CSGE602055 Operating Systems
CSF2600505 Sistem Operasi
Week 05: Virtual Memory

Rahmat M. Samik-Ibrahim

University of Indonesia

http://rms46.vlsm.org/2/207.html
Always check for the latest revision!

REV134 12-Apr-2018

Operating Systems 2018-1 (Room 3114 Tue/Thu)
Class: A (10:00-12:00) | B (13:00-15:00) | C (16:00-18:00)

Week	Schedule	Topic	OSC9
Week 00	06 Feb - 12 Feb 2018	Overview 1	Ch. 1, 16
Week 01	13 Feb - 19 Feb 2018	Overview 2 & Scripting	Ch. 1, 2
Week 02	20 Feb - 26 Feb 2018	Protection, Security, Privacy, & C-language	Ch. 14, 15
Week 03	27 Feb - 05 Mar 2018	I/O, BIOS, Loader, & Systemd	Ch. 13
Week 04	06 Mar - 12 Mar 2018	Addressing, Shared Lib, & Pointer	Ch. 8
Week 05	13 Mar - 19 Mar 2018	Virtual Memory	Ch. 9
Reserved	20 Mar - 24 Mar 2018		
Mid-Term	03 Apr 2018	13:00 - 15:30 (UTS)	
Week 06	05 Apr - 11 Apr 2018	Concurency: Processes & Threads	Ch. 3, 4
Week 07	12 Apr - 18 Apr 2018	Synchronization	Ch. 5, 7
Week 08	19 Apr - 25 Apr 2018	Scheduling	Ch. 6
Week 09	26 Apr - 07 May 2018	File System & Persistent Storage	Ch. 10, 11, 12
Reserved	08 May - 14 May 2018		
Week 10	15 May - 21 May 2018	I/O Programming & Network Sockets Programming	
Reserved	22 May - 22 May 2018		
Final	23 May - 26 May 2018	(UAS)	
Deadline	07 Jun 2018 16:00	Extra assignment **deadline**	

- The Check List (Operating Systems)
  - **Starting Point**: `http://rms46.vlsm.org/2/207.html`
  - **Text Book**: any recent/decent OS book but map it to **OSC9**.
  - Create **public** project "os181" on your `github.com` account.
    - Create file "`README.md`" and add an extra line every week. For e.g.[1]:

      ```
      ZCZC Sistem Operasi 2018 Awal (1)
      ZCZC W01 Have tried demo for week 01.
      ZCZC W02 Week 02 is done.
      ZCZC W03 Week 03 is done.
      ```

  - Encode your **QRC** with image size of approximately 250x250 pixels: **"OS181 CLASS ID GITHUB-ACCOUNT SSO-ACCOUNT SIAK-Full-Name"** Special for Week 00: Mail your **embedded** QRC to: `os181@vlsm.org` with Subject: [W00] CLASS ID SIAK-NAME.
  - Write your Memo (with QRC) **every week**.
  - Using your **SSO** account, login to `badak.cs.ui.ac.id` via `kawung.cs.ui.ac.id`.
    - Check folder `badak:///extra/Week00/`
    - Every week, copy the weekly demo files to your own home directory. Eg. for Week00:
      `cp -r /extra/Week00/W00-demos/ W00-demos/`

[1] Week 00 line is optional. The following "ZCZC WXX" weekly tags are mandatory.

Week 05: Memory

Virtual Memory

- Reference: (OSC9-ch09 demo-w05)
- Virtual Memory: Separation Logical from Physical.
- Virtual Address Space: logical view.
- Demand Paging
- Page Flags: Valid / Invalid
- Page Fault
- Demand Paging Performance
- Copy On Write (COW)
- Page Replacement Algorithm
  - Reference String
  - First-In-First-Out (FIFO)
  - Belady Anomaly
  - Optimal Algorithm
  - Least Recently Used (LRU)
  - LRU Implementation
  - Lease Frequently Used (LFU)
  - Most Frequently Used (MFU)

Allocation Algorothm

- Page-Buffering Algorithms
- Allocation of Frames
- Fixed Allocation
- Priority Allocation
- Global vs. Local Allocation
- Non-Uniform Memory Access (NUMA)
- Thrashing
- Working-Set Model
- Shared Memory via Memory-Mapped I/O
- Kernel
  - Buddy System Allocator
  - Slab Allocator

