CSE 232: Programming Assignment 2

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Question 1:

Server Side:
The server starts accepting TCP connection requests and makes a new socket for every new connection, these sockets are then handled by pthreads which goes to the directory /proc then reads names of all the folders, if the folder name is numeric then reads the /proc/[pid]/stat file of the process, finds the top two processes with max running time (user + kernel time), then sends back the details of these processes and closes the socket.

```
nsl405@nsl405:~/cn_assignment$ ./server
Request recieved: get_top_processes
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
top_cpu_processes sent
Request recieved: get_top_processes
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
top_cpu_processes sent
^CRequest recieved: get_top_processes
top_cpu_processes sent
```

Client Side:
The client make n pthreads which is given as a command line argument and then sends n requests to the server using multiple pthreads which wait for the response and print the response before closing the connection.

```
lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ ./client 5
Thread 2: Request Sent
Thread 4: Request Sent
Thread 2: Request Sent
Thread 5: Request Sent
Thread 5: Request Sent
Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523790
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 4: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523790
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523790
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523790
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523790
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ ./client 3
Thread 2: Request Sent
Thread 2: Request Sent
Thread 3: Request Sent
Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523830
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 3: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523830
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523830
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ ./client 1
Thread 1: Request Sent
Thread 1: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 523833
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$
```

Question 2 :

(a) Single Threaded Server:

Same code used as in Q1 but added a pthread_join after every conection request to make the server sequential.

Server side:

Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent

Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
^CRequest recieved: get_top_processes
top_cpu_processes sent

 Performance counter stats for 'sudo ./server 0':

          22.72 msec task-clock   #   0.003 CPUs utilized
             35   context-switches   #   1.540 K/sec
              1   cpu-migrations   #   44.005 /sec
            735   page-faults   #   32.344 K/sec
     88,945,805   cycles   #   3.914 GHz
    112,393,014   instructions   #   1.26 insn per cycle
     20,961,786   branches   # 922.425 M/sec
        298,481   branch-misses   #   1.42% of all branches

    6.808869076 seconds time elapsed

    0.001176000 seconds user
    0.004295000 seconds sys

```
nsl405@nsl405:~/cn_assignment$ sudo perf stat sudo ./server 0
 Request recieved: get_top_processes
 top_cpu_processes sent
 Request recieved: get_top_processes
 top_cpu_processes sent
 Request recieved: get_top_processes
 top_cpu_processes sent
 Request recieved: get_top_processes
 top_cpu_processes sent
 Request recieved: get_top_processes
 top_cpu_processes sent
 ^CRequest recieved: get_top_processes
 top_cpu_processes sent

  Performance counter stats for 'sudo ./server 0':

             22.72 msec task-clock                #      0.003 CPUs utilized
                35      context-switches          #      1.540 K/sec
                 1      cpu-migrations            #     44.005 /sec
               735      page-faults               #     32.344 K/sec
        88,945,805      cycles                    #      3.914 GHz
       112,393,014      instructions              #      1.26  insn per cycle
        20,961,786      branches                  #    922.425 M/sec
           298,481      branch-misses             #      1.42% of all branches

      6.808869076 seconds time elapsed

      0.001176000 seconds user
      0.004295000 seconds sys
```

```
lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ sudo perf stat sudo ./client 5
Thread 2: Request Sent
Thread 3: Request Sent
Thread 5: Request Sent
Thread 4: Request Sent
Thread 5: Request Sent
Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 3: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 4: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371


 Performance counter stats for 'sudo ./client 5':

          20.07 msec task-clock                #    0.634 CPUs utilized
             29      context-switches          #    1.445 K/sec
              6      cpu-migrations            #  298.990 /sec
            800      page-faults               #   39.865 K/sec
     38,631,541      cycles                    #    1.925 GHz
     13,189,162      stalled-cycles-frontend   #   34.14% frontend cycles idle
     26,180,515      instructions              #    0.68  insn per cycle
                                               #    0.50  stalled cycles per insn
      5,432,196      branches                  #  270.695 M/sec
        590,626      branch-misses             #   10.87% of all branches

    0.031674267 seconds time elapsed

    0.003129000 seconds user
    0.011475000 seconds sys
```

Client side:

Thread 2: Request Sent
Thread 3: Request Sent
Thread 5: Request Sent
Thread 4: Request Sent
Thread 5: Request Sent
Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 3: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 4: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521259
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

