Project 3 I/O Monitoring (Linux)

Task 5.1

Task 5.1.1 Rotational Delay and IOPS of a 5400 RPM Drive

5.1) Rotational Delay :-

- RPM to RPS (Revolution Per Second) :-

$$RPS = \frac{5400}{60} = 90\ RPS$$

- Time taken per rotation :-

$$1\ rotation = \frac{1}{90} = 0.011\ seconds$$

$$1\ rotation \approx 11\ ms$$

- Rotational delay is half of time taken for 1 rotation :-

$$Rotational\ delay = \frac{11 ms}{2}$$

$$\boxed{RD = 5.5 ms}$$

- Add an average of 3ms for seek time :-

$$time = 5.5ms + 3ms$$
$$= 8.5ms$$

- Add 2ms for latency (internal transfer) :-

$$time = 8.5 + 2ms = 10.5ms$$

- IOPS

$$IOPS = \frac{1}{\text{avg. latency} + \text{avg. seek time}}$$

$$\boxed{Avg.\ IOPS = \frac{1}{10.5 \times 10^{-3}} \approx 95\ IOPS}$$

Task 5.2

Task 5.2.1 Monitoring Behavior with IOSTAT

Output 1

```
Device            r/s     rkB/s   rrqm/s  %rrqm r_await rareq-sz     w/s     wkB/s   wrqm/s  %wr
qm w_await wareq-sz     d/s     dkB/s   drqm/s  %drqm d_await dareq-sz     f/s f_await  aqu-sz
%util
loop0            0.00      0.00     0.00   0.00    0.00     1.21    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
loop1            0.09      1.20     0.00   0.00    0.20    12.78    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop2            0.01      0.22     0.00   0.00    0.38    18.73    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
loop3            0.40      5.14     0.00   0.00    0.09    12.93    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop4            0.05      0.64     0.00   0.00    0.16    13.78    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop5            0.44      2.09     0.00   0.00    0.05     4.73    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop6            0.01      0.06     0.00   0.00    0.10     8.97    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
loop7            0.11      3.77     0.00   0.00    0.21    32.89    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.03
loop8            0.00      0.00     0.00   0.00    0.00     1.27    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
vda              6.49    234.96     2.31  26.27    0.23    36.18   14.92    524.83    13.11  46.
77    0.56    35.18    0.93  10323.96     0.00   0.00    0.14 11157.01    7.83    0.15    0.01
 0.61
```

Efficiency for Read IOPS

$$Efficiency\ for\ Read\ IOPS\ =\ \frac{rKB/s}{r/s}$$

$$Efficiency\ for\ Read\ IOPS\ =\ \frac{234.96}{6.49} = 36.20$$

Efficiency for Write IOPS

$$Efficiency\ for\ Write\ \ IOPS\ =\ \frac{wKB/s}{w/s}$$

$$Efficiency\ for\ Write\ \ IOPS\ =\ \frac{524.83}{14.92} = \ 35.17$$

Output 2

```
Device            r/s     rkB/s   rrqm/s  %rrqm r_await rareq-sz     w/s     wkB/s   wrqm/s  %wr
qm w_await wareq-sz     d/s     dkB/s   drqm/s  %drqm d_await dareq-sz     f/s f_await  aqu-sz
%util
loop0            0.00      0.00     0.00   0.00    0.00     1.21    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
loop1            0.08      1.05     0.00   0.00    0.20    12.78    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop2            0.01      0.20     0.00   0.00    0.38    18.73    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
loop3            0.35      4.51     0.00   0.00    0.09    12.93    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop4            0.04      0.56     0.00   0.00    0.16    13.78    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop5            0.39      1.84     0.00   0.00    0.05     4.73    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.01
loop6            0.01      0.05     0.00   0.00    0.10     8.97    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
loop7            0.10      3.31     0.00   0.00    0.21    32.89    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.03
loop8            0.00      0.00     0.00   0.00    0.00     1.27    0.00      0.00     0.00   0.
00    0.00     0.00    0.00      0.00     0.00   0.00    0.00     0.00    0.00    0.00    0.00
 0.00
vda              5.69    205.93     2.03  26.27    0.23    36.18   13.16    460.51    11.52  46.
66    0.56    34.98    0.81   9048.29     0.00   0.00    0.14 11157.01    6.87    0.15    0.01
 0.54
```

