

REPORT

Aim

To estimate the RSS and Virtual Memory occupied by a process. Also to display the physical addresses of pages which have been physically mapped.

Methodology

Software Walk

1. We initialize page pointer to NULL
2. Given page VA, we can perform a software page table walk doing the following in order,
 - pgd_offset() - returns pgd offset given mm_struct of task and VA
 - pud_offset() - returns pud offset given VA and pgd offset
 - pmd_offset() - returns pmd offset given VA and pud offset
 - pte_offset_map() - returns pte given VA and pmd offset
3. If any of the above returns a none and bad value we exit page pointer as NULL
4. If everything executes successfully we obtain the struct page using pte_page() and return the same.

Module flow,

1. Input PID as parameter to the module
2. Extract the task_struct for entered PID using,
 - find_vpid() - Returns struct pid for given pid
 - pid_task() - Returns task_struct for given struct pid
3. Using the task struct get the first virtual memory area (VMA),
 - task_struct -> mm_struct -> vma_struct
4. This struct has the starting and ending virtual addresses (VA) of the current area in,
 - vm_start and vm_end
5. Access each page in the area using the start and end by incrementing with PAGE_SIZE
6. Increment page_size for each page reached
7. For each page in VMA perform a software walk of the page table to obtain its page struct pointer

8. If page struct pointer is not NULL and PA returned is not zero, if so we increment RSS and display the PA
9. Display the RSS and size for current VMA
10. Move to the next VMA using vma_next in the current VMA
11. Repeat steps 4-7 until vma_next hits NULL which indicates end of Virtual memory assigned for the process.
12. Display the total RSS and size

Experiments

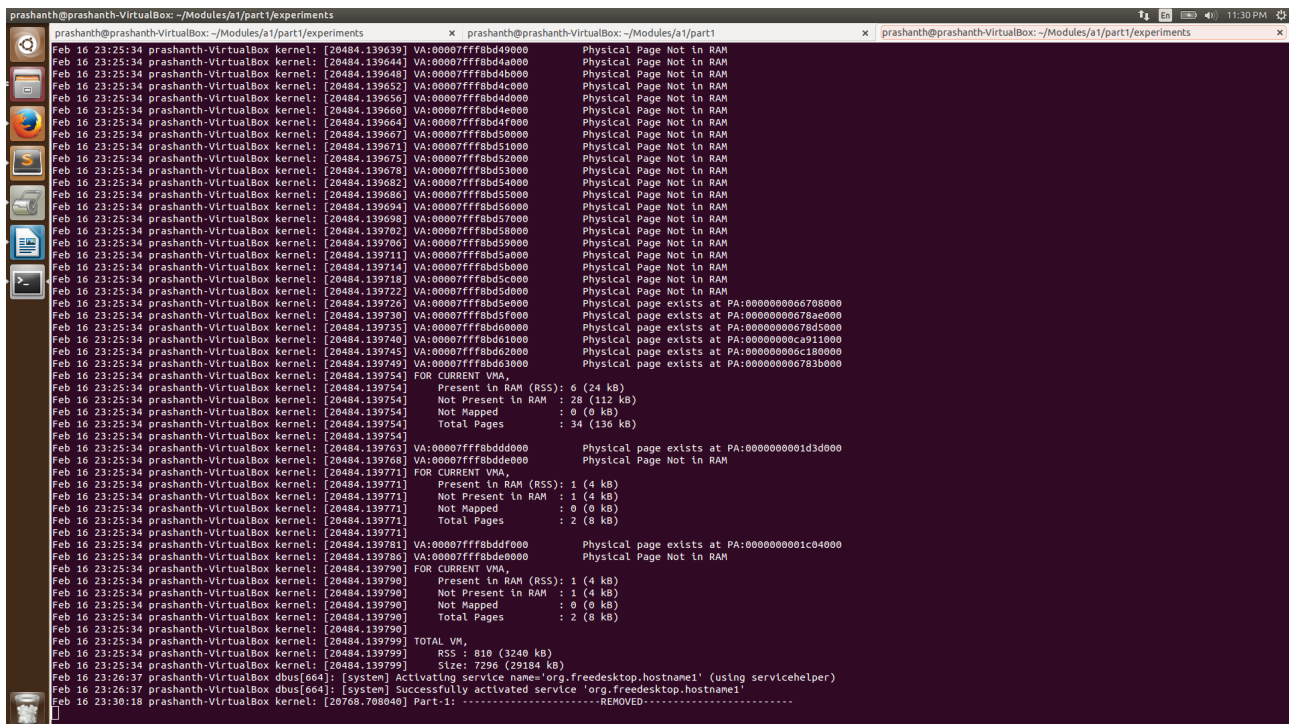
1- Hello World C program

1. A non-terminating hello world program was loaded
2. The VMA tracker module was loaded with hello world's PID
3. Output of log was compared the output of
/proc/<pid>/status
/proc/<pid>/smaps
4. It was observed that VM size was equal in all three cases
5. RSS in /proc/<pid>/status didn't match and this was caused due to sharing of pages
6. But module output nearly matched with smaps difference of 2 pages (8kB) - 1212kB and 1204kB

