Operating Systems

Practical Courses

By Tom Barbette, based on Sylvain Martin's work

Presentation

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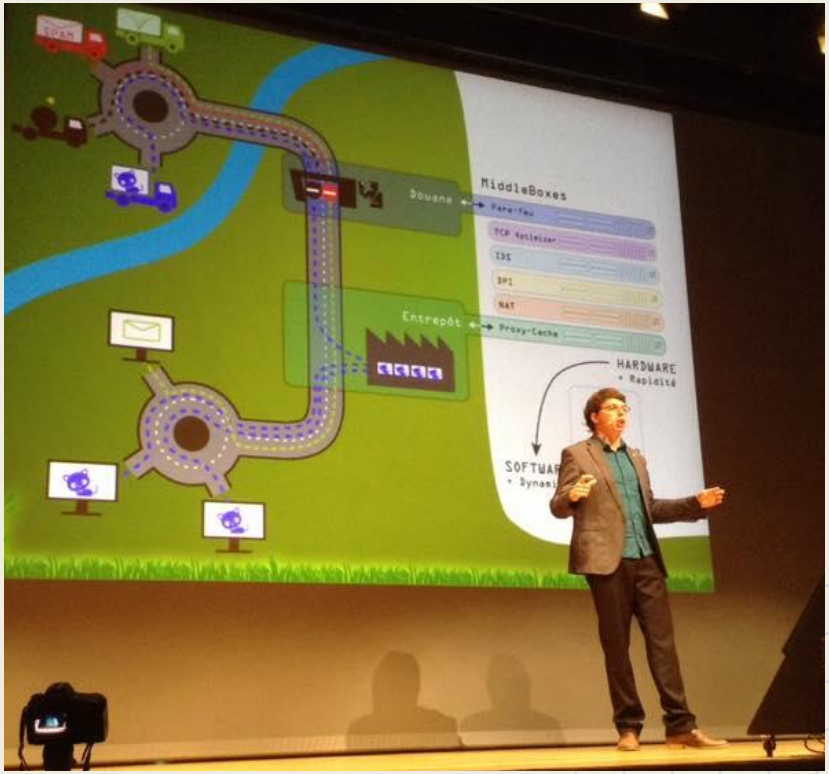


Summary

1. Introduction
2. The computer
3. The Shell
4. Linux Fundamentals
5. Project 1 : Your own shell

PCs & Projects

1. Well… I just said it
2. Bash & Kernel Interaction
3. Virtual Machines & Kernel Compilation
4. Programming in the Linux Kernel
5. Read vs Mmap
6. Modules
7. File systems

Resources

Resources

- http://www.tombarbette.be/courses/os/ all infos, links, reference image, posts about general problems that I see in multiple groups and a lot of “tips” that I gave to lost students in the past
  - I’ll add posts from time to time !
- The theory course and books.
- Slides (links on that same page)

- Google, stackoverflow, …
- https://www.kernel.org/doc/ http://www.win.tue.nl/~aeb/linux/lk/lk.html
- In the kernel sources : .../kernel-4.4.50/Documentation
- Books : http://idak.gop.edu.tr/esmeray/UnderStandingKernel.pdf http://reiber.org/nxt/pub/Linux/LinuxKernelDevelopment/Linux.Kernel.Development.3rd.Edition.pdf

- The course discussion forum on the submission platform
- And after a good search... me.

The Computer

What's inside?

- CPU
  - What is it?
  - What does it do?
  - Is there a program loaded in it or something?
- RAM
  - What is it?
- GPU
  - Is it really needed?
- Disk
  - What types?
  - What sizes?
- Expansion cards (PCI, PCIe)
  - Bus? Still actual?

Booting

- BIOS
- Bootloader
  - Is it an OS?
  - Is it a program?
- Kernel
  - Is it the OS?
  - Is it a program?
- Shell
  - Is it a program?
  - What is special with it?
- Is the kernel still running? Where is it?

