Part 1:

Basic terminology:

Page present: Refers to the pages mapped in the page table and present in memory.

Page Mapped but not present: Refers to the pages which are mapped in the page table but not present in memory.

Pages Not Mapped: Refers to the pages not present in the page table itself.

Residual Set Size [RSS]: Refers to the memory occupied by a process and currently present in main memory.

VMA Size: Refers to the virtual memory address size of a process which, that is the total legal virtual address space of a process allocated to it by kernel.

Abstract Idea:

The basic idea is to find the number of page present; page mapped but not present and page not mapped for a particular user process. When a process starts, it has been allocated with a set virtual address space and a page table of its own. Now the allocated virtual address space is very large for a user process and generally it doesn't use all of them. Hence it is economical for operating systems kernel to allocate the memory frames on demand. Hence, when a new memory access is required, the kernel maps the memory location to the page table. Hence at any point of time among all the virtual address, a part of it should actually contain the page table entries and some of it might be mapped but swapped out from memory as per the memory management policy of the kernel.

Now, our task is to traverse through the complete region of the user's virtual memory space and find out which of the pages are currently present in main memory. Also it should be convenient to find the pages which are although mapped in the pages table but currently not present in memory. Again, there is another category, the set of virtual addresses which are not mapped at all in the page table. It can be mapped in future on a demand basis.

Another concept is important here, that is the resident set size of a process. Resident set size, as mentioned above is the amount of memory occupied by the user process that is present in the main memory at that point of time.

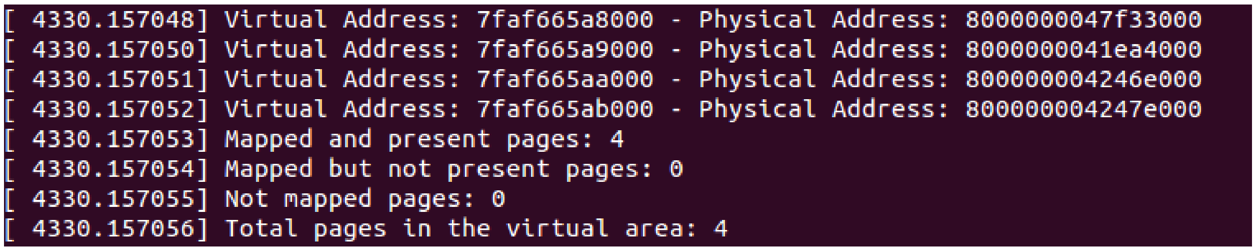
The virtual address space allocated to a user process using a few areas, called the virtual memory areas. A process contains a lot of virtual areas. From kernel prospective, the areas are sores in the mm_struct of a process, which carries a bunch of them. We can traverse through the whole bunch of vm_area allocated to a process using the link list present in VM_AREA_STRUCT. Hence these memory areas are of interest to us. We need to find all the categories mentioned above on a per VM_AREA basis and will also try to sum up the thing on a process level.

Pseudo Code:

```
For a user process:

        Find the number of virtual page addresses for which the page is present, Page is not
present but mapped, page is not mapped and the resident set size of the VM_AREA.

        Repeat for each VM_AREA of the process:

                Need to traverse all the pages of the VM_AREA.

                Traverse through all the pages and Repeat:

                        Try to decipher the virtual address of the page.

                        Virtual address consists of the following levels

                                1. PGD
                                2. PUD
                                3. PMD
                                4. PTE

                        Find all the levels for a virtual address.

                        If any of the levels cannot be found then the page is currently not
                        mapped.

                        If PTE can be found but the PTE value is not present in the PTE level page
                        table, then the page is mapped but not present.

                        For the rest of the pages, we can say that those pages are present and
                        mapped.

                        Print the corresponding physical address for them.

                        These are the pages contributes to the RSS of the user process.

                Calculate the RSS for the VM_AREA

        Calculate the RSS for the user process.
```

