Outline

- Introduction - history
- Command line basics – getting help
- File system
- Working with files and directories
- More file handling
- The shell revisited
- Monitoring resources

Outline detail

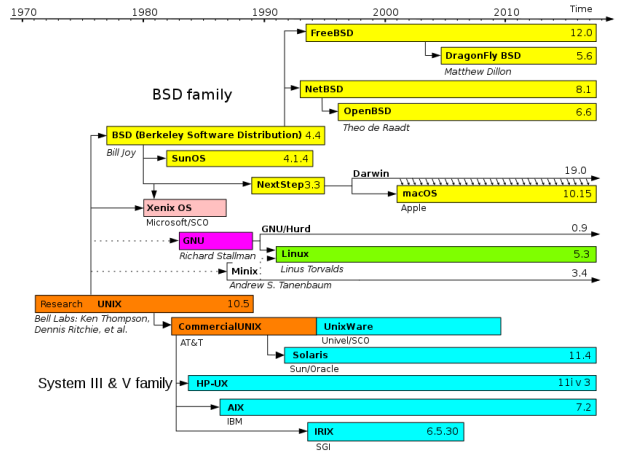
- Background info
- OS kernel shell
- Command Line Interface (CLI)

Some background

Operating system

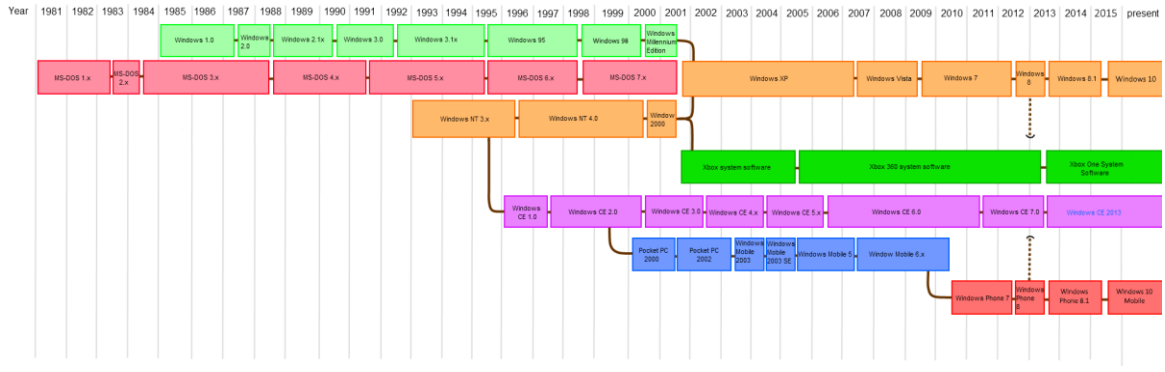
- An operating system (OS) is system software that manages computer hardware, software resources, and provides common services for computer programs. (https://en.wikipedia.org/wiki/Operating_system)
  - Windows
    - Desktop systems
    - https://gs.statcounter.com/os-market-share/desktop/worldwide/
  - Linux
    - Server and supercomputing
  - MacOS
- Linux and Windows are based on foundations developed in the mid-1970s
- DOS, macOS and UNIX are proprietary, i.e., the source code of their kernel is protected

*nix time line



https://upload.wikimedia.org/wikipedia/commons/thumb/c/cd/Unix_timeline.en.svg/850px-Unix_timeline.en.svg.png

Windows time line



https://en.wikipedia.org/wiki/List_of_Microsoft_operating_systems#/media/File:Microsoft_timeline_of_operating_systems_2.png

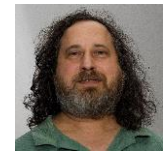
Some history

- UNIX: roots in Bell Labs (AT&T) (https://www.bell-labs.com/about/history/innovation-stories/50-years-unix/#gref)
- 1985 Free Software Foundation (FSF) founded by Richard Stallman. Along with other programmers creates the tools needed to make a UNIX compatible OS
- 1985 Professor Andy Tanenbaum creates a UNIX like operating system based on System V Unix for the IBM PC & PC/AT computers. It is called Minix.
- 1989 Richard Stallman releases GPL and GNU software but lacks a free kernel. https://www.techtarget.com/searchdatacenter/definition/GNU-General-Public-License-GNU-GPL-or-simply-GPL#:~:text=The%20GNU%20General%20Public%20License,software%20from%20being%20made%20proprietary.
- **1991** Building on the concepts in Minix, **Linus Torvalds** (Finnish college student) develops Linux along with help from other users on the web.

