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

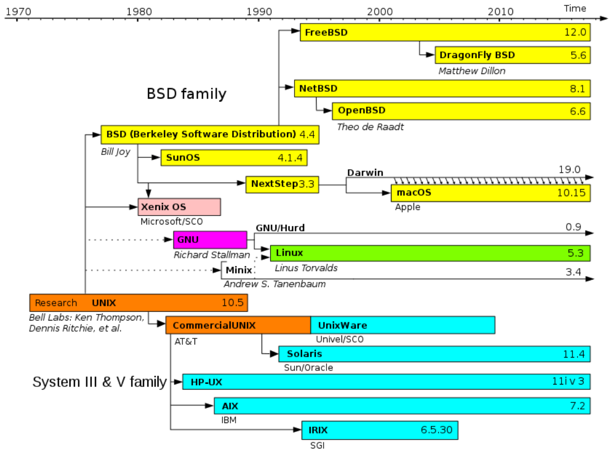
- Background info
- OS kernel shell
- Command Line Interface (CLI)

Some background

Operating system

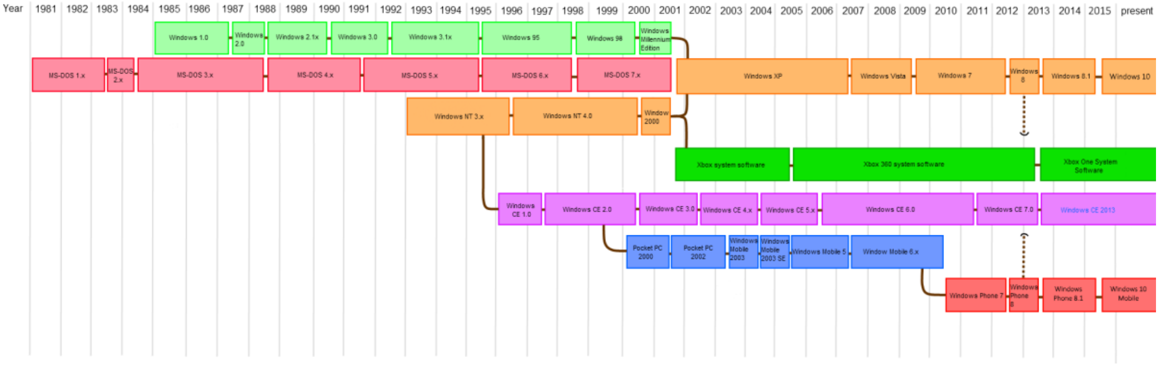
- An operating system (OS) is system software that manages computer hardware, software resources, and provides common services for computer programs. (https://en.wikipedia.org/wiki/Operating_system)
  - Windows
    - Desktop systems
    - https://gs.statcounter.com/os-market-share/desktop/worldwide/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

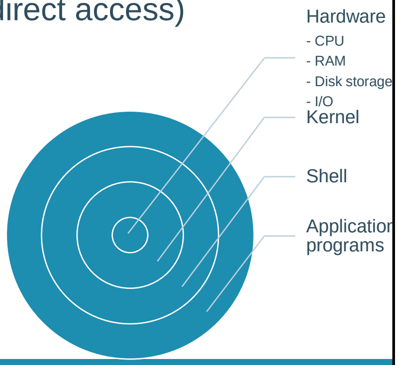
Linux OS

- 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** (https://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.

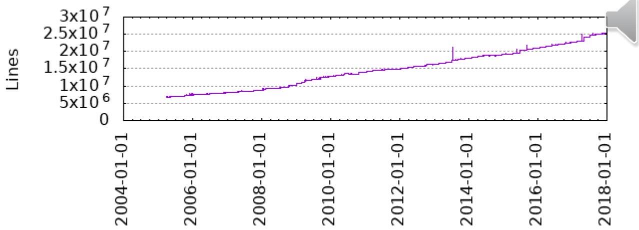
(https://cvw.cac.cornell.edu/Linux/introduction)

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, ...



