

# 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)

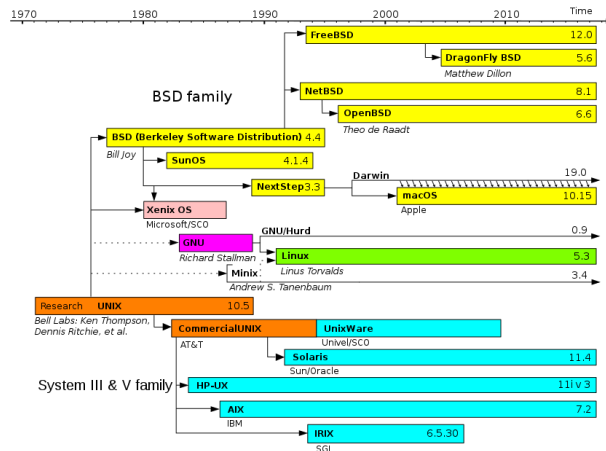
## Some background

## Operating system



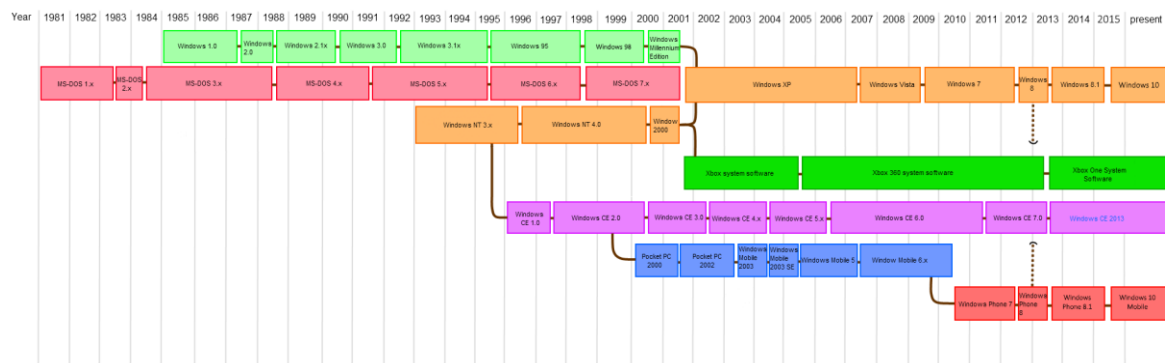
- An operating system (OS) is system software that manages computer hardware, software resources, and provides common services for computer programs.  
([https://en.wikipedia.org/wiki/Operating\\_system](https://en.wikipedia.org/wiki/Operating_system))
  - Windows
    - Desktop systems
    - <https://gs.statcounter.com/os-market-share/desktop/worldwide/>
  - 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](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](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.

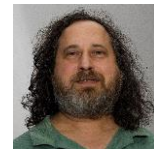


## Some history



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

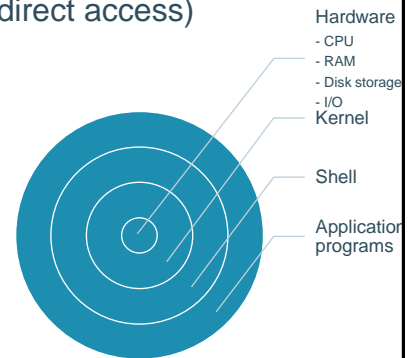


- Linux is not a single operating system, but rather a large family of free and open source operating systems based on the Linux kernel.
- Different variants within this family are referred to as **Linux Distributions** ([www.distrowatch.com](http://www.distrowatch.com)) CentOS, Ubuntu, etc.
- There 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, ...