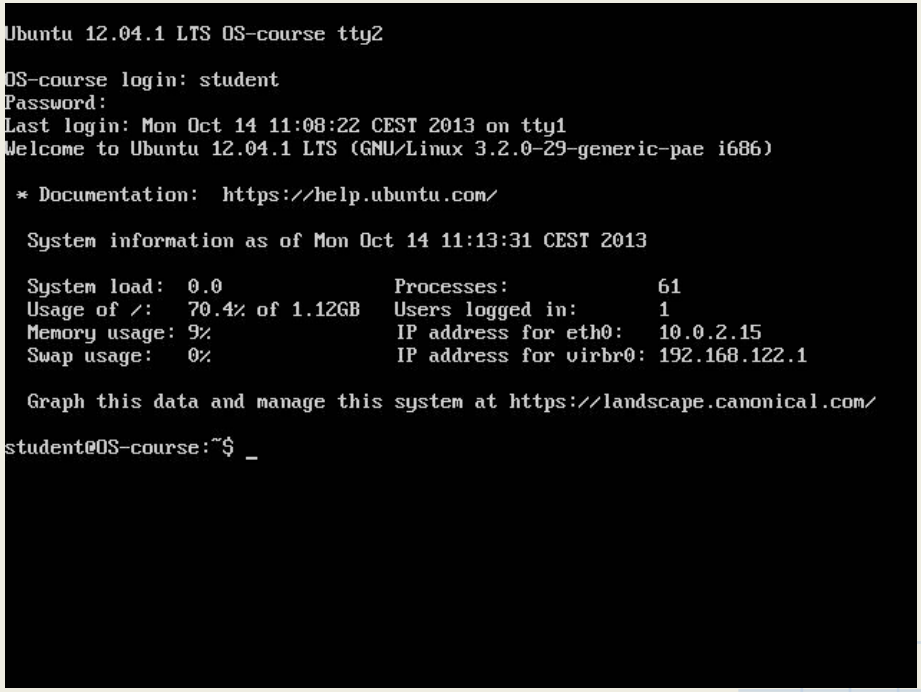
The Shell

What's that?

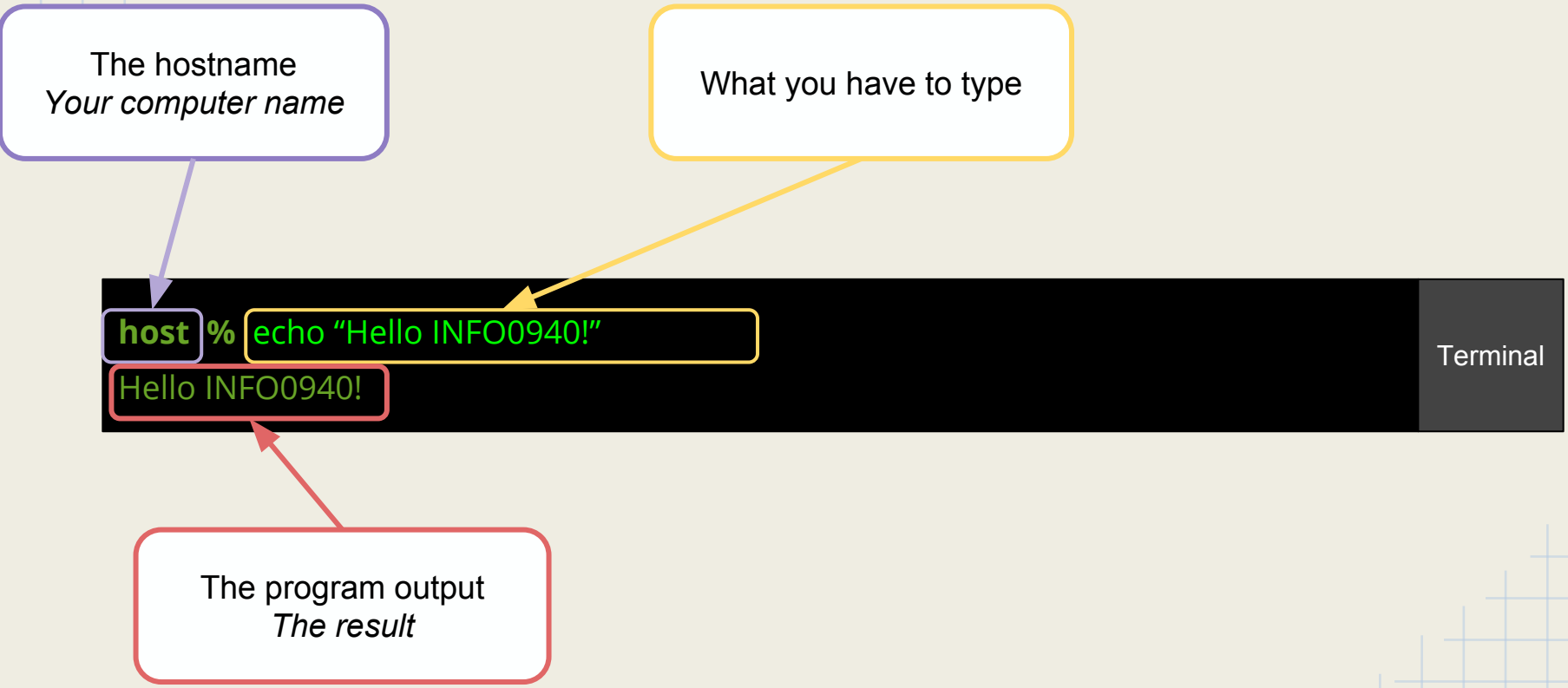
The Shell
What's that?