TOP

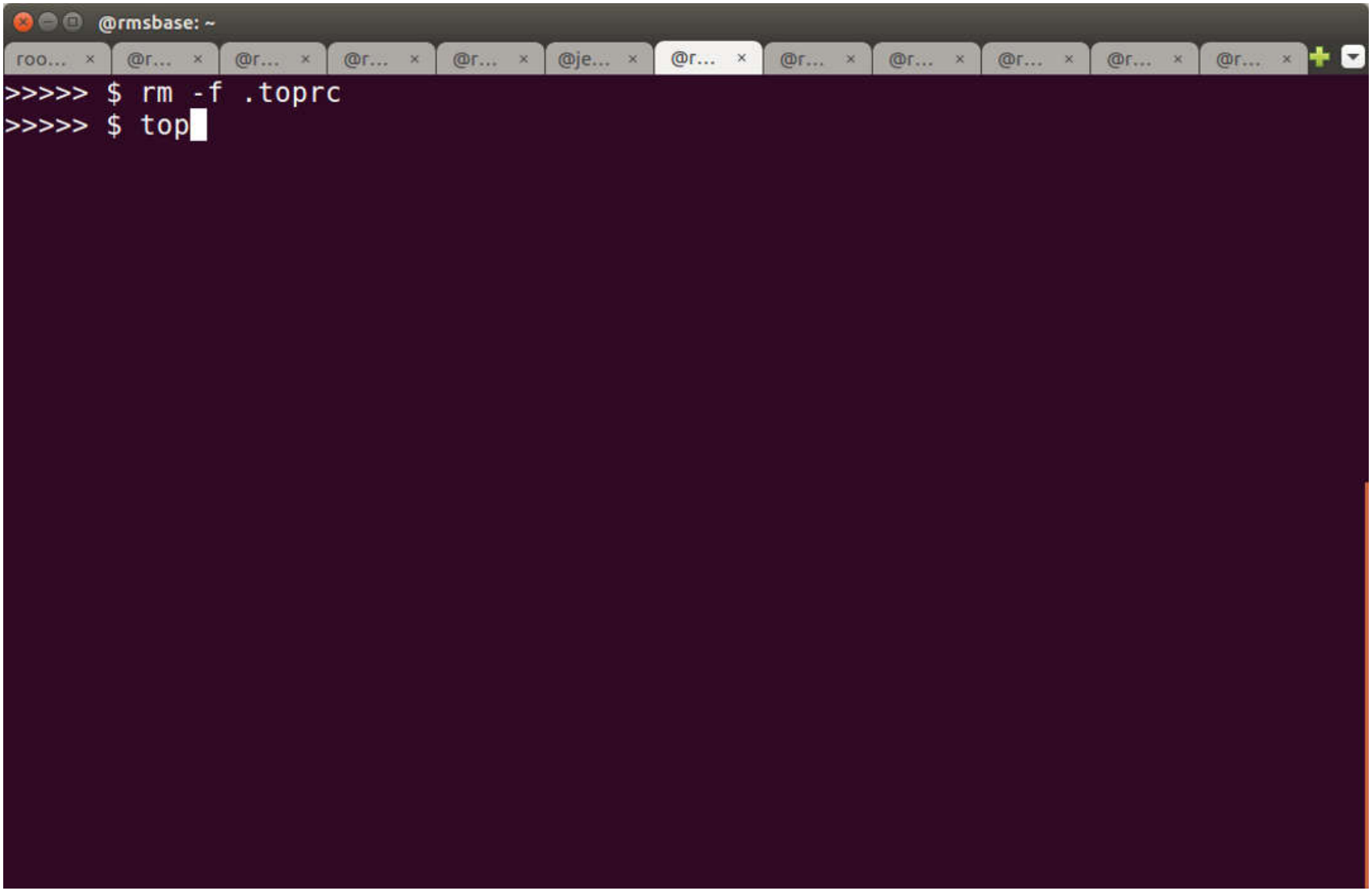

Figure: top

TOP (2)