Some history

GNU project:

- Established in 1984 by **Richard Stallman** (goal: software should be free from restrictions against copying or modification in order to make better and efficient computer programs),
- GNU is a recursive acronym for "**G**NU's **N**ot **U**nix",



- Aim at developing a complete Unix-like operating system which is free for copying and modification,
- Companies make their money by maintaining and distributing the software, e.g. optimally packaging the software with different tools,
- Stallman built the first free GNU C Compiler in **1991**. But still, an OS was yet to be developed

OS, kernel, shell, etc.

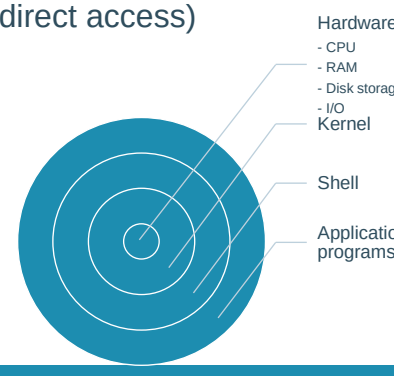
Linux OS

- Linux is not a single operating system, but rather a large family of free and open source operating systems based on the Linux kernel.
- Different variants within this family are referred to as **Linux Distributions** (www.distrowatch.com) CentOS, Ubuntu, etc.
- There are two major components of Linux:
  - The **kernel** is the core of the Linux operating system:
    - Schedules processes and interfaces directly with the hardware.
    - It manages system and user I/O, processes, devices, files, and memory.
  - The **shell** is a text-only interface to the kernel.
    - Users input commands through the shell, and the kernel receives the tasks from the shell and performs them.
    - The shell works interactively (REPL- Read Evaluate Print Loop).
    - Users *do not* interact with the kernel directly, it is done through the shell or a desktop environment.

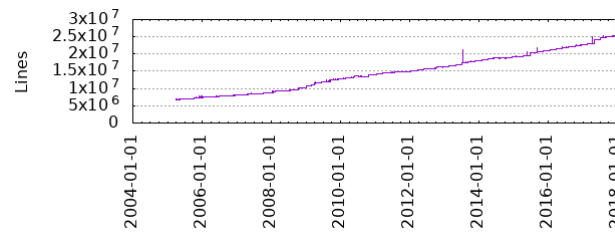
(https://cvw.cac.cornell.edu/Linux/introduction)

Linux kernel

- aka: executive, system monitor.
- Provides a layer between the computer hardware and user applications.
- Provides an interface for software to use hardware (no direct access)
- Planning and assigning:
  - Memory, CPU, disk, etc.
  - Security aspects
  - Fulfill user requests (system calls).
  - Filesystem, networking, ...



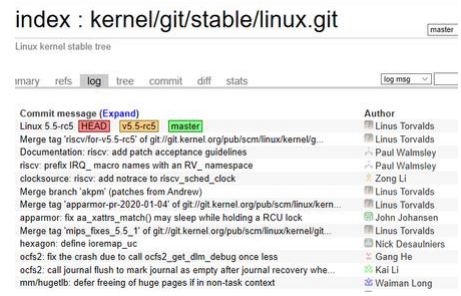
Linux kernel



- Lines of code

(https://www.phoronix.com/scan.php?page=news_item&px=Linux-Kernel-Commits-2017)

- Linux in 2020: 27.8 million lines of code in the kernel
https://www.theregister.co.uk/2020/01/06/linux_2020_kernel_systemd_code/