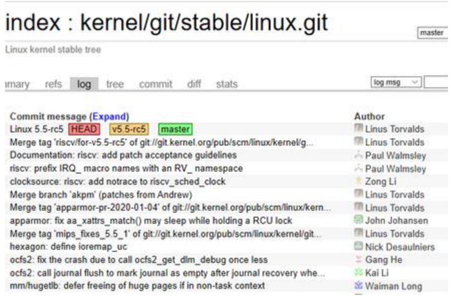
Linux kernel



- Lines of code

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

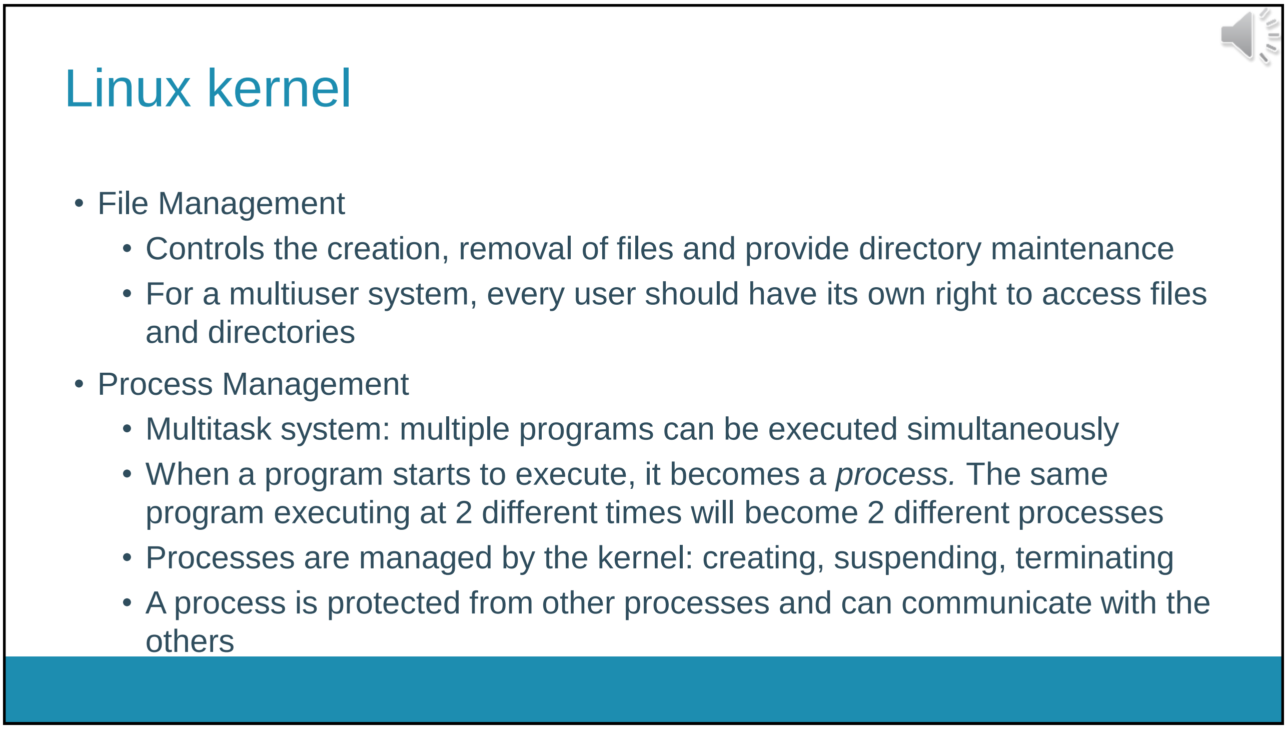
- Linux in 2020: 27.8 million lines of code in the kernel
  https://www.theregister.co.uk/2020/01/06/linux_2020_kernel_systemd_code/