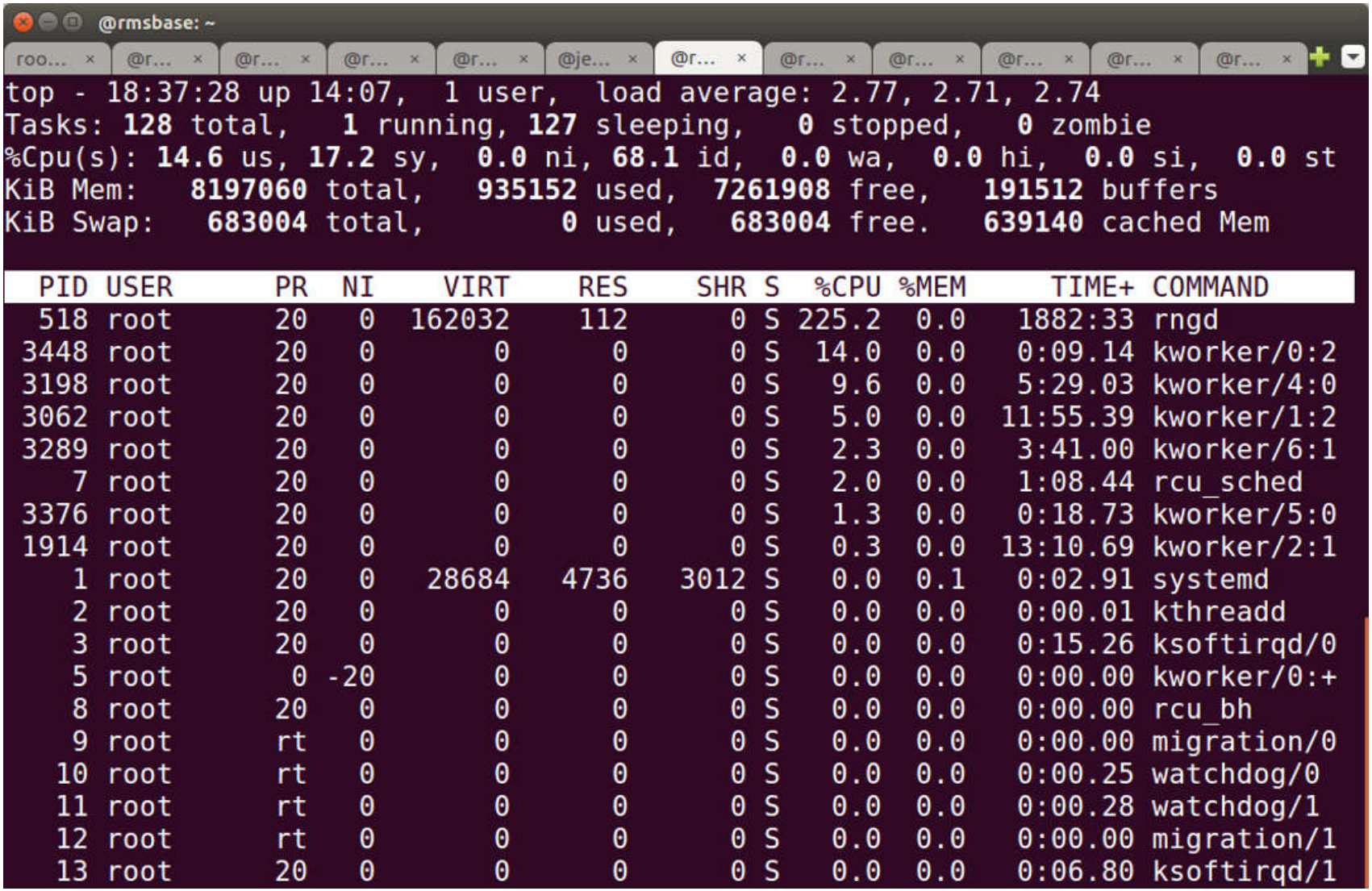

Figure: "h" = help

TOP (3)