Linux kernel

- File Management
  - Controls the creation, removal of files and provide directory maintenance
  - For a multiuser system, every user should have its own right to access files and directories
- Process Management
  - Multitask system: multiple programs can be executed simultaneously
  - When a program starts to execute, it becomes a *process.* The same program executing at 2 different times will become 2 different processes
  - Processes are managed by the kernel: creating, suspending, terminating
  - A process is protected from other processes and can communicate with the others

Linux kernel

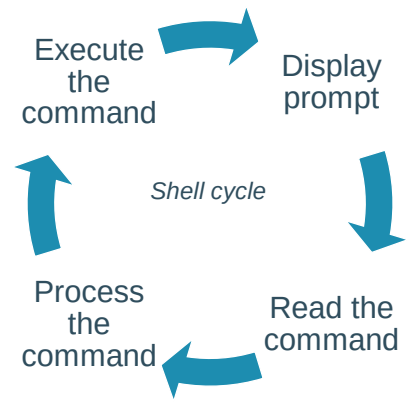
- Memory management
  - Memory in a computer is divided into main memory (RAM) and secondary storage (usually refer to hard disk)
  - Memory is small in capacity but fast in speed, and hard disk is vice versa
  - Data that are not currently used should be saved to hard disk first, while data that are urgently needed should be retrieved and stored in RAM
- Device drivers
  - Interfaces between the kernel and the BIOS (*basic input/output system*)
  - Different device has different driver

Linux kernel

- Get the kernel version
  `uname -r`
- `uname -a` provides the information in the order
  - KERNEL-NAME NODENAME KERNEL-RELEASE KERNEL-VERSION
  - MACHINE PROCESSOR HARDWARE-PLATFORM OPERATING-SYSTEM

Linux shell

- A shell is an interface for accessing the underlying commands of an operating system.
- When you sign in at the command line or launch a terminal window on Linux, the system launches the shell program.
- Is the command line interpreter: a program that accepts input from a user (e.g. a command) and performs the requested task. (REPL - *read–eval–print loop*)
- The shell's **prompt** identifies the type of shell being used



Most popular shells

- There are several types of shells for Linux.
- Check it with
  `$ echo $SHELL`
- Change the shell with
  `chsh`

File:check_shell.sh

Shell	Prompt	Name	Note
sh	$	Bourne Shell	Default on some Unix systems
bash	$	Bourne Again Shell	Enhanced replacement for the Bourne shell Default on most Linux and Mac OS X systems
csh	%	C Shell	Default on many BSD systems
tcsh	>	TC Shell	Enhanced replacement for the C shell
ksh	$	Korn Shell	Default on AIX systems

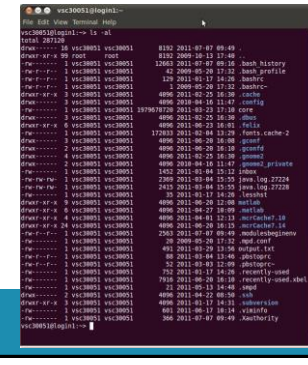
CLI

Linux User Interface

- Traditional *nux (Linux, Unix) systems use **command line interface** (**cli** or text-based interface)
- User needs to type lines of command to instruct the computer to work, similar to Windows DOS command window
- Advantages:
  - Fast: few resources required
  - Reliable: some of these commands have been around for years. Commands change less frequently than the GUI counterparts. GUI counterparts often use these same commands under the hood.
  - Productivity: use the keyboard instead of navigating through a bunch of menus and screens with the mouse and tabbing back and forth between different applications
- Disadvantages:
  - Memorize the commands
  - Typing a command can be error prone

Command Line Interface: Beware!