index : kernel/git/stable/linux.git

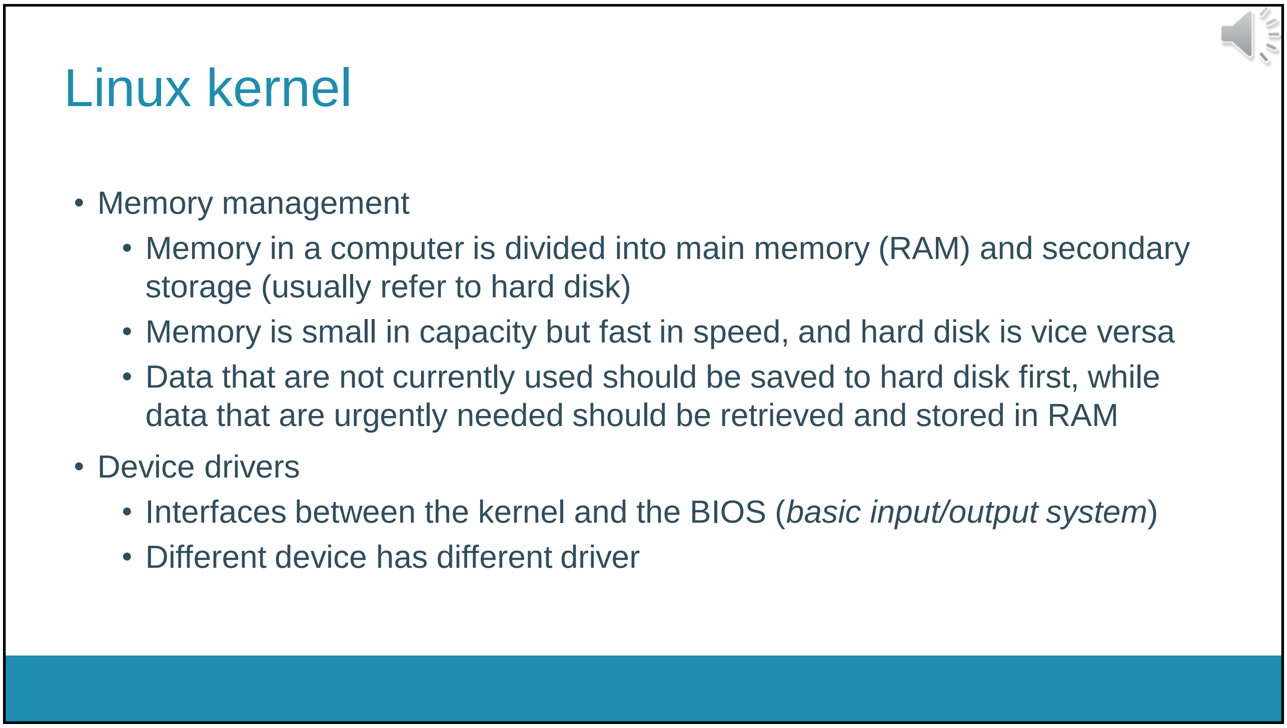
Linux kernel stable tree

Commit message (Expand)	Author
Linux 5.5-rc5 HEAD v5.5-rc5 master	Linus Torvalds
Merge tag 'riscv/for-v5.5-rc5' of git://git.kernel.org/pub/scm/linux/kernel/g...	Linus Torvalds
Documentation: riscv: add patch acceptance guidelines	Paul Walmsley
riscv: prefix IRQ_ macro names with an RV_ namespace	Paul Walmsley
clocksource: riscv: add notrace to riscv_sched_clock	Zong Li
Merge branch 'akpm' (patches from Andrew)	Linus Torvalds
Merge tag 'apparmor-pr-2020-01-04' of git://git.kernel.org/pub/scm/linux/kern...	Linus Torvalds
apparmor: fix aa_xattrs_match() may sleep while holding a RCU lock	John Johansen
Merge tag 'mips_fixes_5.5_1' of git://git.kernel.org/pub/scm/linux/kernel/git...	Linus Torvalds
hexagon: define ioremap_uc	Nick Desaulniers
ocfs2: fix the crash due to call ocfs2_get_dlm_debug once less	Gang He
ocfs2: call journal flush to mark journal as empty after journal recovery whe...	Kai Li
mm/hugetlb: defer freeing of huge pages if in non-task context	Waiman 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

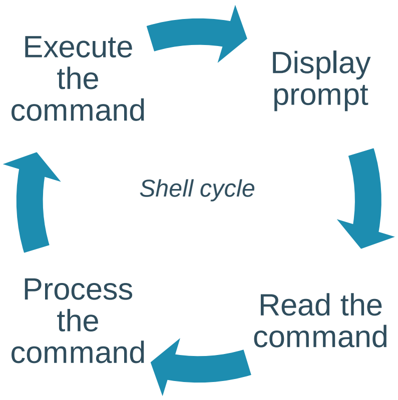
- Memory management
  - Memory in a computer is divided into main memory (RAM) and secondary storage (usually refer to hard disk)
  - Memory is small in capacity but fast in speed, and hard disk is vice versa
  - Data that are not currently used should be saved to hard disk first, while data that are 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



