

OSTEP Chapter 21

ECE 3600, Fall 2022

Table of Contents

[1. Memory Hierarchy](#)

[2. Exercises](#)

[3. Example](#)

1. Memory Hierarchy

(fastest) L1 cache, L2 cache, L3 cache, main memory, disk/swap (slowest)

page table present bit, page fault

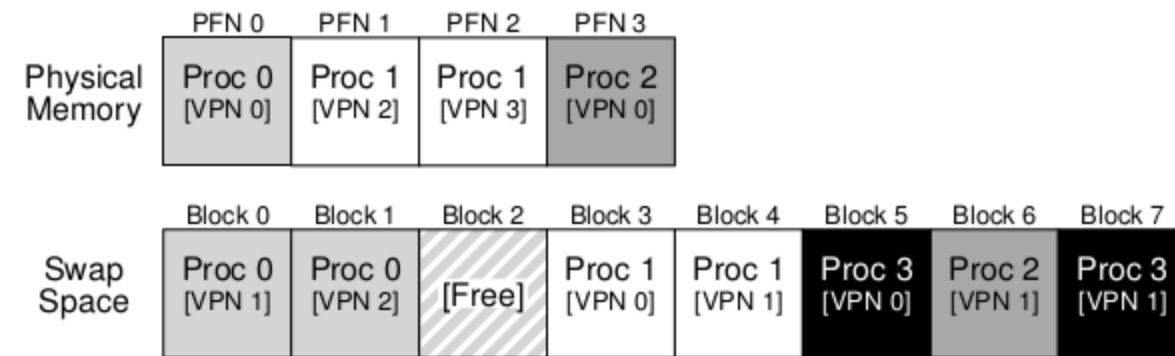


Figure 21.1: Physical Memory and Swap Space

2. Exercises

See the book for exercises using [mem.c](#) and [vmstat](#)

```
$ /sbin/swapon -s
```

Filename	Type	Size	Used	Priority
/dev/md1	partition	7806972	827184	-2

```
$ cat /proc/swaps
```

Filename	Type	Size	Used	Priority
/dev/md1	partition	7806972	827184	-2

```
$ top
```

```
top - 12:11:30 up 10 days, 4:36, 6 users, load average: 0.09, 0.42, 0.42
Tasks: 286 total, 1 running, 220 sleeping, 4 stopped, 0 zombie
%Cpu(s): 1.4 us, 1.1 sy, 0.0 ni, 97.4 id, 0.1 wa, 0.0 hi, 0.1 si, 0.0 st
KiB Mem : 16188300 total, 2665948 free, 1447960 used, 12074392 buff/cache
KiB Swap: 7806972 total, 6979788 free, 827184 used. 14136572 avail Mem
```

PID	USER	PR	NI	VIRT	RES	SHR	S	%CPU	%MEM	TIME+	COMMAND
11226	perry	20	0	44216	3936	3264	R	12.5	0.0	0:00.03	top
2488	perry	20	0	3944640	334564	74652	S	6.2	2.1	275:49.35	gnome-shell
1	root	20	0	225676	6100	3968	S	0.0	0.0	2:11.45	systemd
2	root	20	0	0	0	0	S	0.0	0.0	0:00.33	kthreadd

```
...
```

3. Example

In one window:

```
$ ./mem 12000 <<-- time 1
allocating 12582912000 bytes (12000.00 MB)
  number of integers in array: 3145728000
loop 0 in 5604.98 ms (bandwidth: 2140.95 MB/s)
loop 1 in 2092.22 ms (bandwidth: 5735.54 MB/s)
loop 2 in 2088.83 ms (bandwidth: 5744.85 MB/s)
loop 3 in 2103.87 ms (bandwidth: 5703.77 MB/s)
^C <<-- time 2
$
```

In another window:

```
$ vmstat 1
procs -----memory-----  ---swap--  -----io-----  -system--  -----cpu-----
 r  b   swpd   free   buff   cache   si  so    bi   bo    in   cs  us  sy  id  wa  st
 1  0  827184  8436620  4084564  2224596    0   2   118   61    3    4   1   1  97   0   0
 0  0  827184  8436496  4084564  2224596    0   0    0    0   181  534   1   0  99   0   0
 0  0  827184  8436364  4084564  2224588    0   0    0    0   307 1054   2   1  96   0   0
 1  0  827184  8441324  4084564  2219468    0   0    0    0   318 1452   4   1  96   0   0
 1  0  827184  7307468  4084564  2224956    0   0    0   127  380  991   8   7  85   0   0 <<-- time 1
 1  0  827184  5073352  4084564  2225108    0   0    0    0   459  773  14  12  74   0   0
 1  0  827184  2856232  4084564  2224596    0   0    0    0   468  503  14  12  74   0   0
 1  0  827184   616916  4084564  2224596    0   0    0    0   463  467  15  11  74   0   0
 2  0  827184   165356  3384604  1191244    0  40    0   43   798 1245  13  20  66   0   0
 2  0  838704   153824  1897456   534920    0 11480  168 11516 1045 1368  13  25  62   0   0
 1  0  840496   258872  1662480   511156    0 1716   794  1717   700  952  25   4  71   1   0
 1  0  840496   258624  1662500   511664    0   0   264    0   458  499  26   0  74   0   0
 1  0  840496   258624  1662632   511664    0   0   132    0   469  468  25   0  74   0   0
 1  0  840496   258624  1662632   511664    0   0    0    0   439  504  25   0  74   0   0
 1  0  840496  10478440  1662632  513316    0   0  1652    0   490  817  17   9  74   0   0 <<-- time 2
 0  0  840496  12568236  1662632  513384    0   0    60    0   253  609   0   3  97   0   0
 0  0  840496  12573568  1662632  507976    0   0    0    3   183  570   1   0  99   0   0
 0  0  840496  12568112  1662632  513268    0   0    0    0   245  980   2   1  98   0   0
^C
$
```