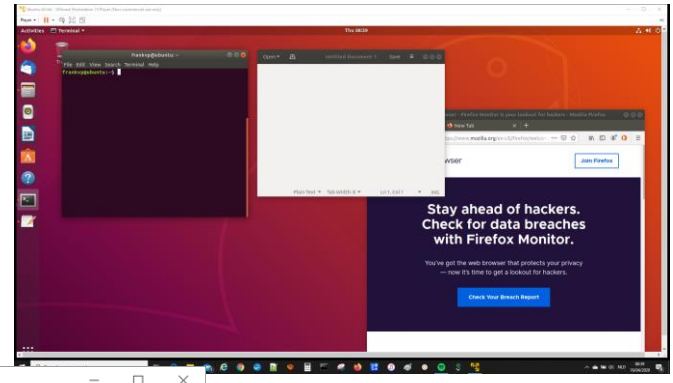
- Common use on servers and HPC system
- Implicitly assumes that you know what you are doing. Don't be scared!
- Often there are no warnings with commands, no *undo*
- No recycle bin!
- If anything goes wrong, you can stop the command with **`ctrl+C`**

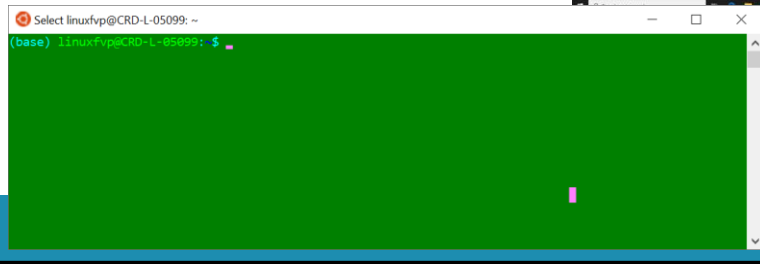


Linux User Interface

- By adopting the X-Window technology, graphical user interface (GUI) is available for Linux.
- Uses pointing devices (e.g. mouse) to control the system, similar to Microsoft's Windows
- Provide menu-driven and/or icon-driven interfaces
  - menu-driven: user is provided with a menu of choices. Each choice refers to a particular task
  - icon-driven: tasks are represented by pictures (icon) and shown to user. Click on an icon invokes one task
- Advantages:
  - No need to memorize commands. Always select task from menus or icons
- Disadvantages:
  - Slow and requires resources for its implementation
  - Suitable for general users and systems, such as PC use