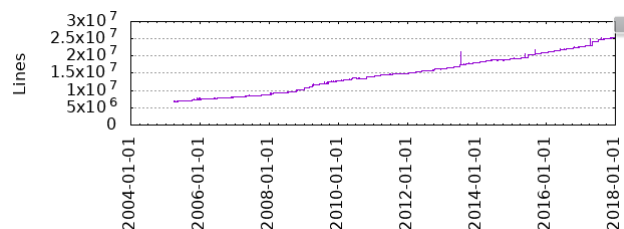
# Linux kernel

- Lines of code

([https://www.phoronix.com/scan.php?page=news\\_item&px=Linux-Kernel-Commits-2017](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/](https://www.theregister.co.uk/2020/01/06/linux_2020_kernel_systemd_code/)



index : kernel/git/stable/linux.git

Linux kernel stable tree

primary refs log tree commit diff stats log msg

Commit message (Expand)

Linux 5.5-rc5 **HEAD** **v5.5-rc5** **master** Author: Linus Torvalds

Merge tag 'riscv-for-v5.5-rc5' of git://git.kernel.org/pub/scm/linux/kernel... Author: Linus Torvalds

Documentation: riscv: add patch acceptance guidelines Author: Paul Walmsley

riscv: prefix IRQ\_ macro names with an RV\_ namespace Author: Paul Walmsley

clocksource: riscv: add notrace to riscv\_sched\_clock Author: Zong Li

Merge branch 'akpm' (patches from Andrew)

Merge tag 'apparmor-pr-2020-01-04' of git://git.kernel.org/pub/scm/linux/kern... Author: Linus Torvalds

apparmor: fix aa\_xattr\_match() may sleep while holding a RCU lock Author: John Johansen

Merge tag 'mips\_fixes\_5\_5\_1' of git://git.kernel.org/pub/scm/linux/kernelgit... Author: Linus Torvalds

hexagon: define loremap\_uc Author: Nick Desaulniers

oct2: fix the crash due to call oct2\_get\_dtm\_debug once less Author: Gang He

oct2: call journal flush to mark journal as empty after journal recovery whe... Author: Kai Li

mm/hugetlb: defer freeing of huge pages if in non-task context Author: Walman Long



## 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

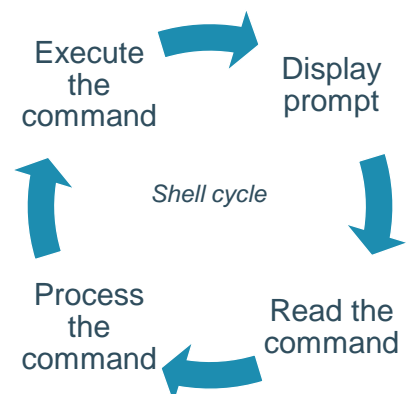
```
uname -r
```

- `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
csch	%	C Shell	Default on many BSD systems
tcsh	>	TC Shell	Enhanced replacement for the C shell
ksh	\$	Korn Shell	Default on AIX systems