- What you see in movies involving hackers

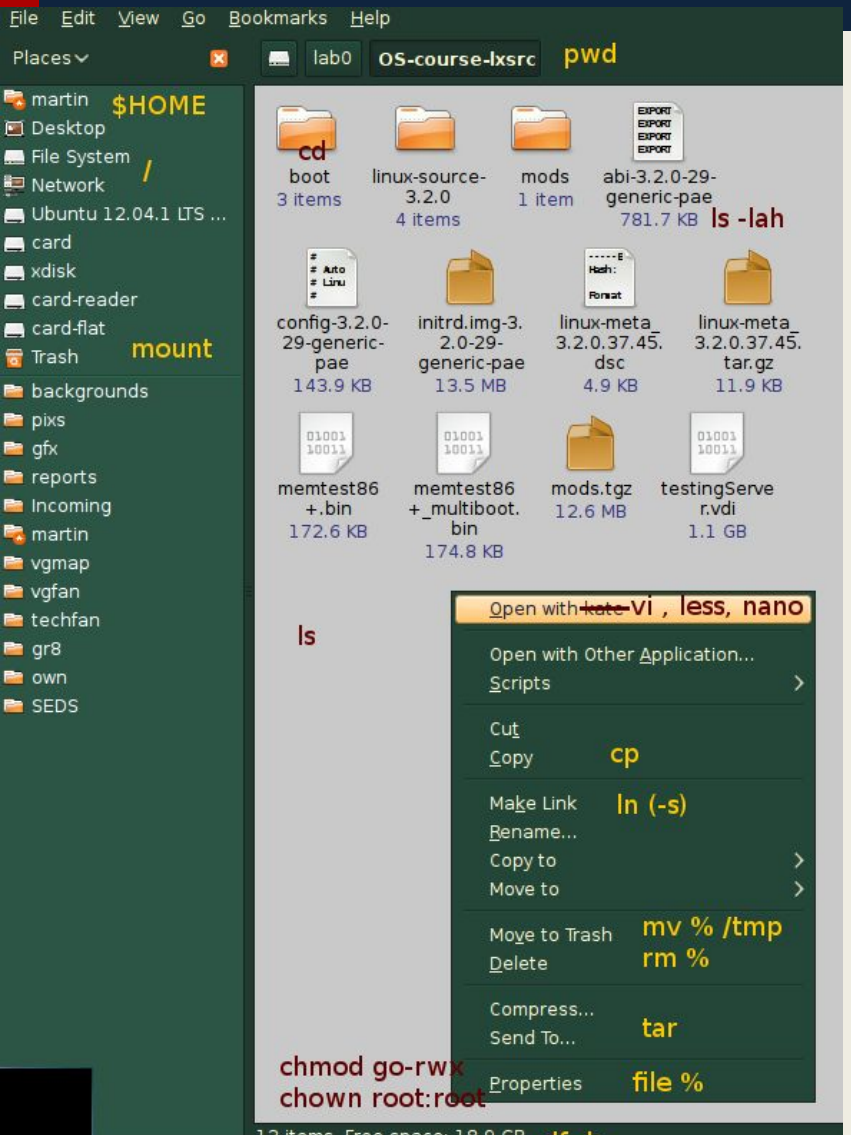
- Takes commands
- Execute them
- Show you the result



Prompt


The hostname
Your computer name
What you have to type
host % echo “Hello INFO0940!”
Hello INFO0940!
Terminal
The program output
The result