Efficiency for Read IOPS

$$Efficiency\ for\ Read\ IOPS\ =\ \frac{rKB/s}{r/s}$$

$$Efficiency\ for\ Read\ IOPS\ =\ \frac{205.93}{5.69} = 36.19$$

Efficiency for Write IOPS

$$Efficiency\ for\ Write\ \ IOPS\ =\ \frac{wKB/s}{w/s}$$

$$Efficiency\ for\ Write\ \ IOPS\ =\ \frac{460.51}{13.16}\ =\ 34.99$$

Data Written

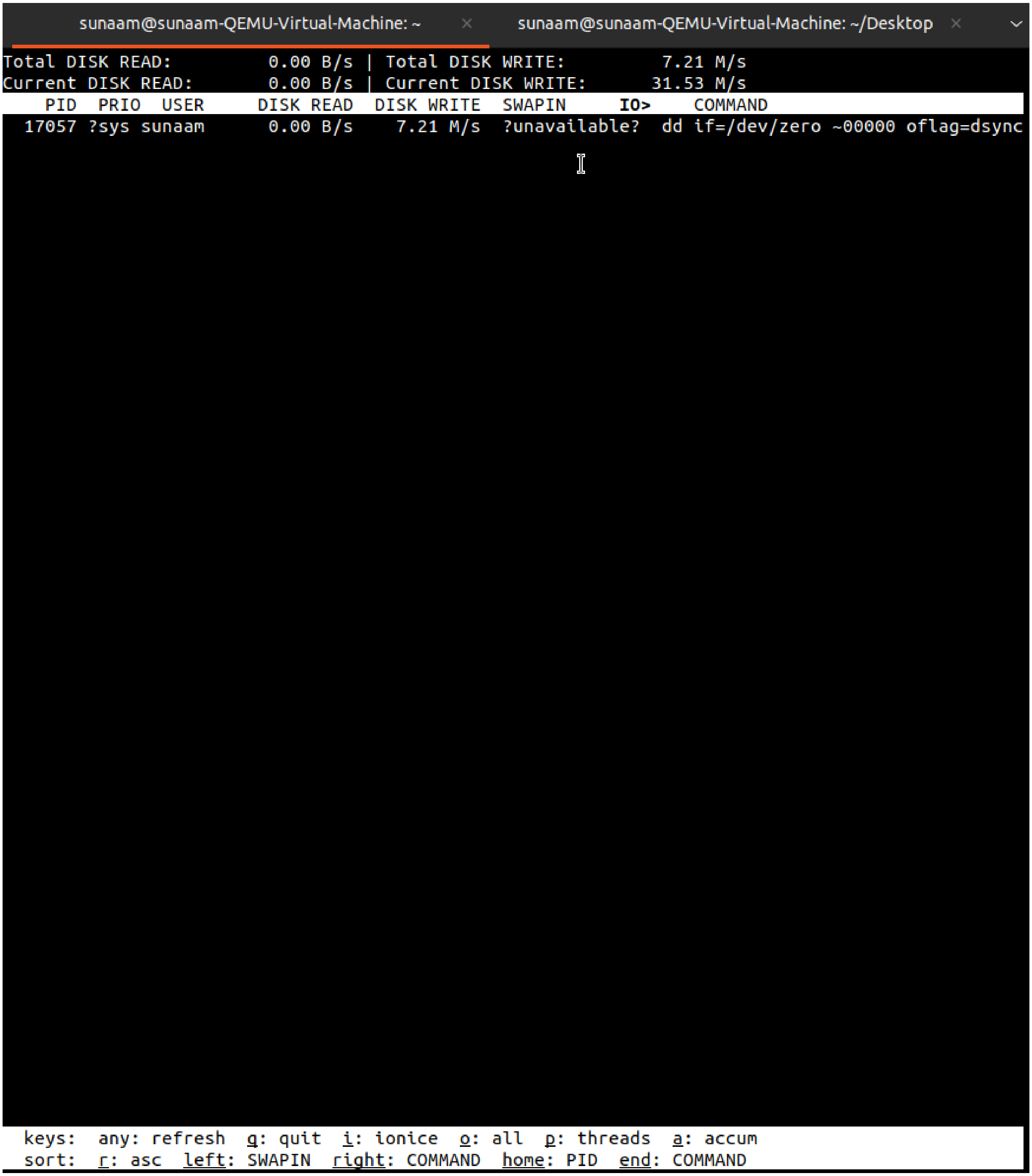
As the efficiency for the Wrtie IOPS decreases ever so slightly, we can say that the amount of data written has decreased. Although the change is very small, on a general level if the efficiency decreases, it means that the amount of data being written is decreasing.

Loop Devices

```
sunaam@sunaam-QEMU-Virtual-Machine:~$ df -kh /dev/loop*
Filesystem      Size  Used Avail Use% Mounted on
/dev/loop0      128K  128K     0 100% /snap/bare/5
/dev/loop1       69M   69M     0 100% /snap/core22/867
/dev/loop2      227M  227M     0 100% /snap/firefox/3259
/dev/loop3      476M  476M     0 100% /snap/gnome-42-2204/143
/dev/loop4       12M   12M     0 100% /snap/snap-store/963
/dev/loop5       92M   92M     0 100% /snap/gtk-common-themes/1535
/dev/loop6      512K  512K     0 100% /snap/snapd-desktop-integration/85
/dev/loop7       36M   36M     0 100% /snap/snapd/20298
udev            1.9G     0  1.9G   0% /dev
udev            1.9G     0  1.9G   0% /dev
```