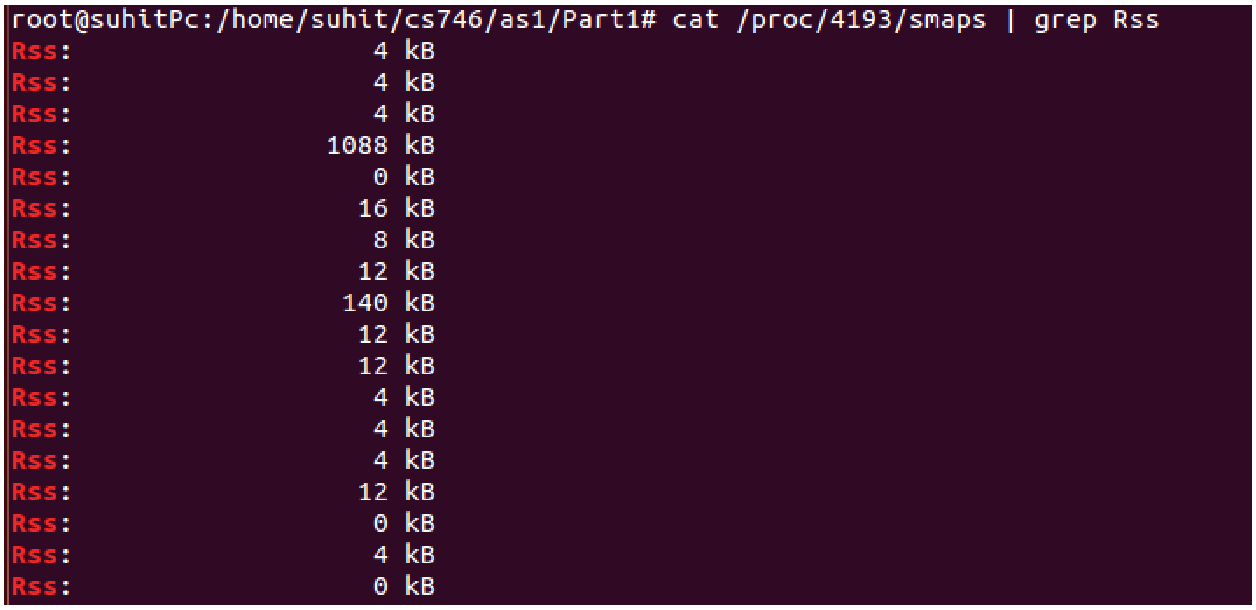
Results and Experiment:

Physical address for the corresponding virtual address:



