12
System time (seconds): 0.71
Percent of CPU this job got: 13%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:06.27
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 1152
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 61
Voluntary context switches: 25493
Involuntary context switches: 1246
Swaps: 0
File system inputs: 0
File system outputs: 0
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 0
kitkat2@ubuntuchhota:~/Desktop/final_rev2$

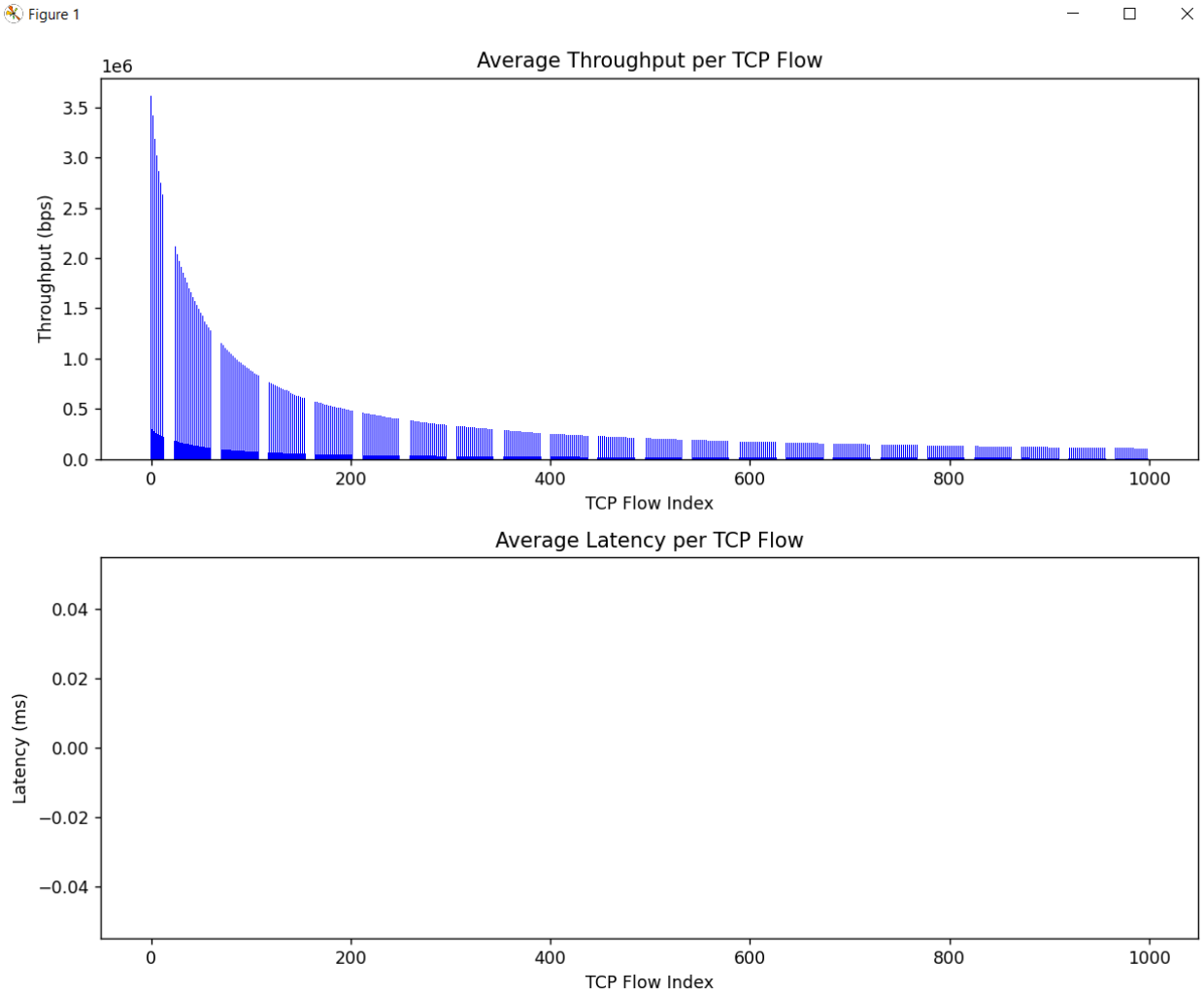
1000


Processes
Resources
File Systems
CPU
CPU1 2.0%
CPU2 3.9%
CPU3 4.9%
CPU4 3.8%
CPU5 2.9%
Memory and Swap
Memory
3.1 GB (40.9%) of 7.5 GB
Cache 3.9 GB
Swap
0 bytes (0.0%) of 2.2 GB
Network
Receiving 0 bytes/s
Total Received 617.2 MiB
Sending 0 bytes/s
Total Sent 147.3 MiB
Rhythmbox
Requests Sent : 50
Response Recieved : 50
Socket fd : 544
Requests Sent : 50
Response Recieved : 50
mand being timed: "./client_x86_64 10.0.2.15:8081 50 1000"
User time (seconds): 0.28
System time (seconds): 1.37
Percent of CPU this job got: 13%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:12.40
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 1280
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 73
Voluntary context switches: 50994
Involuntary context switches: 171
Swaps: 0
File system inputs: 0
File system outputs: 0
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 0
kitkat2@ubuntuchhota:~/Desktop/final_rev2$