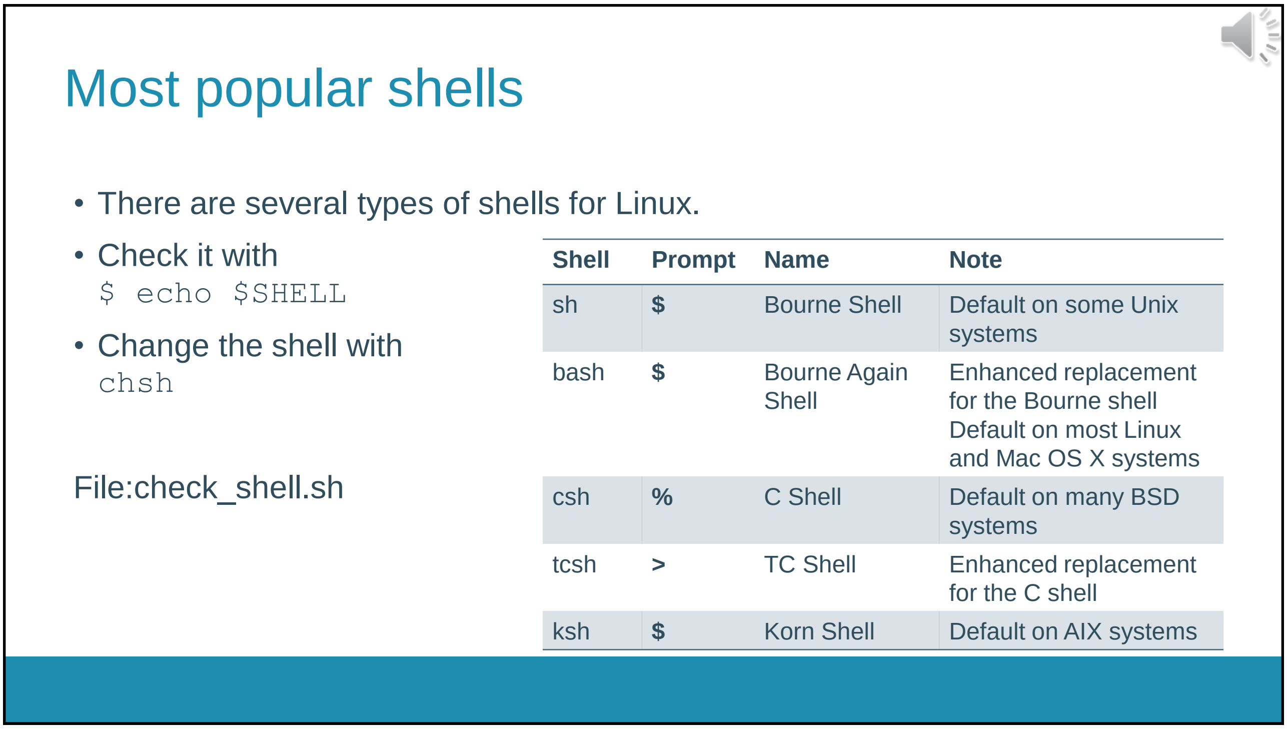
Execute the command

Display prompt

Shell cycle

Read the command

Process the command

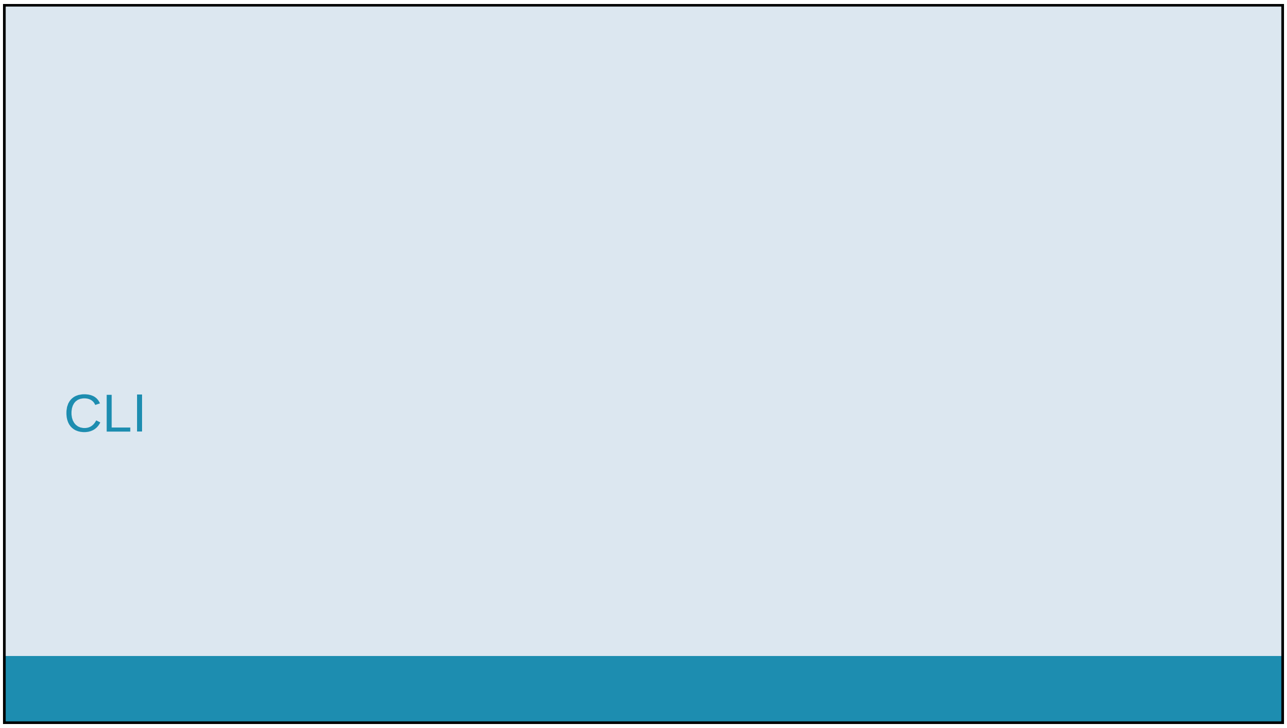


Most popular shells

- 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



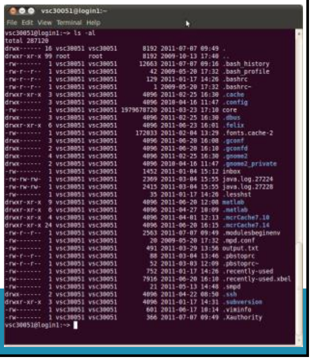
CLI

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`

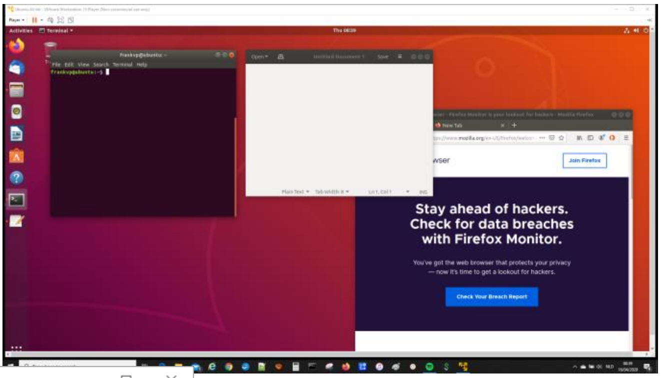


```
vsc30051@login1:~> ls -al
total 287120
drwx------ 16 vsc30051 vsc30051       8192 2011-07-07 09:49 .
drwxr-xr-x 99 root     root           8192 2009-10-13 17:40 ..
-rw-------  1 vsc30051 vsc30051      12663 2011-07-07 09:16 .bash_history
-rw-r--r--  1 vsc30051 vsc30051         42 2009-05-20 17:32 .bash_profile
-rw-r--r--  1 vsc30051 vsc30051        129 2011-01-17 14:26 .bashrc
-rw-r--r--  1 vsc30051 vsc30051          1 2009-05-20 17:32 .bashrc~
drwxr-xr-x  3 vsc30051 vsc30051       4096 2011-02-25 16:30 .cache
drwx------  3 vsc30051 vsc30051       4096 2010-04-16 11:47 .config
-rw-------  1 vsc30051 vsc30051 1979678720 2011-03-23 17:10 core
drwx------  3 vsc30051 vsc30051       4096 2011-02-25 16:30 .dbus
drwxr-xr-x  6 vsc30051 vsc30051       4096 2011-06-23 16:01 .felix
-rw-------  1 vsc30051 vsc30051     172033 2011-02-04 13:29 .fonts.cache-2
drwx------  3 vsc30051 vsc30051       4096 2011-06-20 16:08 .gconf
drwx------  2 vsc30051 vsc30051       4096 2011-06-20 16:10 .gconfd
drwx------  4 vsc30051 vsc30051       4096 2011-02-25 16:30 .gnome2