Basic commands



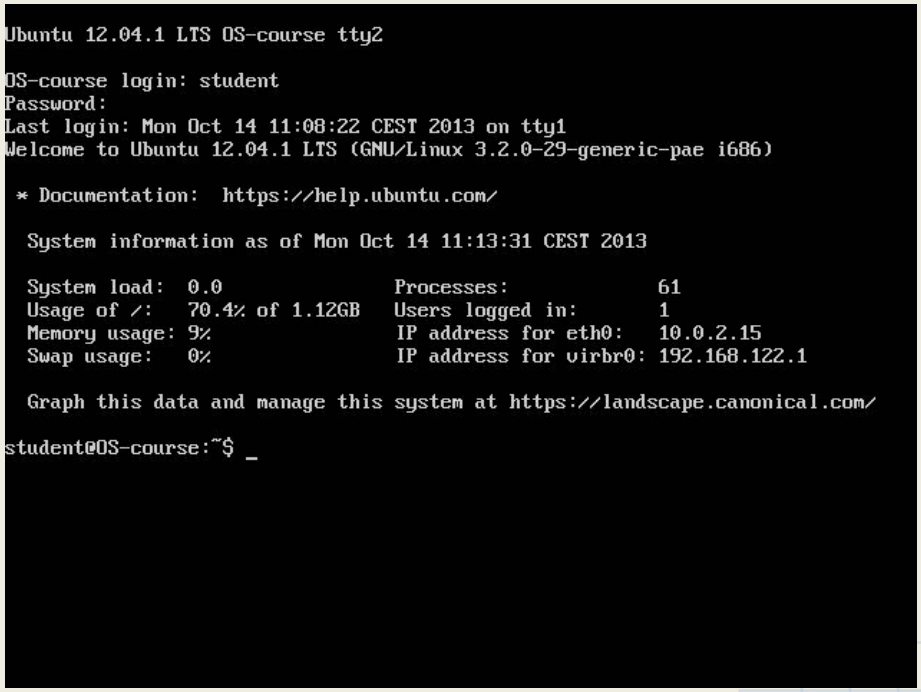
- type commands, even to *list* (**ls**) and change directory (**cd**)
- every time the system is ready, you see the *prompt*

- most commands have *manual pages*. Try e.g.

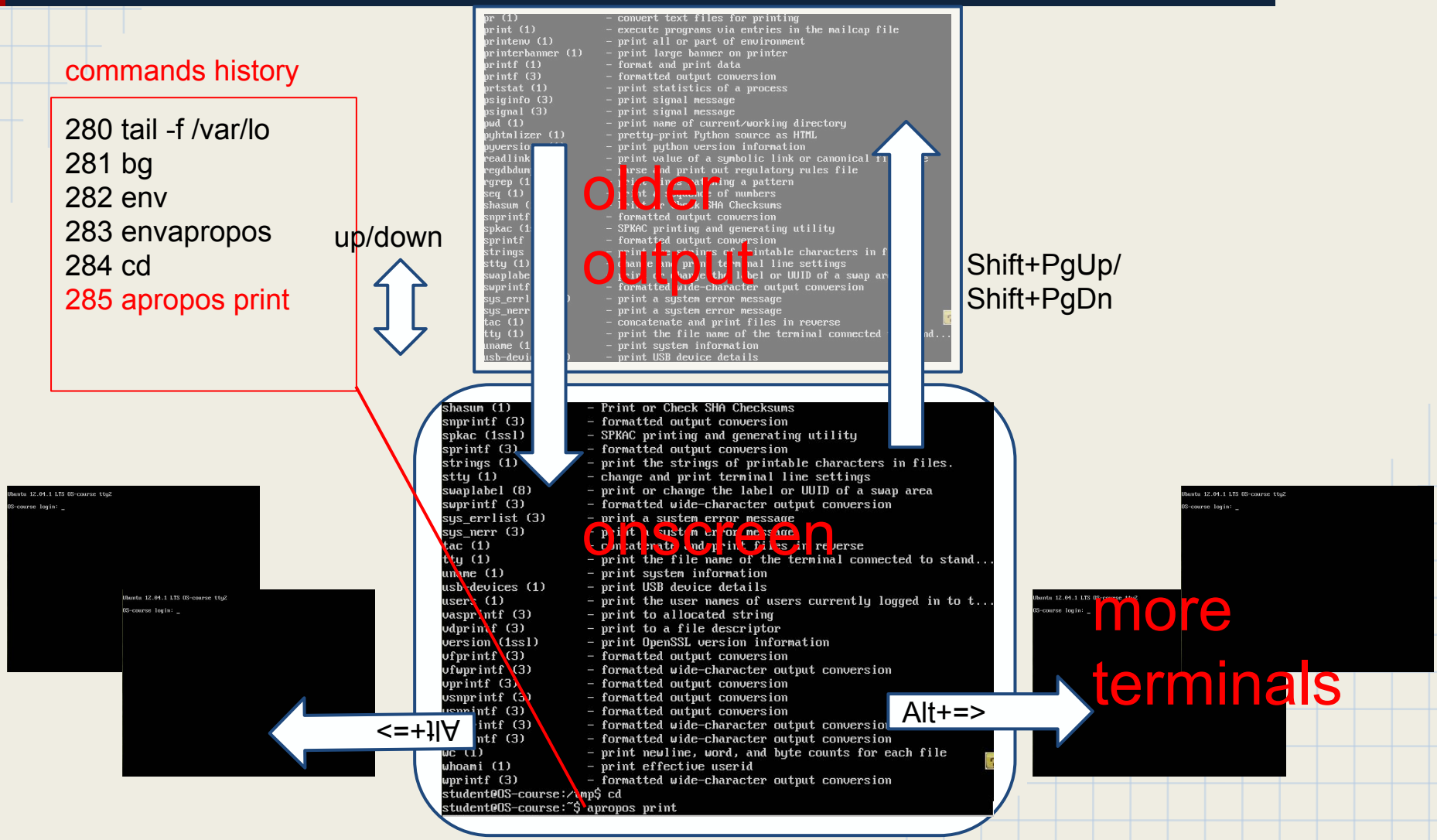
```
OS-course:~$ apropos print
...
wc (1)    - print newline,
word ...
whoami (1) - print
effective userid
wprintf (3) - formatted
wide-char
OS-course:~$ man wc
```