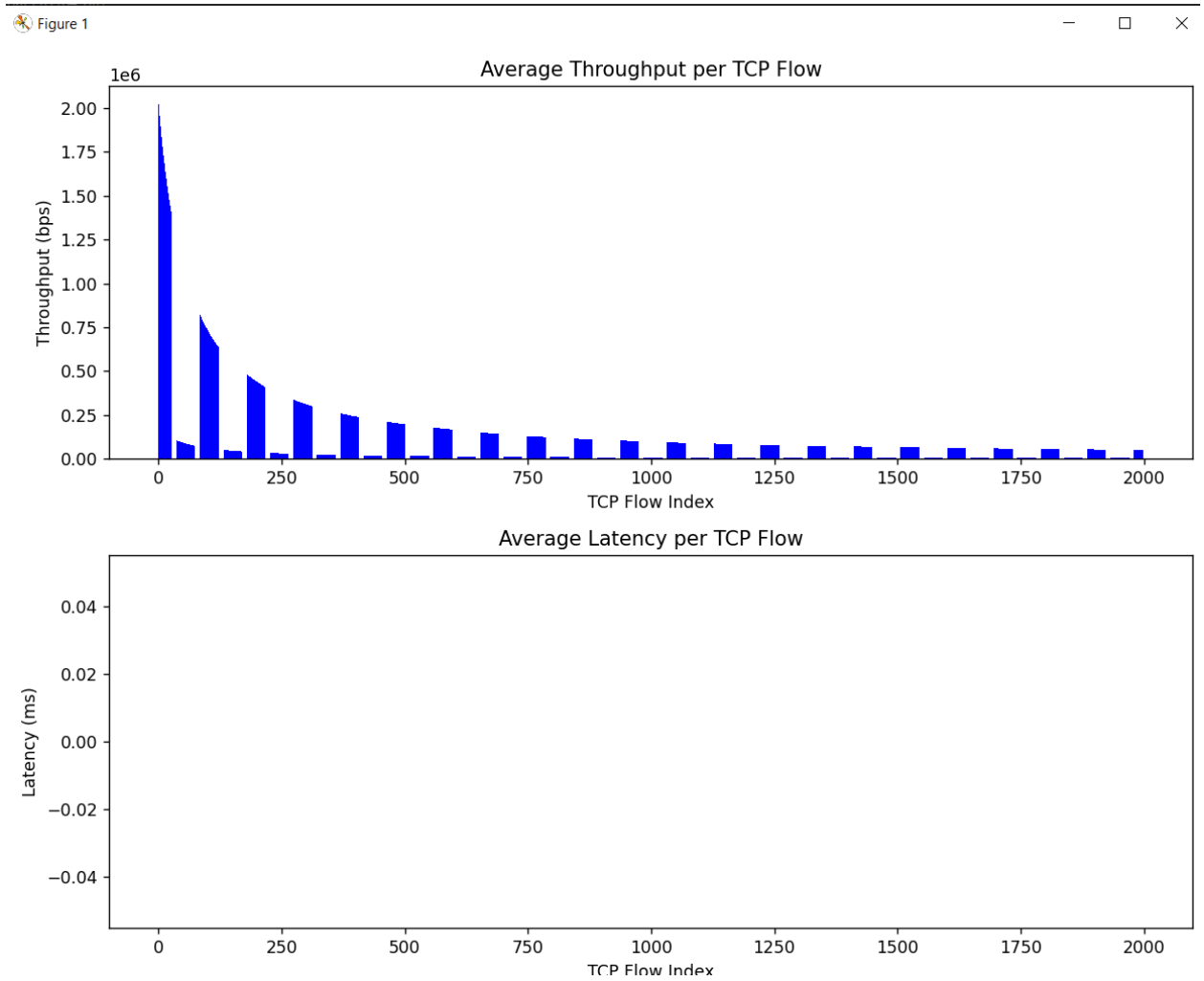
3000


Processes
Resources
File Systems
CPU
CPU1 34.0%
CPU2 36.4%
CPU3 38.4%
CPU4 32.0%
CPU5 37.4%
Memory and Swap
Memory
3.1 GB (41.0%) of 7.5 GB
Cache 4.0 GB
Swap
0 bytes (0.0%) of 2.2 GB
Network
Requests Sent : 50
Response Recieved : 50
Socket fd : 2360
Requests Sent : 50
Response Recieved : 50
Command being timed: "./client_x86_64 10.0.2.15:8081 50 3000"
User time (seconds): 0.71
System time (seconds): 4.02
Percent of CPU this job got: 12%
Elapsed (wall clock) time (h:mm:ss or m:ss): 0:37.04
Average shared text size (kbytes): 0
Average unshared data size (kbytes): 0
Average stack size (kbytes): 0
Average total size (kbytes): 0
Maximum resident set size (kbytes): 1408
Average resident set size (kbytes): 0
Major (requiring I/O) page faults: 0
Minor (reclaiming a frame) page faults: 125
Voluntary context switches: 152999
Involuntary context switches: 2880
Swaps: 0
File system inputs: 0
File system outputs: 0
Socket messages sent: 0
Socket messages received: 0
Signals delivered: 0
Page size (bytes): 4096
Exit status: 0
kitkat2@ubuntuchhota:~/Desktop/final_rev2$