drwx------  2 vsc30051 vsc30051       4096 2010-04-16 11:47 .gnome2_private
-rw-------  1 vsc30051 vsc30051       1452 2011-01-04 15:12 inbox
-rw-rw-rw-  1 vsc30051 vsc30051       2369 2011-03-04 15:55 java.log.27224
-rw-rw-rw-  1 vsc30051 vsc30051       2415 2011-03-04 15:55 java.log.27228
-rw-------  1 vsc30051 vsc30051         35 2011-01-17 14:20 .lesshst
drwxr-xr-x  9 vsc30051 vsc30051       4096 2011-06-20 12:08 matlab
drwxr-xr-x  6 vsc30051 vsc30051       4096 2011-04-27 10:09 .matlab
drwxr-xr-x  4 vsc30051 vsc30051       4096 2011-04-01 12:13 .mcrCache7.10
drwxr-xr-x 24 vsc30051 vsc30051       4096 2011-06-20 16:15 .mcrCache7.14
-rw-r--r--  1 vsc30051 vsc30051       2563 2011-07-07 09:49 .modulesbeginenv
-rw-------  1 vsc30051 vsc30051         20 2009-05-20 17:32 .mpd.conf
-rw-------  1 vsc30051 vsc30051        491 2011-03-29 13:56 output.txt
-rw-r--r--  1 vsc30051 vsc30051         88 2011-03-04 13:46 .pbstoprc
-rw-r--r--  1 vsc30051 vsc30051         52 2011-03-03 12:09 .pbstoprc~
-rw-------  1 vsc30051 vsc30051        752 2011-01-17 14:26 .recently-used
-rw-------  1 vsc30051 vsc30051       7916 2011-06-20 16:10 .recently-used.xbel
-rw-------  1 vsc30051 vsc30051         21 2011-05-13 14:48 .smpd
drwx------  2 vsc30051 vsc30051       4096 2011-04-22 08:50 .ssh
drwxr-xr-x  3 vsc30051 vsc30051       4096 2011-01-17 14:31 .subversion
-rw-------  1 vsc30051 vsc30051        601 2011-06-17 10:14 .viminfo
-rw-------  1 vsc30051 vsc30051        366 2011-07-07 09:49 .Xauthority
vsc30051@login1:~> 
```