 Performance counter stats for 'sudo ./client 5':

```
        20.07 msec task-clock              #      0.634 CPUs utilized
           29     context-switches         #      1.445 K/sec
            6     cpu-migrations           #  298.990 /sec
      800    page-faults                   #  39.865 K/sec
   38,631,541    cycles                    #      1.925 GHz
   13,189,162    stalled-cycles-frontend      #  34.14% frontend cycles
idle
   26,180,515    instructions             #      0.68  insn per cycle
                      #      0.50  stalled cycles per insn
    5,432,196    branches                     # 270.695 M/sec
      590,626    branch-misses                #  10.87% of all branches


    0.031674267 seconds time elapsed

    0.003129000 seconds user
    0.011475000 seconds sys
```

The client has to resend the requests multiple times since the server is single threaded hence we see a 10.87% branch miss rate on the client side, while the server is mostly idle which can be inferred from the low cpu migrations.

(b) Multi Threaded Server:

Same code as Q1.

Server side:

```
Request recieved: get_top_processes
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
Request recieved: get_top_processes
top_cpu_processes sent
top_cpu_processes sent
top_cpu_processes sent
^C^[[ARequest recieved: get_top_processes
top_cpu_processes sent
```

Performance counter stats for 'sudo ./server':

```
        23.06 msec task-clock              #    0.001 CPUs utilized
           32     context-switches         #    1.387 K/sec
            0     cpu-migrations           #    0.000 /sec
          756     page-faults              #   32.778 K/sec
   90,024,606     cycles                   #    3.903 GHz
  113,420,776     instructions             #    1.26  insn per cycle
   21,165,526     branches                 #  917.663 M/sec
      296,894     branch-misses            #    1.40% of all branches

  21.091551288 seconds time elapsed

   0.004055000 seconds user
   0.001351000 seconds sys
```

```
nsl405@nsl405:~/cn_assignment$ sudo perf stat sudo ./server
[sudo] password for nsl405:
Request recieved: get_top_processes
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
Request recieved: get_top_processes
top_cpu_processes sent
top_cpu_processes sent
top_cpu_processes sent
^C^[[ARequest recieved: get_top_processes
top_cpu_processes sent

 Performance counter stats for 'sudo ./server':

            23.06 msec task-clock               #      0.001 CPUs utilized
               32      context-switches         #      1.387 K/sec
                0      cpu-migrations           #      0.000 /sec
              756      page-faults              #     32.778 K/sec
       90,024,606      cycles                   #      3.903 GHz
      113,420,776      instructions             #      1.26  insn per cycle
       21,165,526      branches                 #    917.663 M/sec
          296,894      branch-misses            #      1.40% of all branches

     21.091551288 seconds time elapsed

      0.004055000 seconds user
      0.001351000 seconds sys
```

```
lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ gcc -o client client.c
lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ sudo perf stat sudo ./client 5
[sudo] password for lakshya:
Thread 2: Request Sent
Thread 2: Request Sent
Thread 5: Request Sent
Thread 4: Request Sent
Thread 3: Request Sent
Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 3: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 4: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371


 Performance counter stats for 'sudo ./client 5':

            20.81 msec task-clock                       #    0.628 CPUs utilized
               30      context-switches                 #    1.442 K/sec
                0      cpu-migrations                   #    0.000 /sec
              807      page-faults                      #   38.787 K/sec
       39,769,368      cycles                           #    1.911 GHz
       14,028,244      stalled-cycles-frontend          #   35.27% frontend cycles idle
       26,248,624      instructions                     #    0.66  insn per cycle
                                                        #    0.53  stalled cycles per insn
        5,444,433      branches                         #  261.675 M/sec
          591,062      branch-misses                    #   10.86% of all branches

      0.033152431 seconds time elapsed

      0.004207000 seconds user
      0.011571000 seconds sys
```

Client side:

Thread 2: Request Sent
Thread 2: Request Sent
Thread 5: Request Sent
Thread 4: Request Sent
Thread 3: Request Sent
Thread 2: Message recieved: Top 2 CPU-consuming processes on the server
are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 3: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 2: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 4: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Thread 5: Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521083
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

 Performance counter stats for 'sudo ./client 5':

           20.81 msec task-clock   #   0.628 CPUs utilized
               30   context-switches   #   1.442 K/sec
                0   cpu-migrations   #   0.000 /sec
             807   page-faults   # 38.787 K/sec
       39,769,368   cycles   #   1.911 GHz
       14,028,244   stalled-cycles-frontend   #   35.27% frontend cycles
idle
       26,248,624   instructions   #   0.66 insn per cycle
                         #   0.53 stalled cycles per insn
        5,444,433   branches   # 261.675 M/sec
          591,062   branch-misses   #   10.86% of all branches

       0.033152431 seconds time elapsed

       0.004207000 seconds user
       0.011571000 seconds sys

Since the server is waiting for requests from the client it has very low user+system time with a blocking accept call thereby having a low number of CPUs used. Since our server side computation is very limited, therefore the client shows similar results in multi threaded as well as single threaded server.