Epoll 500 throughput



Epoll 1000 Throughput



Epoll 3000 throughput

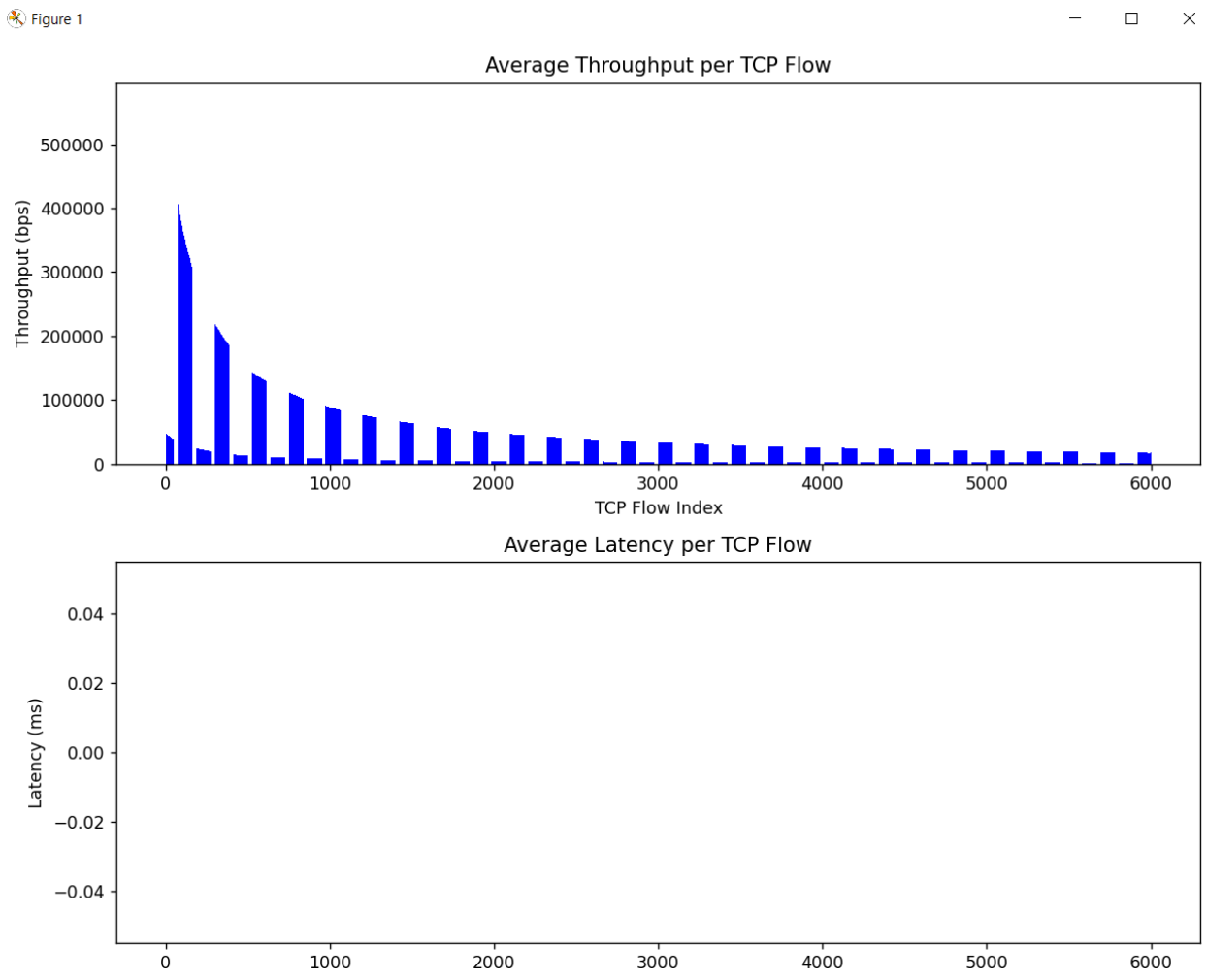