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

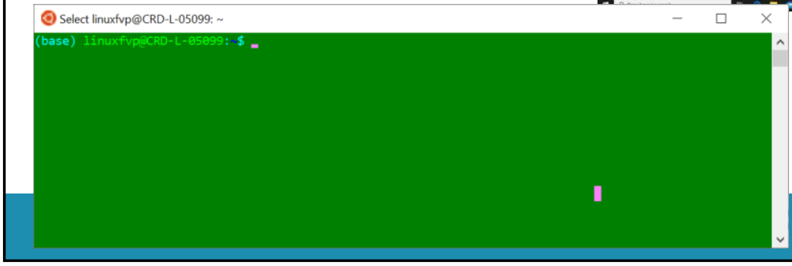


```
frankvp@ubuntu:~$
```

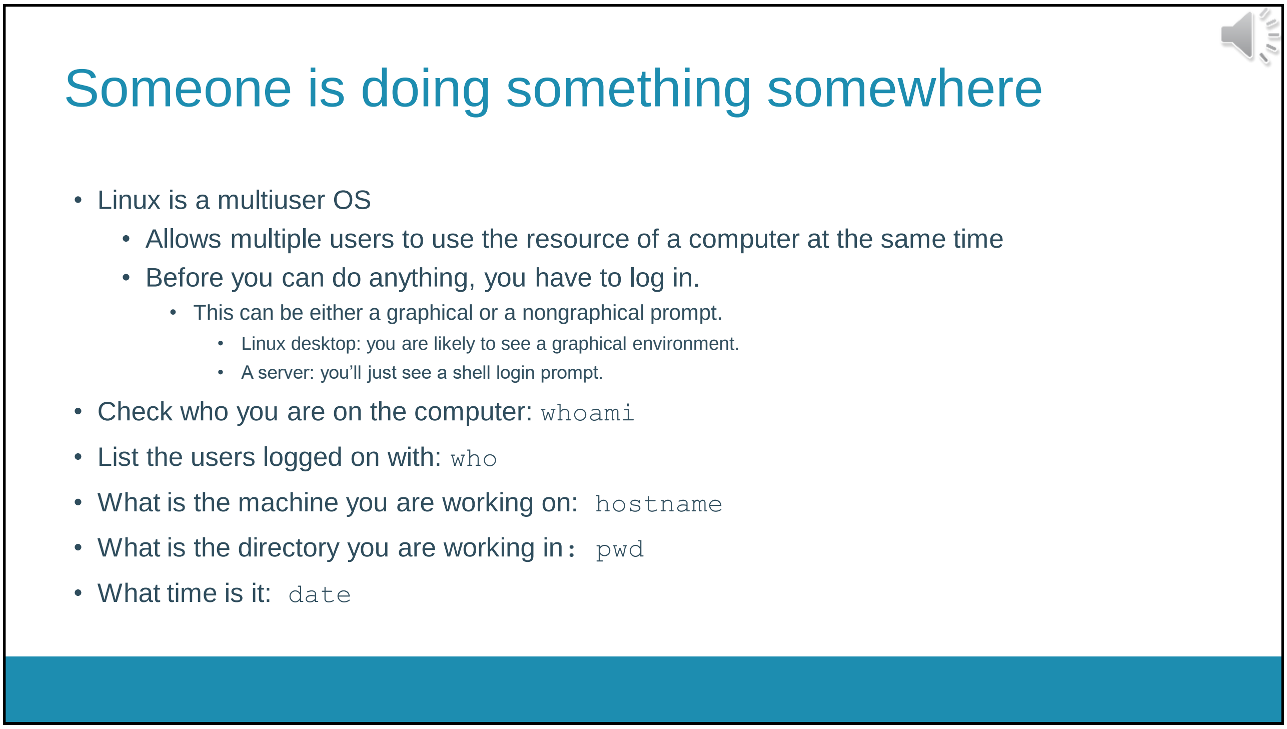
Stay ahead of hackers.
Check for data breaches