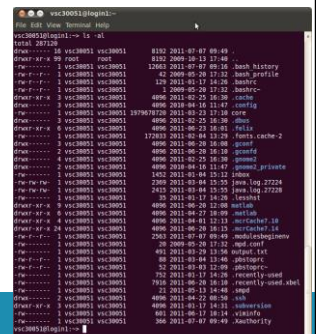
CLI

# 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**



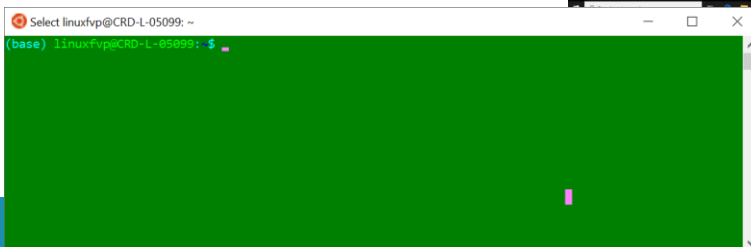
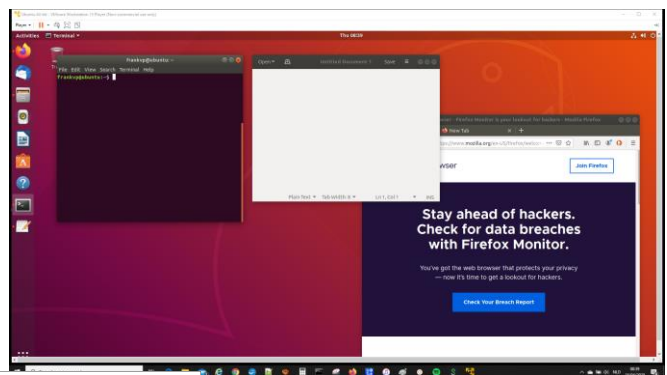
```
vas30051@login:~$ ls -la
total 287120
drwxr-xr-x 16 vsc30051 vsc30051 4096 2011-07-07 09:49 .
drwxr-xr-x  9 root      root      4096 2009-10-13 16:46 ..
-rw-r--r-- 1 vsc30051 vsc30051 15362 2011-07-07 09:16 .bash_history
-rw-r--r-- 1 vsc30051 vsc30051  62 2009-05-20 17:25 .bash_profile
-rw-r--r-- 1 vsc30051 vsc30051 170 2011-01-17 14:26 .bashrc
-rw-r--r-- 1 vsc30051 vsc30051  28 2009-05-20 17:25 .bashrcrc
drwxr-xr-x 3 vsc30051 vsc30051 4096 2011-02-25 16:38 .cache
-rw-r--r-- 3 vsc30051 vsc30051 4096 2011-04-10 11:47 .config
-rw-r--r-- 1 vsc30051 vsc30051 187618728 2011-03-23 17:18 .core
-rw-r--r-- 3 vsc30051 vsc30051 4096 2011-02-22 16:38 .cvs
drwxr-xr-x 6 vsc30051 vsc30051 4096 2011-06-23 16:01 .cvs
-rw-r--r-- 1 vsc30051 vsc30051 11913 2011-03-04 13:13 .cvsCache.1
-rwxr-xr-x 3 vsc30051 vsc30051 4096 2011-06-20 16:08 .gnupg
-rwxr-xr-x 2 vsc30051 vsc30051 4096 2011-06-20 16:18 .gnupg
-rwxr-xr-x 4 vsc30051 vsc30051 4096 2011-02-25 16:38 .gnupg
-rwxr-xr-x 2 vsc30051 vsc30051 4096 2011-04-10 11:47 .gnupg-private
-rw-r--r-- 1 vsc30051 vsc30051 1432 2011-01-04 13:12 .index
-rw-r--r-- 1 vsc30051 vsc30051 2303 2011-03-04 13:55 .java.log.27224
-rw-r--r-- 1 vsc30051 vsc30051 2412 2011-03-04 13:55 .java.log.27228
-rw-r--r-- 1 vsc30051 vsc30051  28 2011-03-17 14:26 .leash
drwxr-xr-x 9 vsc30051 vsc30051 4096 2011-06-20 12:08 .netlab
drwxr-xr-x 6 vsc30051 vsc30051 4096 2011-04-27 16:09 .netlab
drwxr-xr-x 4 vsc30051 vsc30051 4096 2011-04-01 12:13 .netCache.1a
drwxr-xr-x 4 vsc30051 vsc30051 4096 2011-04-01 12:13 .netCache.1b
-rw-r--r-- 1 vsc30051 vsc30051 2562 2011-07-07 09:49 .netlabbeginner
-rw-r--r-- 1 vsc30051 vsc30051  20 2009-05-20 17:25 .net.conf
-rw-r--r-- 1 vsc30051 vsc30051 492 2011-03-23 16:56 .netlab.txt
-rw-r--r-- 1 vsc30051 vsc30051  80 2011-03-04 13:46 .netlabrc
-rw-r--r-- 1 vsc30051 vsc30051  72 2011-03-04 13:09 .netlabrcrc
-rw-r--r-- 1 vsc30051 vsc30051 752 2011-03-17 14:26 .recently-used
-rw-r--r-- 1 vsc30051 vsc30051 7928 2011-04-20 16:18 .recently-used.stat
-rw-r--r-- 1 vsc30051 vsc30051  21 2011-05-13 14:48 .segs
-rw-r--r-- 2 vsc30051 vsc30051 4096 2011-04-22 16:56 .ssh
drwxr-xr-x 3 vsc30051 vsc30051 4096 2011-01-17 14:11 .subversion
-rw-r--r-- 1 vsc30051 vsc30051 480 2011-06-13 14:14 .vscode
-rw-r--r-- 1 vsc30051 vsc30051 368 2011-07-07 09:49 .Xauthority
vas30051@login:~$
```



# 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 $SHELL
/bin/bash
bash-4.2$
```