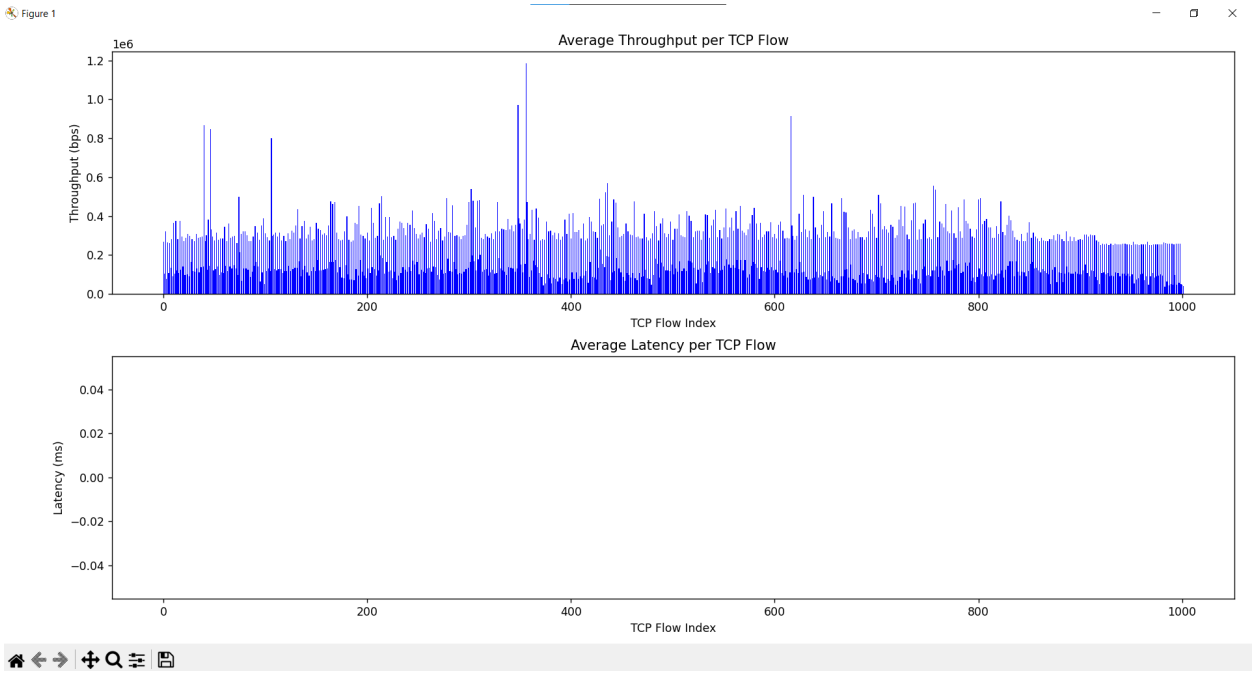
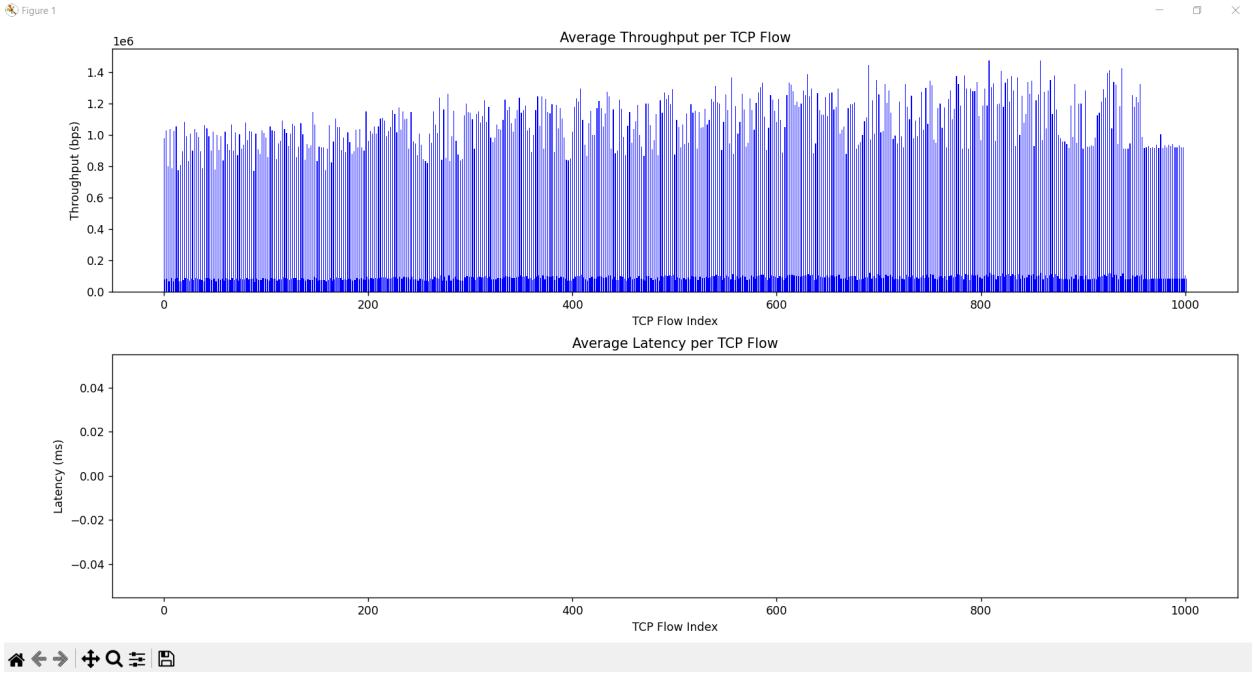