with Firefox Monitor.

You've got the web browser that protects your privacy
— now it's time to get a lookout for hackers.

Check Your Breach Report

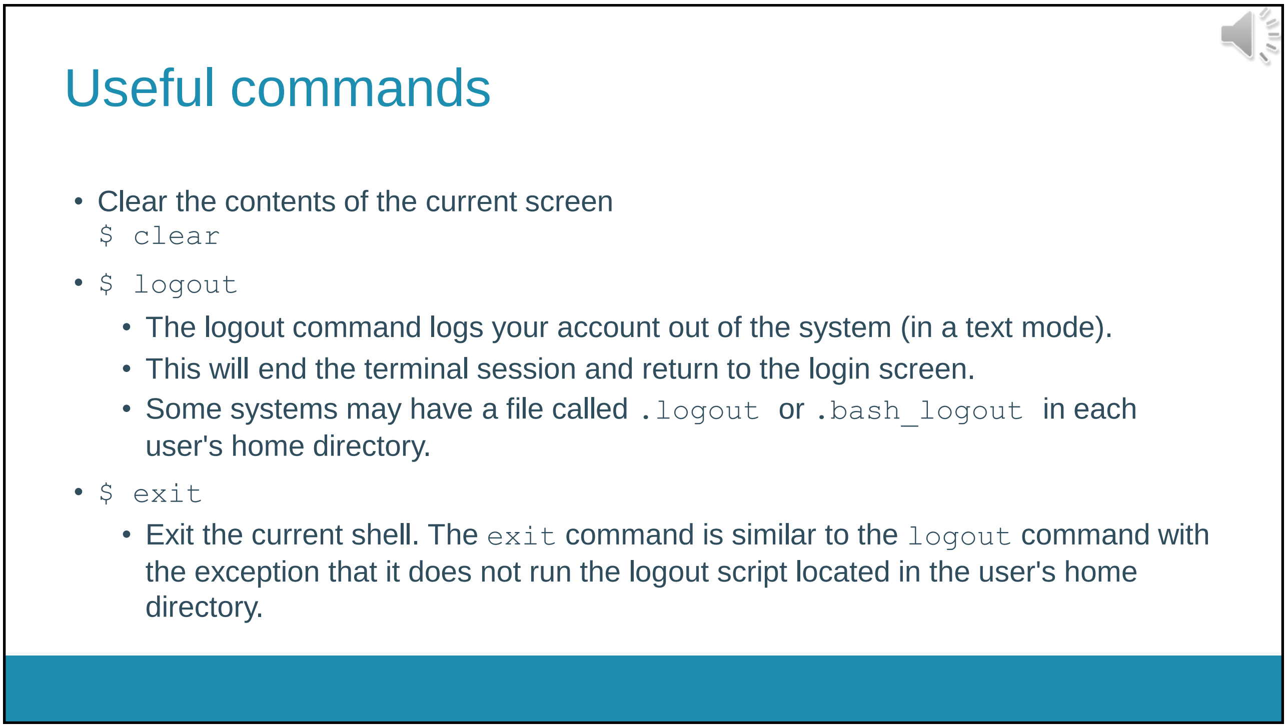


```
(base) linuxfvp@CRD-L-05099:~$
```