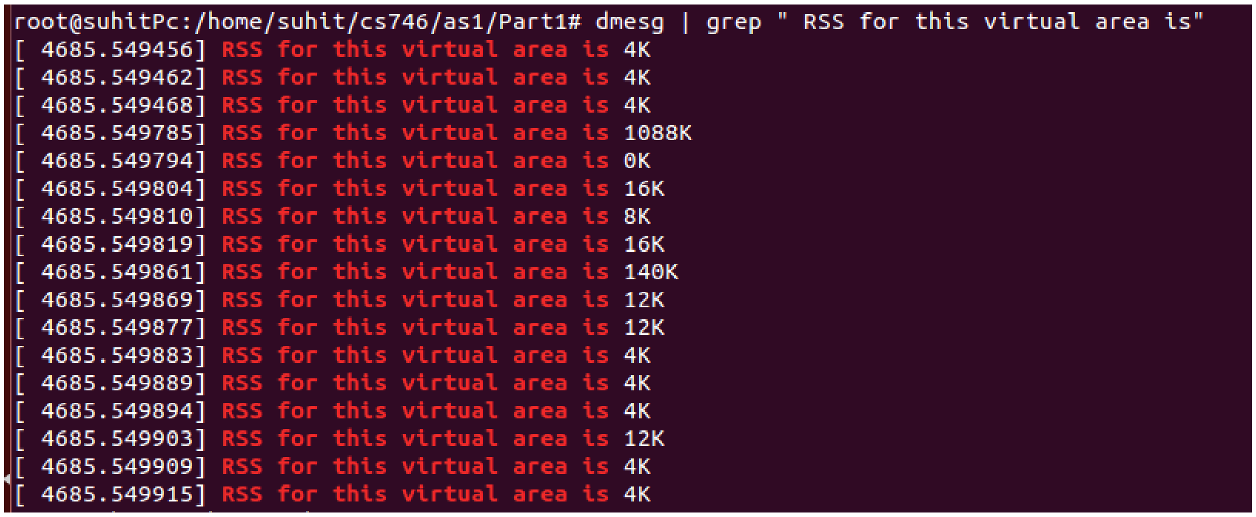
```
[ 4330.157048] Virtual Address: 7faf665a8000 - Physical Address: 8000000047f33000
[ 4330.157050] Virtual Address: 7faf665a9000 - Physical Address: 8000000041ea4000
[ 4330.157051] Virtual Address: 7faf665aa000 - Physical Address: 800000004246e000
[ 4330.157052] Virtual Address: 7faf665ab000 - Physical Address: 800000004247e000
[ 4330.157053] Mapped and present pages: 4
[ 4330.157054] Mapped but not present pages: 0
[ 4330.157055] Not mapped pages: 0
[ 4330.157056] Total pages in the virtual area: 4
```

RSS size for a given process [PID-4193] using **smaps**:



```
root@suhitPc:/home/suhit/cs746/as1/Part1# cat /proc/4193/smaps | grep Rss
Rss:                   4 kB
Rss:                   4 kB
Rss:                   4 kB
Rss:                1088 kB
Rss:                   0 kB
Rss:                  16 kB
Rss:                   8 kB
Rss:                  12 kB
Rss:                 140 kB
Rss:                  12 kB
Rss:                  12 kB
Rss:                   4 kB
Rss:                   4 kB
Rss:                   4 kB
Rss:                  12 kB
Rss:                   0 kB
Rss:                   4 kB
Rss:                   0 kB
```

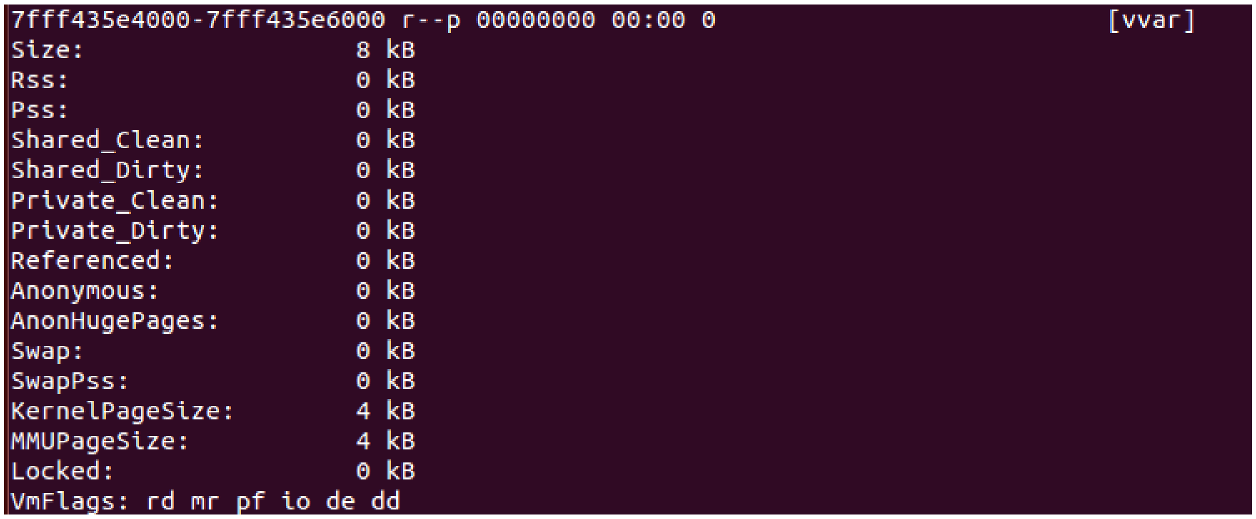
RSS size for a given process [PID-4193] using **our module**:



```
root@suhitPc:/home/suhit/cs746/as1/Part1# dmesg | grep " RSS for this virtual area is"
[ 4685.549456] RSS for this virtual area is 4K
[ 4685.549462] RSS for this virtual area is 4K
[ 4685.549468] RSS for this virtual area is 4K
[ 4685.549785] RSS for this virtual area is 1088K
[ 4685.549794] RSS for this virtual area is 0K
[ 4685.549804] RSS for this virtual area is 16K
[ 4685.549810] RSS for this virtual area is 8K
[ 4685.549819] RSS for this virtual area is 16K
[ 4685.549861] RSS for this virtual area is 140K
[ 4685.549869] RSS for this virtual area is 12K
[ 4685.549877] RSS for this virtual area is 12K
[ 4685.549883] RSS for this virtual area is 4K
[ 4685.549889] RSS for this virtual area is 4K
[ 4685.549894] RSS for this virtual area is 4K
[ 4685.549903] RSS for this virtual area is 12K
[ 4685.549909] RSS for this virtual area is 4K
[ 4685.549915] RSS for this virtual area is 4K
```