Task 5.2.2 Monitoring Behavior with IOTOP

IOTOP with Script Running

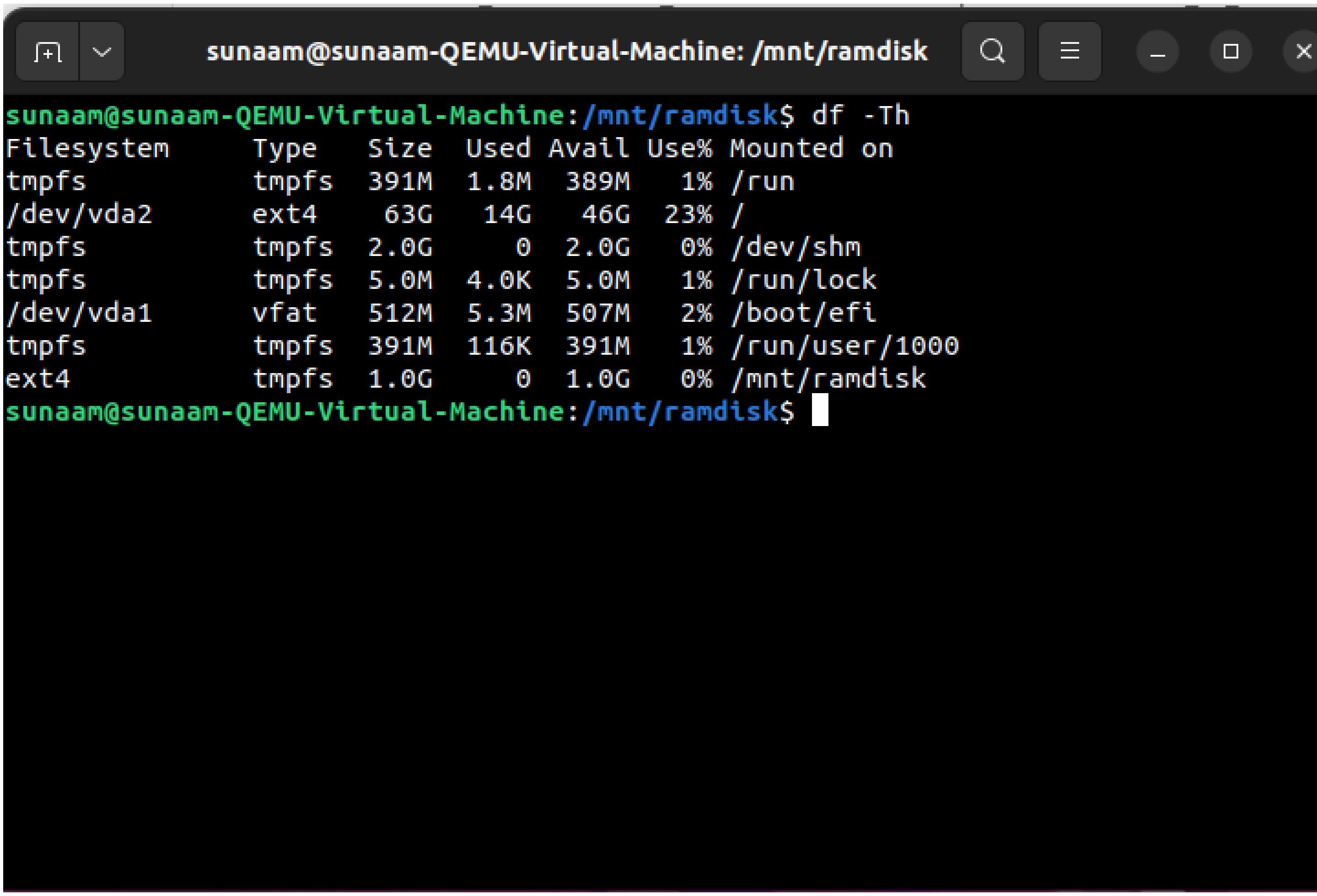


IOTOP when Script is killed

Task 5.3

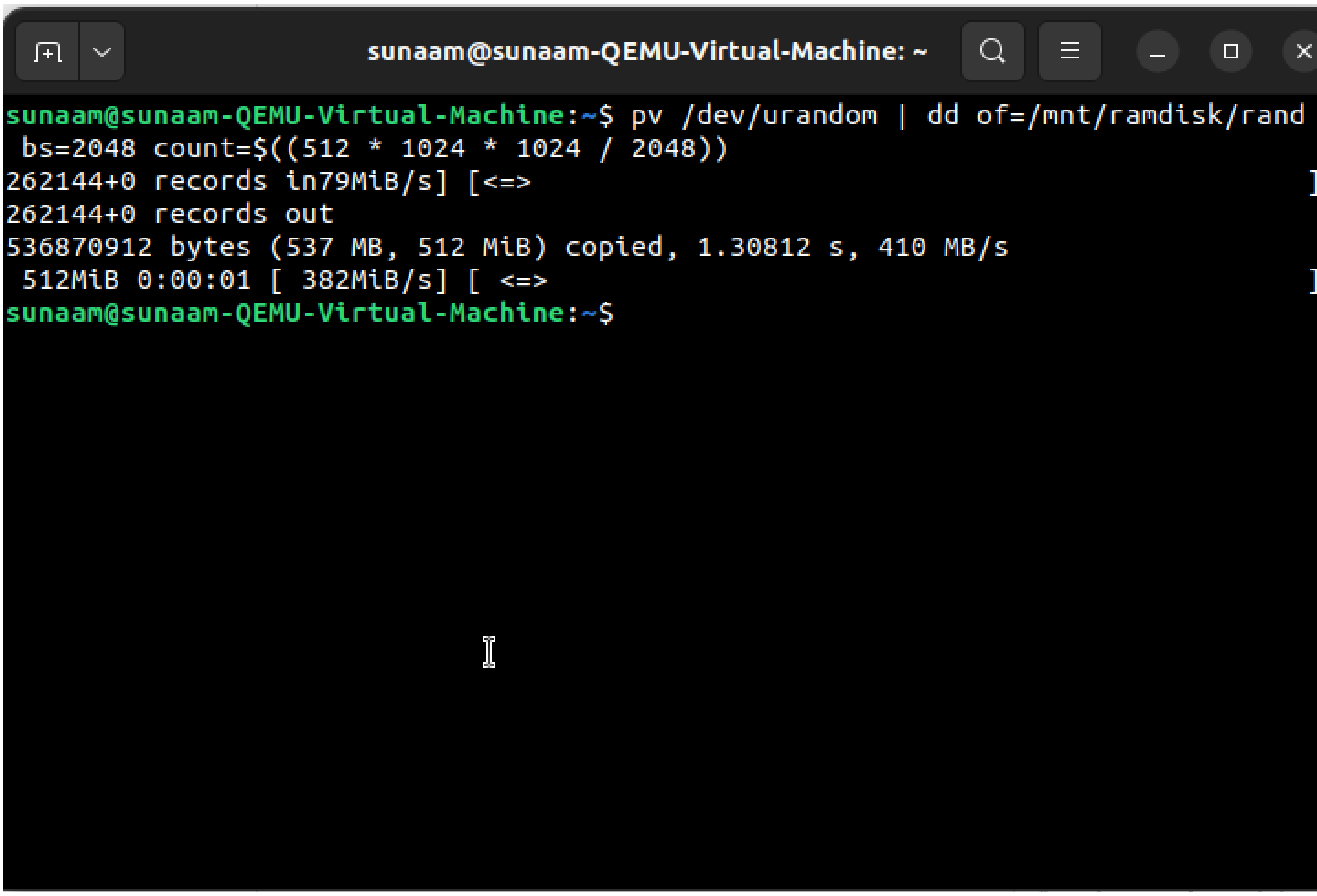
Task 5.3.1

A ext4 RAM Disk is created at /mnt/ramdisk.