Someone is doing something somewhere

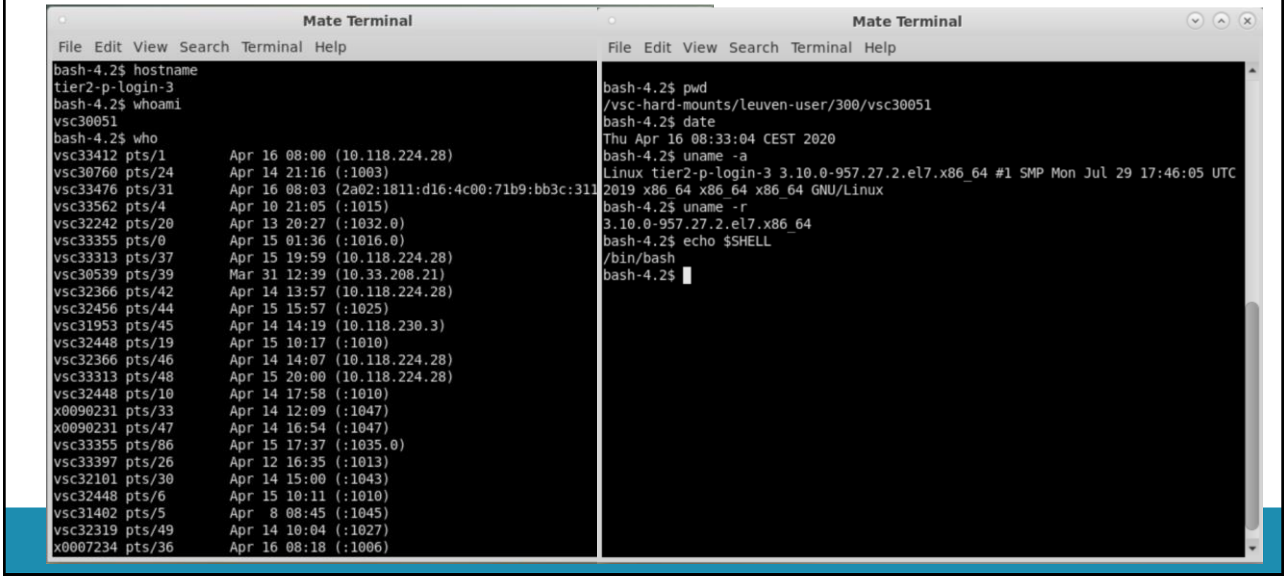
- Linux is a multiuser OS
  - Allows multiple users to use the resource of a computer at the same time
  - Before you can do anything, you have to log in.
    - This can be either a graphical or a nongraphical prompt.
      - Linux desktop: you are likely to see a graphical environment.
      - A server: 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
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)
```

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