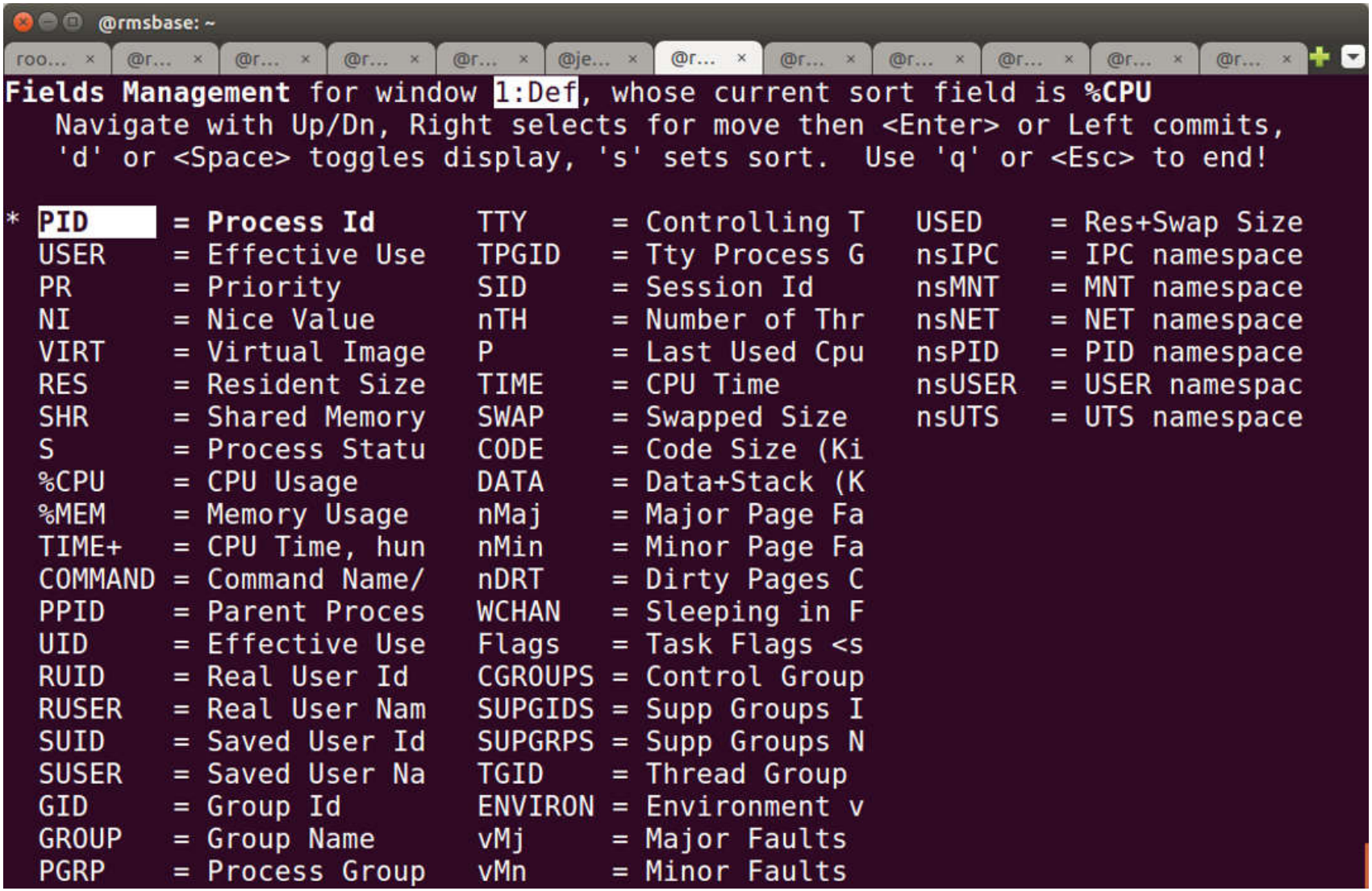

Figure: Moving Fields: "f"

TOP (4)