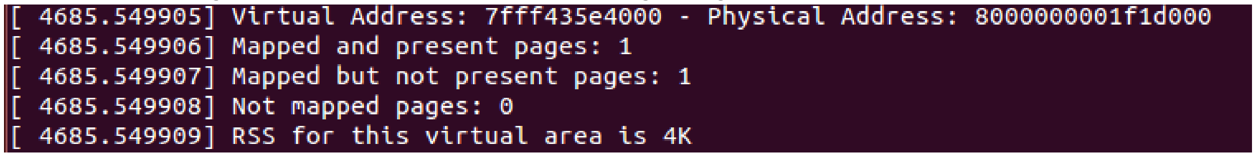
The RSS data is matching with **smaps** with following discrepancies:

1. For virtual area:



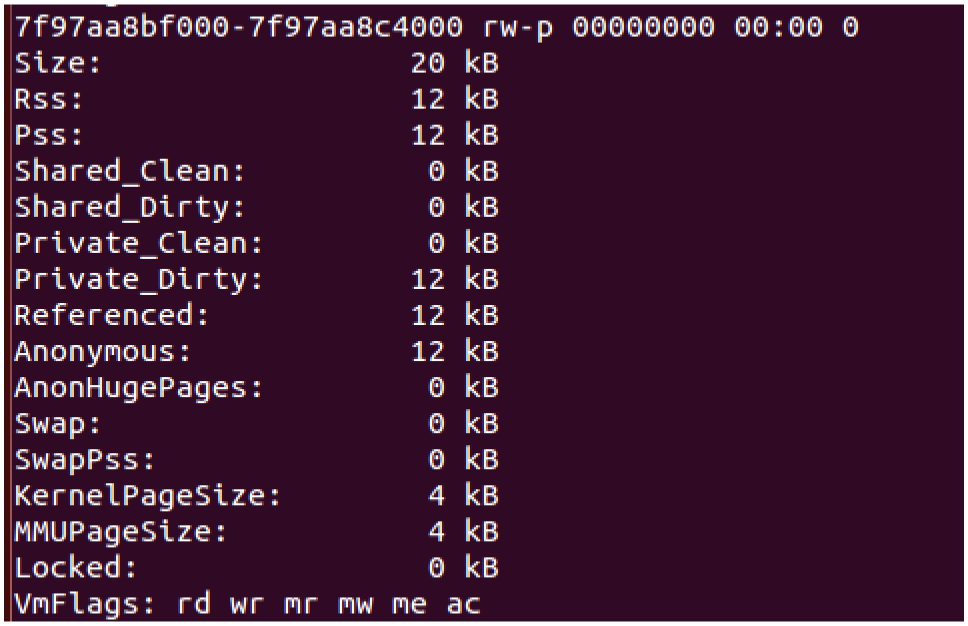
```
7fff435e4000-7fff435e6000 r--p 00000000 00:00 0                          [vvar]
Size:                  8 kB
Rss:                   0 kB
Pss:                   0 kB
Shared_Clean:          0 kB
Shared_Dirty:          0 kB
Private_Clean:         0 kB
Private_Dirty:         0 kB
Referenced:            0 kB
Anonymous:             0 kB
AnonHugePages:         0 kB
Swap:                  0 kB
SwapPss:               0 kB
KernelPageSize:        4 kB
MMUPageSize:           4 kB
Locked:                0 kB
VmFlags: rd mr pf io de dd
```