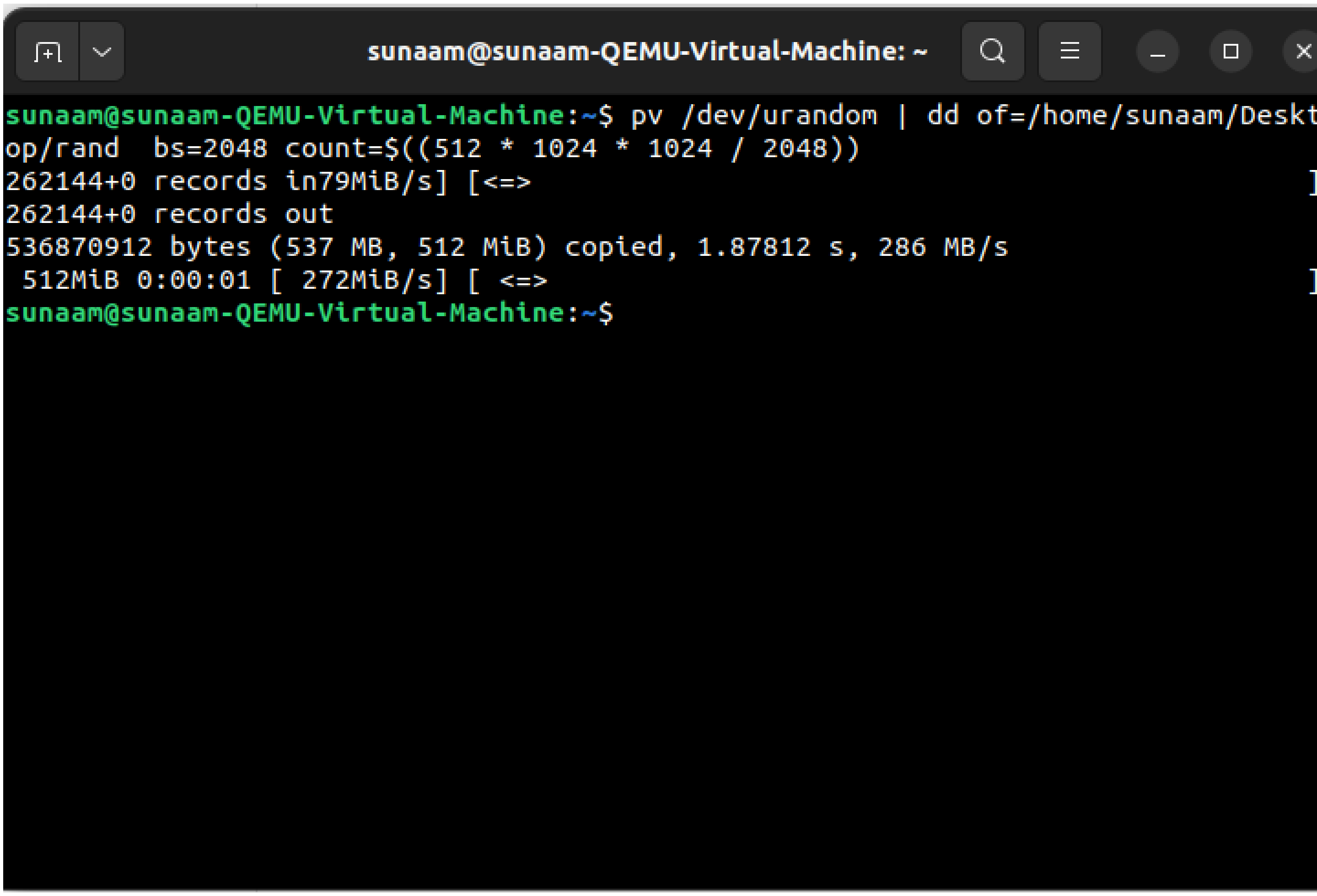

sunaam@sunaam-QEMU-Virtual-Machine: /mnt/ramdisk
sunaam@sunaam-QEMU-Virtual-Machine:/mnt/ramdisk$ df -Th
Filesystem   Type   Size Used Avail Use% Mounted on
tmpfs   tmpfs 391M 1.8M 389M   1% /run
/dev/vda2   ext4   63G   14G   46G 23% /
tmpfs   tmpfs 2.0G   0 2.0G   0% /dev/shm
tmpfs   tmpfs 5.0M 4.0K 5.0M   1% /run/lock
/dev/vda1   vfat   512M 5.3M 507M   2% /boot/efi
tmpfs   tmpfs 391M 116K 391M   1% /run/user/1000
