**CSC-3044 Operating Systems & System Programming**

**Laboratory 5 Report**

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1. **How do you think used and free in the output is calculated?**  
     
   I believe the `free` program checks /proc/meminfo, where the Linux kernel stores information about how much memory it has allocated.
2. **What trends do you notice from calling free after Firefox started up?**  
     
   My virtual machine doesn’t support GUI programs, but Firefox would significantly increase RAM consumption.
3. **What trends can you deduce from running such a benchmark on your virtual system?**  
     
   Unknown.
4. **Do you get different types of information from this tool than free?**  
     
   It certainly does. It reports, per the man page, “information about processes, memory, paging, block IO, traps, disks and cpu activity,” not just basic information about RAM and swap usage.
5. **What types of information are the same?**  
     
   It does still report the basic information about RAM and swap usage.
6. **Does this tool really add anything useful for the general user or programmer?**  
     
   It does if the general user or programmer is looking for the information it reports. That being said, I might be more inclined to use an alternate tool to look at the information separately.
7. **Is the vmstat utility appropriately named? If so, why; if not, why not and what should it be called?**  
     
   Its scope seems to be a little beyond virtual memory statistics, so maybe it could be called `sysstat` or something similar.
8. **Do you gain any new insights with this tool? You may want to look at the man page for htop to see if there are any interesting memory counters you can use.**`htop` is very useful for keeping track of real-time data and process uptime. I can see the CPU usage and memory modulating per process, which I suppose is useful.
9. **Using the entry that just lists /usr/lib/firefox/firefox without any of the switches for tabs or plugins, what insights are you able to gather by looking at the memory-related /proc files that you couldn't by using the htop, vmstat, and htop tools?**  
     
   You can find almost any sort of information on memory use that you like in /proc. You can find specific information on the usage of memory segments and regions, how the stack and heap are being used, information on swapping and page faults, and any number of other useful bits of information.
10. **How can you explain that your program now has allocated over 2 GB, but the virtual machine only has 2.0 GB of RAM?**  
      
    This should largely be due to the effect of memory blocks being swapped to disk, but memory compression may also contribute.
11. **Check where this latest address is found in the maps with respect to the previously allocated blocks. Did it re-use any of the address range that was previously deallocated?**  
      
    Yes. I allocated and then deallocated a 500 MB block, and the 100 MB block was stored at the same address that it was.
12. **Record the total memory and swap space used, using the free –h command.**  
      
    Mem: 952Mi  
    Swap: 2.0Gi
13. **Record the total memory and swap space used, again using the free –h command.**  
      
    Mem: 952Mi  
    Swap: 2.0Gi
14. **Record the total memory and swap space used, again using the free –h command.**  
      
    Mem: 952Mi  
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15. **Record the total memory and swap space used, again using the free –h command.**  
      
    Mem: 952Mi  
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16. **Explain how the amount of memory and swap space used in these examples is related to the use of demand paging in Linux.**  
      
    If my program used lazy allocation or if my VM had less memory, the effect would possibly be more noticeable. As it is, I can say that demand paging would keep more memory data stored on disk until it was in use.