(c) Server with select:
Using the provided code for select and add the necessary functions from Q1, the client just makes one connection with the server and sends the requests.

Server side:

```
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
read: Success
Host disconnected, ip 192.168.243.162, port 44680
^C
 Performance counter stats for 'sudo ./server_select':

        21.57 msec task-clock                #    0.003 CPUs utilized
           38      context-switches          #    1.762 K/sec
            1      cpu-migrations            #   46.362 /sec
          729      page-faults               #   33.798 K/sec
   85,540,766      cycles                    #    3.966 GHz
  111,140,081      instructions              #    1.30  insn per cycle
   20,700,272      branches                  #  959.713 M/sec
      289,389      branch-misses             #    1.40% of all branches

   6.891477636 seconds time elapsed

   0.003353000 seconds user
   0.002054000 seconds sys
```

```
nsl405@nsl405:~/cn_assignment$ sudo perf stat sudo ./server_select
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
Request recieved: get_top_processes
top_cpu_processes sent
read: Success
Host disconnected, ip 192.168.243.162, port 44680
^C
 Performance counter stats for 'sudo ./server_select':

             21.57 msec task-clock                #    0.003 CPUs utilized
                38      context-switches          #    1.762 K/sec
                 1      cpu-migrations            #   46.362 /sec
               729      page-faults               #   33.798 K/sec
        85,540,766      cycles                    #    3.966 GHz
       111,140,081      instructions              #    1.30  insn per cycle
        20,700,272      branches                  #  959.713 M/sec
           289,389      branch-misses             #    1.40% of all branches

       6.891477636 seconds time elapsed

       0.003353000 seconds user
       0.002054000 seconds sys
```

```
lakshya@lakshya-Vostro-5625:~/Desktop/cn_assignment$ sudo perf stat sudo ./client_select_automated 5
Connected to server
Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371


 Performance counter stats for 'sudo ./client_select_automated 5':

             19.56 msec task-clock                #    0.538 CPUs utilized
                19      context-switches          #  971.583 /sec
                 2      cpu-migrations            #  102.272 /sec
               788      page-faults               #   40.295 K/sec
        39,382,657      cycles                    #    2.014 GHz
        13,393,158      stalled-cycles-frontend   #   34.01% frontend cycles idle
        25,363,911      instructions              #    0.64  insn per cycle
                                                  #    0.53  stalled cycles per insn
         5,255,182      branches                  #  268.729 M/sec
           561,424      branch-misses             #   10.68% of all branches

       0.036361420 seconds time elapsed

       0.003177000 seconds user
       0.012708000 seconds sys
```

Client side:

Connected to server
Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

Request Sent
Message recieved: Top 2 CPU-consuming processes on the server are:
PID: 3405, Name: (firefox), Total CPU Time: 521797
PID: 10751, Name: (tracker-miner-f), Total CPU Time: 435371

 Performance counter stats for 'sudo ./client_select_automated 5':

          19.56 msec task-clock   #   0.538 CPUs utilized
             19   context-switches   # 971.583 /sec
              2   cpu-migrations   # 102.272 /sec
       788   page-faults   #   40.295 K/sec
     39,382,657   cycles   #   2.014 GHz
     13,393,158   stalled-cycles-frontend   #   34.01% frontend cycles
idle
     25,363,911   instructions   #   0.64 insn per cycle
                        #   0.53 stalled cycles per insn
      5,255,182   branches   # 268.729 M/sec
        561,424   branch-misses   #   10.68% of all branches

      0.036361420 seconds time elapsed

      0.003177000 seconds user
      0.012708000 seconds sys

In all the cases the client has similar performance due to the low cpu intensity
tasks on the server side, The gave better performance in this case since it was

not waiting for I/O most of the time due to having an active connection from the client. The main downside of using select is that the maximum number of clients would be limited as specified in the server side code.