ext4   tmpfs 1.0G   0 1.0G   0% /mnt/ramdisk
sunaam@sunaam-QEMU-Virtual-Machine:/mnt/ramdisk$

Task 5.3.2

Transfer in RAM DISK



Transfer in Other DISK



Conclusion

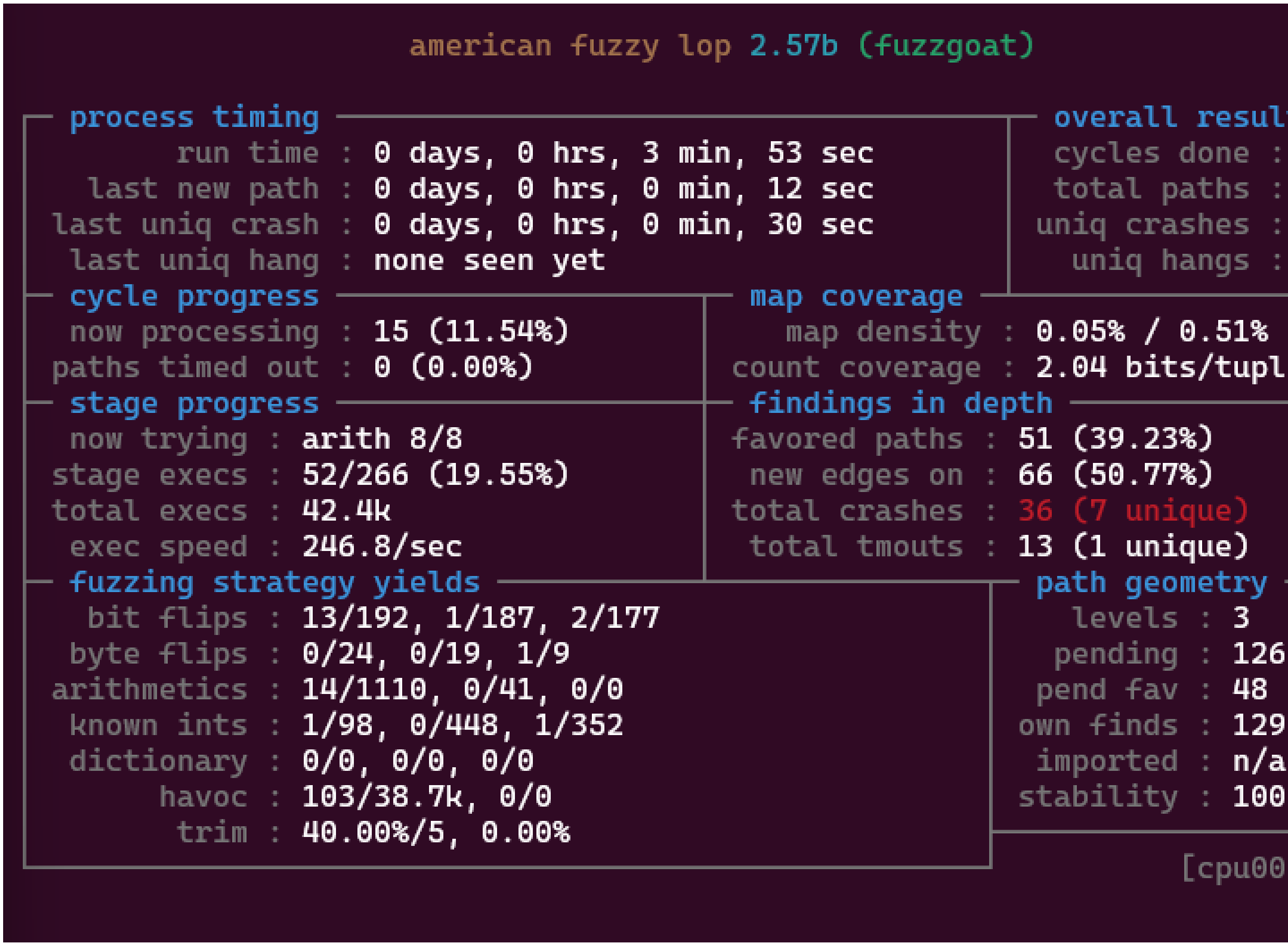
In the first screenshot, the data is being transferred to a tmpfs filesystem mounted at /mnt/ramdisk. As tmpfs is stored in RAM, the data transfer speed is faster compared to traditional disk-based filesystems.