Figure 1
Average Throughput per TCP Flow
Throughput (bps)
500000
400000
300000
200000
100000
0
0
1000
2000
3000
4000
5000
6000
TCP Flow Index
Average Latency per TCP Flow
Latency (ms)
0.04
0.02
0.00
−0.02
−0.04
0
1000
2000
3000
4000
5000
6000

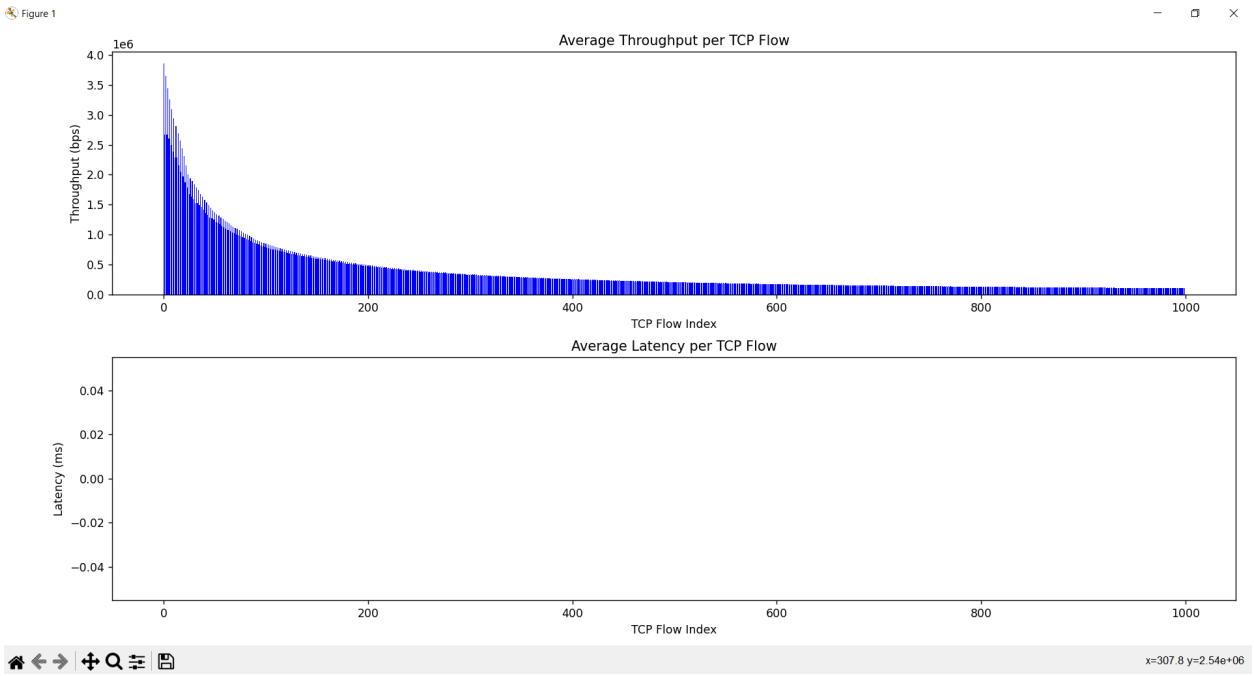
Fork 500 throughput



Thread Throughput



SELECTG THROUGHPUT



Fork-based servers:

- Spawning of new process per connection escalates memory usage due to isolated resource allocation.
- CPU overhead intensified by increased process count and higher context-switching frequency.
-

pthread-based servers:

- Threads within a single process share memory, reducing overall memory footprint compared to process-per-connection model.
- High thread counts still strain CPU with scheduling overhead.
- Thread synchronization introduces significant resource overhead.
-

I/O Multiplexing (select, poll, epoll):

- Single process/thread manages multiple connections, leveraging asynchronous polling of file descriptors, optimizing memory and CPU usage.
- select and poll exhibit linear complexity, leading to decreased efficiency as file descriptor count grows.
- epoll provides near-constant time complexity post-initialization, enhancing performance consistency.
-

Resource utilization factors:

- Management overhead for each process/thread and their associated data structures.
- CPU load correlates with context switch rates, system call overhead, and computation-intensive operations such as factorial calculations.
- Each bullet point reflects a more precise and technical language suited for an audience familiar with server architectures and performance considerations.