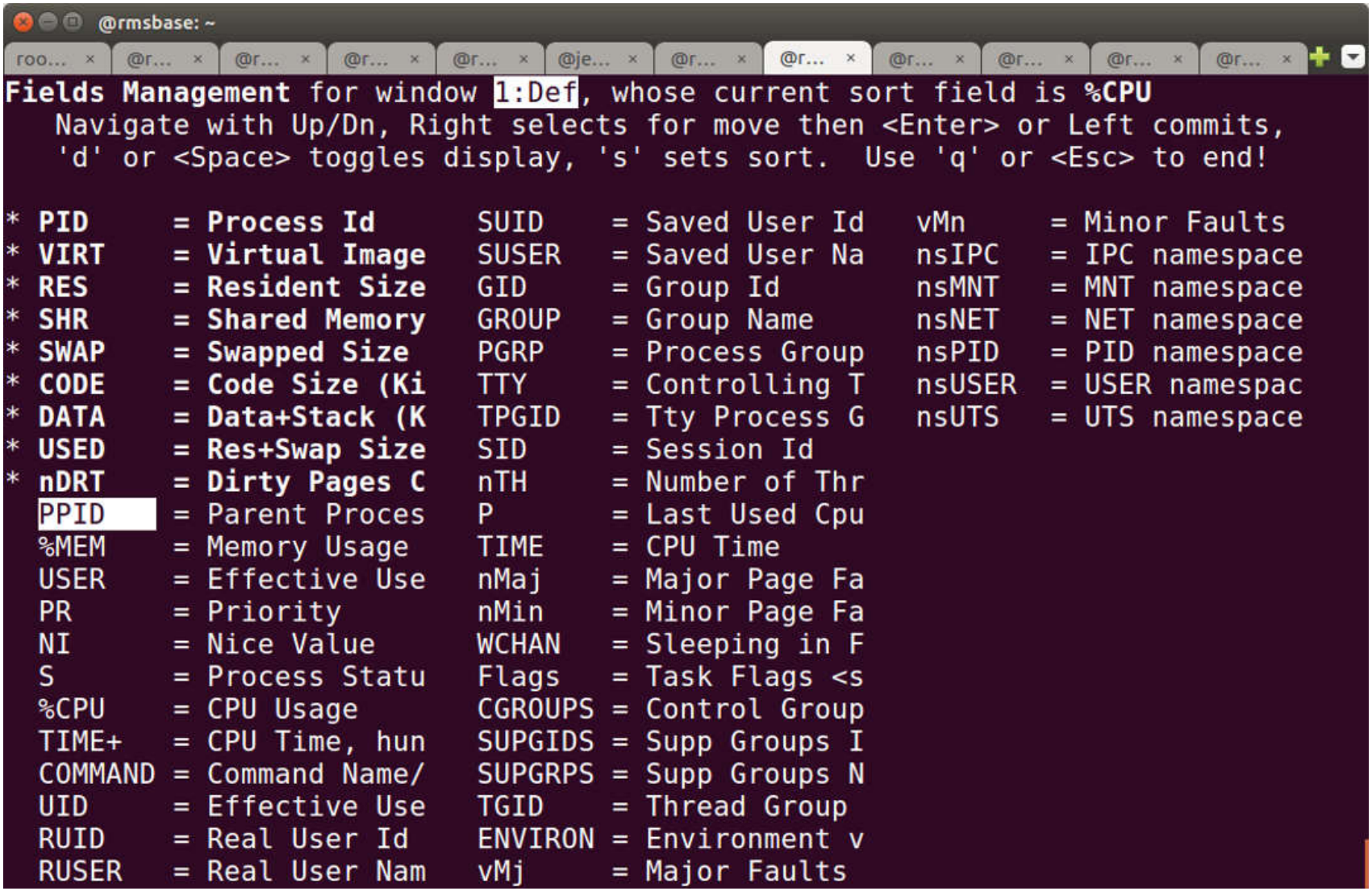

Figure: Moving Fields

TOP (5)

@rmsbase: ~/Downloads

```
top - 19:57:14 up 11:38,  1 user,  load average: 0.43, 0.54, 0.58
Tasks: 285 total,   2 running, 283 sleeping,   0 stopped,   0 zombie
%Cpu(s):  3.8 us,  1.3 sy,  0.0 ni, 94.6 id,  0.3 wa,  0.0 hi,  0.0 si,  0.0 st
KiB Mem : 16385976 total,   269672 free,  3179788 used, 12936516 buff/cache
KiB Swap:  1000444 total,   994752 free,     5692 used. 12649780 avail Mem

  PID    VIRT    RES    SHR   SWAP   CODE    DATA    USED nDRT
 3547 2377296 394828 165776      0    196 1642748  394828    0
 1234  278216  87880  59116      0   2288   25164   87880    0
 3321 2683572 433176 149376      0    196 1856708  433176    0
 2708 1687448 214112  80608      0     12 1179008  214112    0
 2841  679488  50860  30484      0    292  389096   50860    0
 3748 1896812 321288  76656      0 133688 1474084  321288    0
 3971 2047252 440112  97384      0 133688 1587052  440112    0
32501  630768  33500  27960      0     76  373220   33500    0
 4067 8554396 320516 109756      0    196 7954584  320516    0
 4130 2391592 341632 117636      0    196 1717824  341632    0
22635 2198448 274812 108000      0    196 1532152  274812    0
 1292       0      0      0      0      0       0       0    0
 2514  930224  34304  26028      0     36  448864   34304    0
 3233 4515228 360812 126784      0 133688 3757984  360812    0
32495   33488   3380   2836      0     96    1264    3380    0
 2388   44036   4424   2724      0    212    1716    4424    0
 2412  423204  11380   5264      0    152  374232   11380    0
 2512  685824  74188  36868      0    552  399836   74188    0
```

Figure: Write Configuration .toprc: "W"

