

# OS08b: Virtual Memory with Linux \*

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## 1 Looking at Memory with Linux

(Specifics of Linux are not part of learning objectives; however, the following illustrates [shared memory](#), and `/proc` will be revisited in other presentations.)

### 1.1 Linux Kernel: `/proc/<pid>/`

- `/proc` is a pseudo-filesystem
  - See <https://man7.org/linux/man-pages/man5/proc.5.html>
    - \* (Specific to Linux kernel; incomplete or missing elsewhere)
  - “Pseudo”: Look and feel of any other filesystem
    - \* Sub-directories and files
    - \* However, files are no “real” files but meta-data
  - Interface to internal **kernel data structures**
    - \* One sub-directory per process ID
    - \* OS identifies process by integer number
    - \* Here and elsewhere, `<pid>` is meant as **placeholder** for such a number

#### 1.1.1 Video about `/proc`

This video, “Looking at `/proc`” by Jens Lechtenbörger, shares the presentation’s license terms, namely [CC BY-SA 4.0](#).

The video shows some aspects of the `/proc` filesystem related to memory management, which are described in more abstract form on subsequent slides.

#### 1.1.2 Drawing about `/proc`

**Warning!** External figure **not** included: “`/proc`” © 2018 Julia Evans, all rights reserved from [julia’s drawings](#). Displayed here with personal permission. (See [HTML presentation](#) instead.)

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### 1.1.3 Drawing about man pages

**Warning!** External figure **not** included: “Man pages are amazing” © 2016 Julia Evans, all rights reserved from julia’s drawings. Displayed here with personal permission.

(See HTML presentation instead.)

## 1.2 Linux Kernel Memory Interface

- Memory allocation (and much more) visible under `/proc/<pid>`
- E.g.:
  - `/proc/<pid>/pagemap`: One 64-bit value per virtual page
    - \* Mapping to RAM or swap area
  - `/proc/<pid>/maps`: Mapped memory regions
  - `/proc/<pid>/smaps`: Memory usage for mapped regions
- Notice: Memory regions include **shared** libraries that are used by lots of processes

## 1.3 GNU/Linux Reporting: smem

- User space tool to read `smaps` files: `smem`
  - See <https://linoxide.com/memory-usage-reporting-smem/>
- Terminology
  - **Virtual set size (VSS)**: Size of virtual address space
  - **Resident set size (RSS)**: Allocated main memory
    - \* Standard notion, yet overestimates memory usage as lots of memory is shared between processes
      - Shared memory is added to the RSS of every sharing process
  - **Unique set size (USS)**: memory allocated exclusively to process
    - \* That much would be returned upon process’ termination
  - **Proportional set size (PSS)**: USS plus “fair share” of shared pages
    - \* If page shared by 5 processes, each gets a fifth of a page added to its PSS

### 1.3.1 Sample smem Output

```
$ smem -c "pid command uss pss rss vss" -P "bash|xinit|emacs"
PID Command                USS    PSS    RSS    VSS
765 /usr/bin/xinit /etc/X11/Xse 220    285    2084   15952
1390 /bin/bash -c libreoffice5.3 240    510    2936   13188
826 /bin/bash /usr/bin/qubes-se 256    524    3008   13204
750 -su -c /usr/bin/xinit /etc/ 316    587    3368   21636
1251 bash                    4864   5136   7900   26024
2288 /usr/bin/python /usr/bin/sm 5272   6035   9432   24688
1145 emacs                    90876  93224  106568 662768
```

### 1.3.2 Sample smem Graph

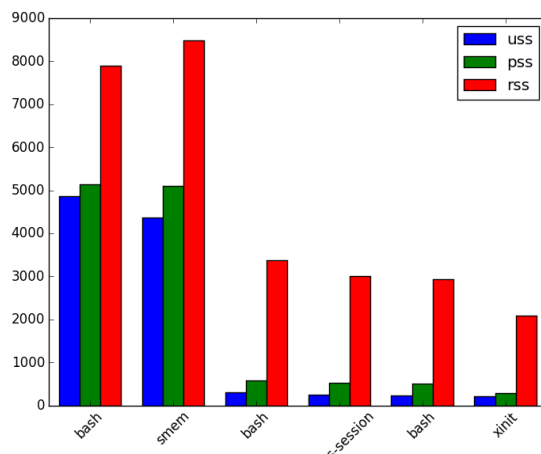


Figure 1: `smem --bar pid -c "uss pss rss" -P "bash|xinit"` (“Screenshot of smem” under CC0 1.0; from GitLab)

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