In the second screenshot, the data is being transferred to a regular filesystem located at /home/student. The performance here may be influenced by the characteristics of the underlying storage device (HDD or SSD) where /home is located. It is slower than the RAM DISK.

The tmpfs-based transfer (/mnt/ramdisk/rand) shows significantly faster transfer speeds and shorter elapsed times, it suggests that utilizing tmpfs (RAM) for certain types of operations can offer better performance, especially for temporary or frequently accessed data.

Task 5.4

Installed AFL



Perf Report

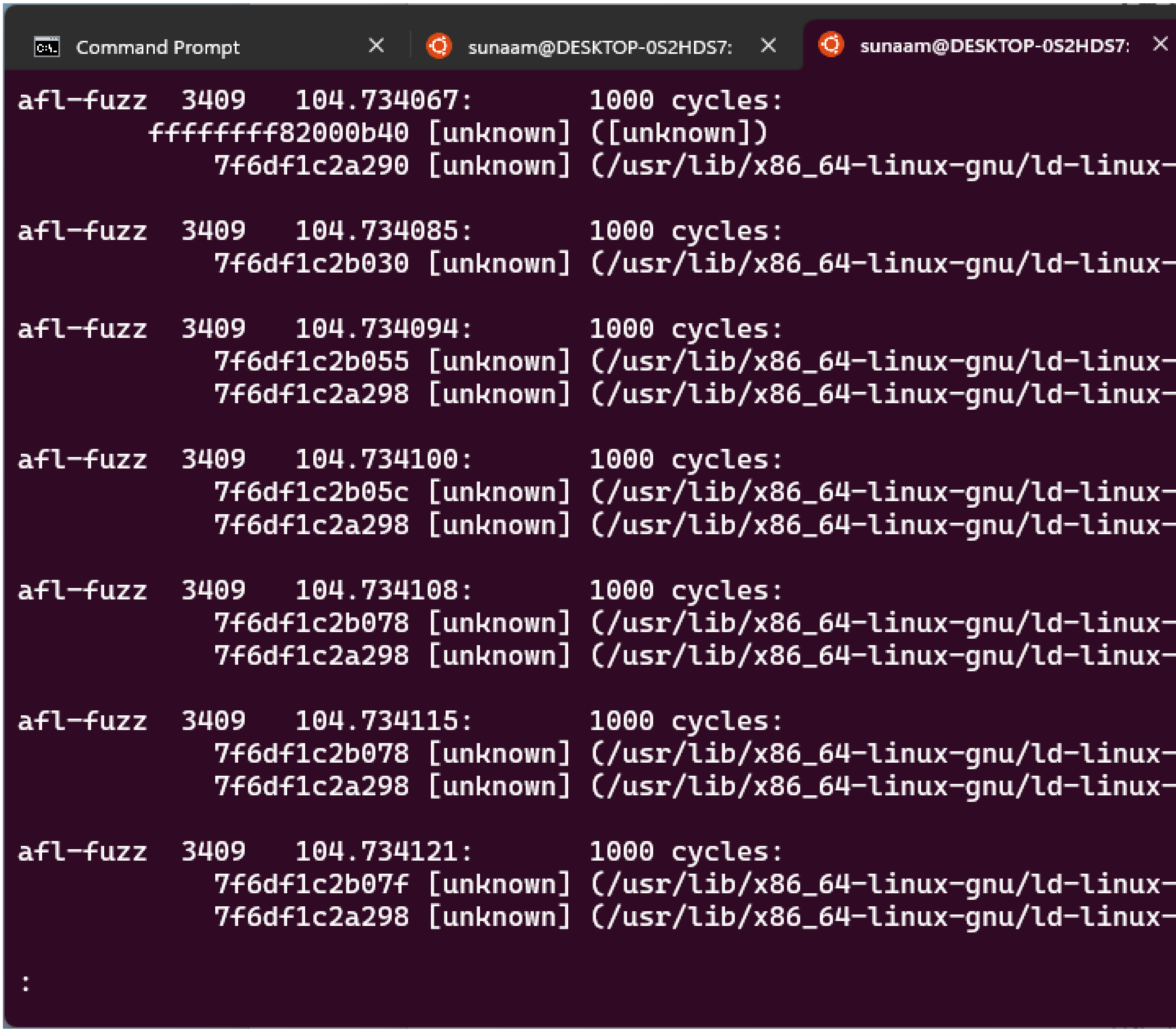
```
Command Prompt    sunaam@DESKTOP-0S2HDS7:    sunaam@DESKTOP-0S2HDS7:

sunaam@DESKTOP-0S2HDS7:~$ perf report -i perf.data
# To display the perf.data header info, please use --header/--header-only options.
#
#
# Total Lost Samples: 0
#
# Samples: 635K of event 'cycles'
# Event count (approx.): 635821000
#
# Children      Self  Command   Shared Object         Symbol
# ........  ........  ........  ....................  ........................
#
    88.87%    88.77%  afl-fuzz  afl-fuzz              [.] run_target
             |
             |--79.29%--0
             |          run_target
             |
              --9.51%--run_target

    79.38%     0.00%  afl-fuzz  [unknown]             [.] 0000000000000000
             |
            ---0
                |
                 --79.36%--run_target

     2.46%     1.83%  fuzzgoat  libc.so.6             [.] read
             |
              --2.46%--read
```