06-memory

```
/* Copyright (C) 2016-2018 Rahmat M. Samik-Ibrahim
 * http://rahmatm.samik-ibrahim.vlsm.org/
 * This program is free script/software. This program is distributed in the
 * hope that it will be useful, but WITHOUT ANY WARRANTY; without even the
 * implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.
 * REV04 Mon Mar 12 17:33:30 WIB 2018
 * START Mon Oct  3 09:26:51 WIB 2016
 */
#define MSIZE0 0x10000
#define MSIZE1 0x10008
#define MSIZE2 0x10009
#define MSIZE3 0x1000A
#define MSIZE4 0x20978
#define MSIZE5 0x20979
#define MSIZE6 0x2097A
#define MSIZE7 0xF0000
#define MSIZE8 0x10000
#define MSIZE9 0x1000
#define LINE   75
#define MAXSTR 80
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <string.h>
#include <sys/types.h>

void printLine(int line) {
   while(line-- > 0) putchar('x');
   putchar('\n');
   fflush(NULL);
}
```

06-memory (2)

```
void main (void) {
   int   msize[] = {MSIZE0, MSIZE1, MSIZE2, MSIZE3, MSIZE4,
                    MSIZE5, MSIZE6, MSIZE7, MSIZE8, MSIZE9};
   int   ii, jj;
   int   myPID   = (int) getpid();
   char  strSYS1[MAXSTR], strOUT[MAXSTR];
   char* chrStr  = strSYS1;
   char* chrPTR;

   printLine(LINE);
   sprintf(strSYS1, "top -b -n 1 -p%d | tail -5", myPID);
   system (strSYS1);
   sprintf(strSYS1, "top -b -n 1 -p%d | tail -1", myPID);
   for (ii=0; ii< (sizeof(msize)/sizeof(int)); ii++){
      chrStr = malloc(msize[ii]);
      fgets(strOUT, sizeof(strOUT)-1, popen(strSYS1, "r"));
      strOUT[(int) strlen(strOUT)-1]='\0';
      printf("%s [%X]\n", strOUT, msize[ii]);
      free(chrStr);
   }
   for (ii=0; ii< (sizeof(msize)/sizeof(int)); ii++){
      chrPTR = chrStr = malloc(msize[ii]);
      for (jj=0;jj<msize[ii];jj++)
         *chrPTR++='x';
      fgets(strOUT, sizeof(strOUT)-1, popen(strSYS1, "r"));
      strOUT[(int) strlen(strOUT)-1]='\0';
      printf("%s [%X]\n", strOUT, msize[ii]);
      free(chrStr);
   }
}
```

06-memory (2)

```
>>>>> $ ./06-memory
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
KiB Mem:   8197060 total,   957928 used,  7239132 free,   192520 buffers
KiB Swap:   683004 total,        0 used,   683004 free.   660108 cached
    Mem

  PID    VIRT    RES    SHR   SWAP   CODE    DATA   USED nDRT
 4362    4172    640    564      0      4     320    640    0
 4362    4172    640    564      0      4     320    640    0 [10000]
 4362    4172    640    564      0      4     320    640    0 [10008]
 4362    4308    640    564      0      4     456    640    0 [10009]
 4362    4244   1176   1068      0      4     392   1176    0 [1000A]
 4362    4244   1176   1068      0      4     392   1176    0 [20978]
 4362    4376   1176   1068      0      4     524   1176    0 [20979]
 4362    4376   1192   1068      0      4     524   1192    0 [2097A]
 4362    5340   1192   1068      0      4    1488   1192    0 [F0000]
 4362    4376   1200   1068      0      4     524   1200    0 [10000]
 4362    4376   1200   1068      0      4     524   1200    0 [1000]
```

06-memory (3)

```
 4362    4376    1200    1068    0    4    524    1200    0 [1000]
 4362    4376    1200    1068    0    4    524    1200    0 [10000]
 4362    4376    1276    1068    0    4    524    1276    0 [10008]
 4362    4376    1276    1068    0    4    524    1276    0 [10009]
 4362    4376    1284    1068    0    4    524    1284    0 [1000A]
 4362    4376    1284    1068    0    4    524    1284    0 [20978]
 4362    4376    1352    1068    0    4    524    1352    0 [20979]
 4362    4376    1352    1068    0    4    524    1352    0 [2097A]
 4362    5340    2144    1068    0    4   1488    2144    0 [F0000]
 4362    5340    2324    1068    0    4   1488    2324    0 [10000]
 4362    5340    2324    1068    0    4   1488    2324    0 [1000]
>>>>> $
```

The End

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