Linux User Interface





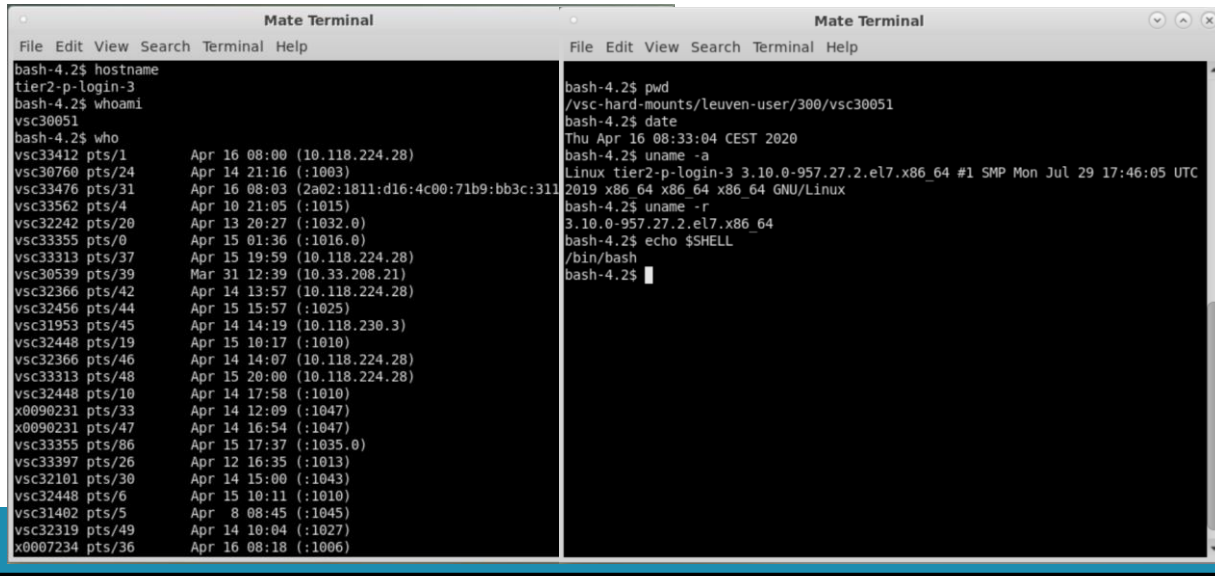
Someone is doing something somewhere

- Linux is a multiuser OS
  - Allows multiple users to use the resource of a computer at the same time
  - Before you can do anything, you have to log in.
    - This can be either a graphical or a nongraphical prompt.
      - Linux desktop: you are likely to see a graphical environment.
      - A server: you'll just see a shell login prompt.
- Check who you are on the computer: `whoami`
- List the users logged on with: `who`
- What is the machine you are working on: `hostname`
- What is the directory you are working in: `pwd`
- What time is it: `date`

Useful commands

- Clear the contents of the current screen
  `$ clear`
- `$ logout`
  - The logout command logs your account out of the system (in a text mode).
  - This will end the terminal session and return to the login screen.
  - Some systems may have a file called `.logout` or `.bash_logout` in each user's home directory.
- `$ exit`
  - Exit the current shell. The `exit` command is similar to the `logout` command with the exception that it does not run the logout script located in the user's home directory.

HPC


Mate Terminal
File Edit View Search Terminal Help
bash-4.2$ hostname
tier2-p-login-3
bash-4.2$ whoami
vsc30051
bash-4.2$ who
vsc33412 pts/1 Apr 16 08:00 (10.118.224.28)
vsc30760 pts/24 Apr 14 21:16 (:1003)
vsc33476 pts/31 Apr 16 08:03 (2a02:1811:d16:4c00:71b9:bb3c:311
vsc33562 pts/4 Apr 10 21:05 (:1015)
vsc32242 pts/20 Apr 13 20:27 (:1032.0)
vsc33355 pts/0 Apr 15 01:36 (:1016.0)
vsc33313 pts/37 Apr 15 19:59 (10.118.224.28)
vsc30539 pts/39 Mar 31 12:39 (10.33.208.21)
vsc32366 pts/42 Apr 14 13:57 (10.118.224.28)
vsc32456 pts/44 Apr 15 15:57 (:1025)
vsc31953 pts/45 Apr 14 14:19 (10.118.230.3)
vsc32448 pts/19 Apr 15 10:17 (:1010)
vsc32366 pts/46 Apr 14 14:07 (10.118.224.28)
vsc33313 pts/48 Apr 15 20:00 (10.118.224.28)
vsc32448 pts/10 Apr 14 17:58 (:1010)
x0090231 pts/33 Apr 14 12:09 (:1047)
x0090231 pts/47 Apr 14 16:54 (:1047)
vsc33355 pts/86 Apr 15 17:37 (:1035.0)
vsc33397 pts/26 Apr 12 16:35 (:1013)
vsc32101 pts/30 Apr 14 15:00 (:1043)
vsc32448 pts/6 Apr 15 10:11 (:1010)
vsc31402 pts/5 Apr 8 08:45 (:1045)
vsc32319 pts/49 Apr 14 10:04 (:1027)
x0007234 pts/36 Apr 16 08:18 (:1006)
Mate Terminal
File Edit View Search Terminal Help
bash-4.2$ pwd
/vsc-hard-mounts/leuven-user/300/vsc30051
bash-4.2$ date
Thu Apr 16 08:33:04 CEST 2020
bash-4.2$ uname -a
Linux tier2-p-login-3 3.10.0-957.27.2.el7.x86_64 #1 SMP Mon Jul 29 17:46:05 UTC
2019 x86_64 x86_64 x86_64 GNU/Linux
bash-4.2$ uname -r
3.10.0-957.27.2.el7.x86_64
bash-4.2$ echo $SHELL
/bin/bash
bash-4.2$