Perf Script



Identify PID of AFL-Fuzz from Perf Script

Command: $ perf script -i perf.data -F comm,pid | grep afl-fuzz | head -1

Filter Unrelated Samples

Command: $ perf script -i perf.data | grep afl-fuzz > perf_afl_fuzz.out


```
# To display the perf.data header info, please use --header/--header-on
#
#
# Total Lost Samples: 0
#
# Samples: 290K of event 'cycles'
# Event count (approx.): 290588000
#
# Children      Self  Command   Shared Object         Symbol
# ........  ........  ........  ....................  .................
#
    86.07%    85.97%  afl-fuzz  afl-fuzz              [.] run_target
             |
             |--77.51%--0
             |          run_target
             |
              --8.48%--run_target

    77.62%     0.00%  afl-fuzz  [unknown]             [.] 0000000000000
            |
            ---0
               |
                --77.58%--run_target

     2.84%     2.22%  fuzzgoat  libc.so.6             [.] read
             |
              --2.84%--read
:
```

Heavily Used Functions

The top functions are the most heavily used functions.

sunaam@DESKTOP-0S2HDS7:

```
          |
          ---0x56417419b2b0

     0.36%     0.35%  fuzzgoat  fuzzgoat              [.] main
     0.34%     0.34%  afl-fuzz  [unknown]             [k] 0xffffffff820
     0.31%     0.00%  fuzzgoat  [unknown]             [.] 0000000000000
     0.30%     0.30%  fuzzgoat  [unknown]             [k] 0xffffffff820
     0.28%     0.00%  fuzzgoat  [unknown]             [.] 0x00000000000
     0.23%     0.18%  fuzzgoat  fuzzgoat              [.] __afl_store
     0.23%     0.18%  fuzzgoat  libc.so.6             [.] _Fork
     0.19%     0.00%  afl-fuzz  [unknown]             [.] 0x677a7a75662
     0.18%     0.15%  fuzzgoat  libc.so.6             [.] __close
     0.17%     0.00%  afl-fuzz  [unknown]             [.] 0x000055ead61
     0.16%     0.15%  fuzzgoat  fuzzgoat              [.] __afl_return
     0.14%     0.14%  fuzzgoat  fuzzgoat              [.] 0x00000000000
     0.14%     0.00%  fuzzgoat  fuzzgoat              [.] 0x00005641741
     0.12%     0.12%  afl-fuzz  afl-fuzz              [.] save_if_inter
     0.12%     0.12%  fuzzgoat  fuzzgoat              [.] 0x00000000000
     0.12%     0.00%  fuzzgoat  fuzzgoat              [.] 0x00005641741
     0.11%     0.11%  afl-fuzz  libc.so.6             [.] read
     0.10%     0.10%  afl-fuzz  afl-fuzz              [.] 0x00000000000
     0.10%     0.00%  afl-fuzz  afl-fuzz              [.] 0x000055ead5a
     0.09%     0.00%  afl-fuzz  afl-fuzz              [.] 0x000055ead5a
     0.09%     0.09%  afl-fuzz  afl-fuzz              [.] 0x00000000000
     0.08%     0.08%  fuzzgoat  ld-linux-x86-64.so.2  [.] __tunable_get
     0.08%     0.00%  fuzzgoat  [unknown]             [.] 0x00007ffc83d
     0.07%     0.00%  fuzzgoat  libc.so.6             [.] 0x00007ff9ff0
     0.07%     0.06%  fuzzgoat  libc.so.6             [.] malloc
     0.07%     0.00%  fuzzgoat  libc.so.6             [.] 0x00007ff9ff0
     0.07%     0.00%  fuzzgoat  libc.so.6             [.] 0x00007ff9ff0
     0.06%     0.06%  fuzzgoat  libc.so.6             [.] 0x00000000000
     0.06%     0.06%  afl-fuzz  afl-fuzz              [.] 0x00000000000
     0.06%     0.00%  afl-fuzz  afl-fuzz              [.] 0x000055ead5a
     0.06%     0.06%  fuzzgoat  libc.so.6             [.] 0x00000000000
     0.05%     0.05%  fuzzgoat  libc.so.6             [.] wait4
     0.05%     0.00%  afl-fuzz  afl-fuzz              [.] 0x000055ead5a
     0.05%     0.00%  afl-fuzz  libc.so.6             [.] 0x00007f7bb59
     0.05%     0.05%  afl-fuzz  libc.so.6             [.] 0x00000000001
     0.05%     0.05%  afl-fuzz  afl-fuzz              [.] 0x00000000000
     0.05%     0.00%  fuzzgoat  libc.so.6             [.] 0x00007ff9fef
     0.05%     0.05%  afl-fuzz  [unknown]             [k] 0xffffffff820
     0.04%     0.00%  fuzzgoat  libc.so.6             [.] 0x00007ff9ff0
     0.04%     0.04%  fuzzgoat  libc.so.6             [.] 0x00000000000
     0.04%     0.04%  fuzzgoat  libc.so.6             [.] 0x00000000000
     0.04%     0.00%  fuzzgoat  libc.so.6             [.] 0x00007ff9ff0
     0.04%     0.04%  fuzzgoat  libc.so.6             [.] 0x00000000000
```