Smaps is showing RSS as 0 whereas our module is getting RSS value of 4KB.



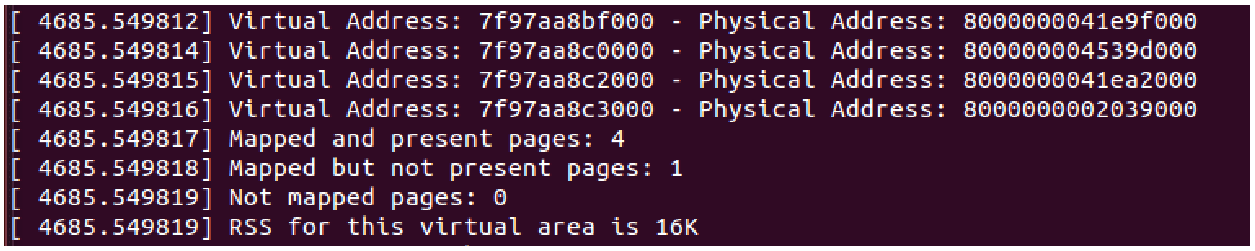
```
[ 4685.549905] Virtual Address: 7fff435e4000 - Physical Address: 8000000001f1d000
[ 4685.549906] Mapped and present pages: 1
[ 4685.549907] Mapped but not present pages: 1
[ 4685.549908] Not mapped pages: 0
[ 4685.549909] RSS for this virtual area is 4K
```

2. For the below virtual area:



```
7f97aa8bf000-7f97aa8c4000 rw-p 00000000 00:00 0
Size:                 20 kB
Rss:                  12 kB
Pss:                  12 kB
Shared_Clean:          0 kB
Shared_Dirty:          0 kB
Private_Clean:         0 kB
Private_Dirty:        12 kB
Referenced:           12 kB
Anonymous:            12 kB
AnonHugePages:         0 kB
Swap:                  0 kB
SwapPss:               0 kB
KernelPageSize:        4 kB
MMUPageSize:           4 kB
Locked:                0 kB
VmFlags: rd wr mr mw me ac
```

smaps is showing the RSS as 12 KB where as our code is showing it as 16 KB.



```
[ 4685.549812] Virtual Address: 7f97aa8bf000 - Physical Address: 8000000041e9f000
[ 4685.549814] Virtual Address: 7f97aa8c0000 - Physical Address: 800000004539d000
[ 4685.549815] Virtual Address: 7f97aa8c2000 - Physical Address: 8000000041ea2000
[ 4685.549816] Virtual Address: 7f97aa8c3000 - Physical Address: 8000000002039000
[ 4685.549817] Mapped and present pages: 4
[ 4685.549818] Mapped but not present pages: 1
[ 4685.549819] Not mapped pages: 0
[ 4685.549819] RSS for this virtual area is 16K
```

Those 2 discrepancies contributing to 8KB, i.e. 2 pages of extra RSS.