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prashanth@prashanth-VirtualBox: ~/Modules/ai/part/experiments
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922477] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922478] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922479] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922481] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922482] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922483] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922484] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922485] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922486] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922487] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922488] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922489] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922490] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922491] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922493] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922494] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922495] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922496] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922497] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922498] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922499] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922500] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922501] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922502] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922504] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922505] VA:00007fddbf0000 Physical page exists at PA:00000000145b0c000
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922506] VA:00007fddbf0000 Physical page exists at PA:0000000011a853000
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922507] FOR CURRENT VMA,
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922507] Present in RAM (RSS): 2 (8 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922507] Not Present in RAM : 32 (128 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922507] Not Mapped : 0 (0 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922507] Total Pages : 34 (136 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922507]
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922510] VA:00007fddbf0000 Physical page exists at PA:000000001d3d000
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922512] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922513] FOR CURRENT VMA,
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922513] Present in RAM (RSS): 1 (4 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922513] Not Present in RAM : 1 (4 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922513] Not Mapped : 0 (0 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922513] Total Pages : 2 (8 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922513]
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922516] VA:00007fddbf0000 Physical page exists at PA:000000001c04000
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922517] VA:00007fddbf0000 Physical Page Not in RAM
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922518] FOR CURRENT VMA,
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922518] Present in RAM (RSS): 1 (4 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922518] Not Present in RAM : 1 (4 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922518] Not Mapped : 0 (0 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922518] Total Pages : 2 (8 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922518]
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922521] TOTAL VM,
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922521] RSS : 384 (1212 kB)
Feb 16 23:17:26 prashanth-VirtualBox kernel: [19995.922521] Size: 1051 (4204 kB)
Feb 16 23:18:30 prashanth-VirtualBox dbus[664]: [system] Activating service name='org.freedesktop.hostname1' (using servicehelper)
Feb 16 23:18:30 prashanth-VirtualBox dbus[664]: [system] Successfully activated service 'org.freedesktop.hostname1'
Feb 16 23:19:07 prashanth-VirtualBox kernel: [20896.969393] Part 1: -----REMOVED-----
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2- Top

1. A top command was invoked
2. The VMA tracker module was loaded with top's PID
3. Output of log was compared the output of
/proc/<pid>/status
/proc/<pid>/smaps
4. RSS in /proc/<pid>/status nearly matched with 1 page difference (4kB)
5. The module output also nearly matched with smaps difference of 1 page (4kB)



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prashanth@prashanth-VirtualBox: ~/Modules/a1/part1/experiments
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139639] VA:00007ffffbd49000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139644] VA:00007ffffbd4a000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139648] VA:00007ffffbd4b000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139652] VA:00007ffffbd4c000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139656] VA:00007ffffbd4d000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139660] VA:00007ffffbd4e000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139664] VA:00007ffffbd4f000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139667] VA:00007ffffbd50000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139671] VA:00007ffffbd51000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139675] VA:00007ffffbd52000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139678] VA:00007ffffbd53000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139682] VA:00007ffffbd54000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139686] VA:00007ffffbd55000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139689] VA:00007ffffbd56000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139693] VA:00007ffffbd57000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139702] VA:00007ffffbd58000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139706] VA:00007ffffbd59000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139711] VA:00007ffffbd5a000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139714] VA:00007ffffbd5b000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139718] VA:00007ffffbd5c000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139722] VA:00007ffffbd5d000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139726] VA:00007ffffbd5e000 Physical page exists at PA:000000006780000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139730] VA:00007ffffbd5f000 Physical page exists at PA:000000006780000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139735] VA:00007ffffbd60000 Physical page exists at PA:000000006780000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139740] VA:00007ffffbd61000 Physical page exists at PA:00000000c911000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139745] VA:00007ffffbd62000 Physical page exists at PA:00000000c180000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139749] VA:00007ffffbd63000 Physical page exists at PA:0000000067830000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139754] FOR CURRENT VMA,
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139754] Present in RAM (RSS): 6 (24 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139754] Not Present in RAM : 28 (112 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139754] Not Mapped : 0 (0 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139754] Total Pages : 34 (136 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139754]
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139763] VA:00007ffffbd6d000 Physical page exists at PA:0000000001d30000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139768] VA:00007ffffbd6e000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139771] FOR CURRENT VMA,
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139771] Present in RAM (RSS): 1 (4 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139771] Not Present in RAM : 1 (4 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139771] Not Mapped : 0 (0 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139771] Total Pages : 2 (8 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139771]
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139781] VA:00007ffffbd6ff000 Physical page exists at PA:0000000001c04000
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139786] VA:00007ffffbd70000 Physical Page Not in RAM
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139790] FOR CURRENT VMA,
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139790] Present in RAM (RSS): 1 (4 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139790] Not Present in RAM : 1 (4 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139790] Not Mapped : 0 (0 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139790] Total Pages : 2 (8 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139790]
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139799] TOTAL VM,
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139799] RSS : 816 (3240 kB)
Feb 16 23:25:34 prashanth-VirtualBox kernel: [20484.139799] Size: 7296 (29184 kB)
Feb 16 23:26:37 prashanth-VirtualBox dbus[664]: [system] Activating service name='org.freedesktop.hostname1' (using servicehelper)
Feb 16 23:26:37 prashanth-VirtualBox dbus[664]: [system] Successfully activated service 'org.freedesktop.hostname1'
Feb 16 23:30:18 prashanth-VirtualBox kernel: [20768.708040] Part 1: -----REMOVED-----
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Observations

1. It was observed that size of VMA output by the module always matched /status.
2. The RSS of module and /status didn't match for some processes - the reason was sharing of pages between processes is accounted differently in /status.
3. RSS nearly matched with /smaps with a minimal difference of 1-3 pages for small processes.
4. Small processes didn't have many unmapped pages, but this number increased as the size of the process increased.
5. Unmapped pages were observed in larger processes like firefox