Task 5.5

Automotive

```
6.248278722140 radians = 358 degrees
6.265732014660 radians = 359 degrees
6.283185307180 radians = 360 degrees

 Performance counter stats for './basicm

              50.52 msec task-clock
                511      context-switches
                  1      cpu-migrations
                 21      page-faults
   <not supported>       cycles
   <not supported>       instructions
   <not supported>       branches
   <not supported>       branch-misses

        0.098760267 seconds time elapsed

        0.021368000 seconds user
        0.029915000 seconds sys

sunaam@sunaam-QEMU-Virtual-Machine:~/Dow
```

Network

```
sunaam@sunaam-QEMU-Virtual-Machine:~/Do
Usage: dijkstra <filename>
Only supports matrix size is #define'd.
./dijkstra_small: Segmentation fault

 Performance counter stats for './dijks

              0.91 msec task-clock
                 2      context-switche
                 1      cpu-migrations
                28      page-faults
   <not supported>      cycles
   <not supported>      instructions
   <not supported>      branches
   <not supported>      branch-misses

       0.076202250 seconds time elapsed

       0.000000000 seconds user
       0.001791000 seconds sys
```

Security

```
sunaam@sunaam-QEMU-Virtual-Machine:~/Dow
Usage: blowfish {e|d} <intput> <output>

 Performance counter stats for './bf':

              0.72 msec task-clock
                 0      context-switches
                 0      cpu-migrations
                25      page-faults
   <not supported>      cycles
   <not supported>      instructions
   <not supported>      branches
   <not supported>      branch-misses

       0.001076098 seconds time elapsed

       0.000000000 seconds user
       0.001381000 seconds sys

sunaam@sunaam-QEMU-Virtual-Machine:~/Dow
```

Telecom

```
sunaam@sunaam-QEMU-Virtual-Machine:~/Dow
Usage: fft <waves> <length> -i
-i performs an inverse fft
make <waves> random sinusoids<length> is

 Performance counter stats for './fft':

              1.64 msec task-clock
                 0      context-switches
                 0      cpu-migrations
                21      page-faults
   <not supported>      cycles
   <not supported>      instructions
   <not supported>      branches
   <not supported>      branch-misses

       0.001987738 seconds time elapsed

       0.000000000 seconds user
       0.002347000 seconds sys
```

Office

```
"guide" is not in "and it will recommend
"regard" is in "in this regard. The Univ
"officers" is not in "Executive Officers
"implement" is in "whether and how to im
"principalities" is not in "principles."

 Performance counter stats for './search

              0.74 msec task-clock
                 0      context-switches
                 0      cpu-migrations
                22      page-faults
   <not supported>      cycles
   <not supported>      instructions
   <not supported>      branches
   <not supported>      branch-misses

       0.001132659 seconds time elapsed

       0.001376000 seconds user
       0.000000000 seconds sys
```

Questions

Do the programs have the same proportion of instructions?

The proportion of instructions may vary among programs based on their nature and functionality. Programs with different computational requirements, control flow structures, and memory access patterns are likely to exhibit different proportions of instructions. For example, compute-intensive programs may have a higher proportion of computational instructions, while programs with frequent branching may have a higher proportion of control flow instructions

Do some programs have higher microarchitectural events than others?

Yes, different programs are likely to have varying microarchitectural events based on their characteristics. For instance, programs with complex control flow may exhibit higher branch miss rates, while programs with intensive memory access patterns may experience higher cache miss rates. The nature of the workload and algorithmic choices significantly influences the occurrence of microarchitectural events.

Can the processor keep its computational speed over the run? Are there periods that the processor becomes relatively slower? If there are, why?

The processor's computational speed may vary over the run of a program. Factors such as changes in workload intensity, memory access patterns, and external interference can influence the processor's speed. For example, if a program enters a phase with a high number of cache misses, the processor may experience slowdowns due to increased memory latency. Similarly, external factors like CPU contention with other processes or system events may lead to fluctuations in computational speed.

Do most programs have different phases? What metrics do you use? How many are they?

Many programs exhibit different phases during execution, characterized by variations in microarchitectural events. Metrics such as cache misses, branch misses, and CPU cycles are commonly used to identify program phases. The number of phases depends on the program's structure and workload. For instance, a sorting algorithm may have distinct phases for data input, sorting, and output, each with unique characteristics. The identification of phases can provide insights into the dynamic behavior of a program and help optimize specific code sections.