The real console

- If you are on Linux, try CTRL+MAJ+ALT F2
  - Go back to the “X terminal” with CTRL+ALT F1 or F7 depending on your distribution
- No GUI ! You can install gpm to have a very restricted mouse support for copy-paste.



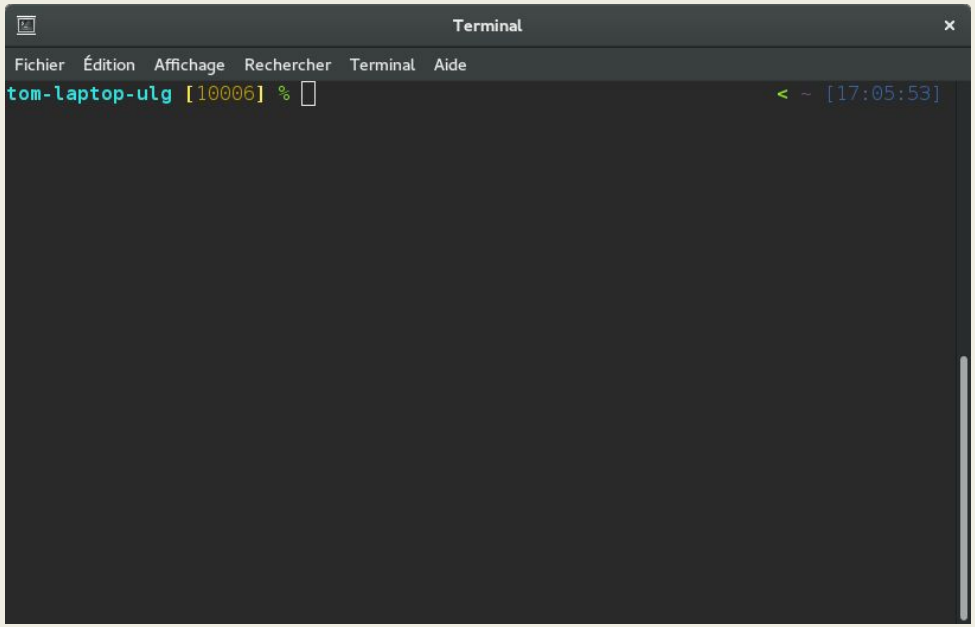
Working with the console



Pseudo Terminal

Painless terminal

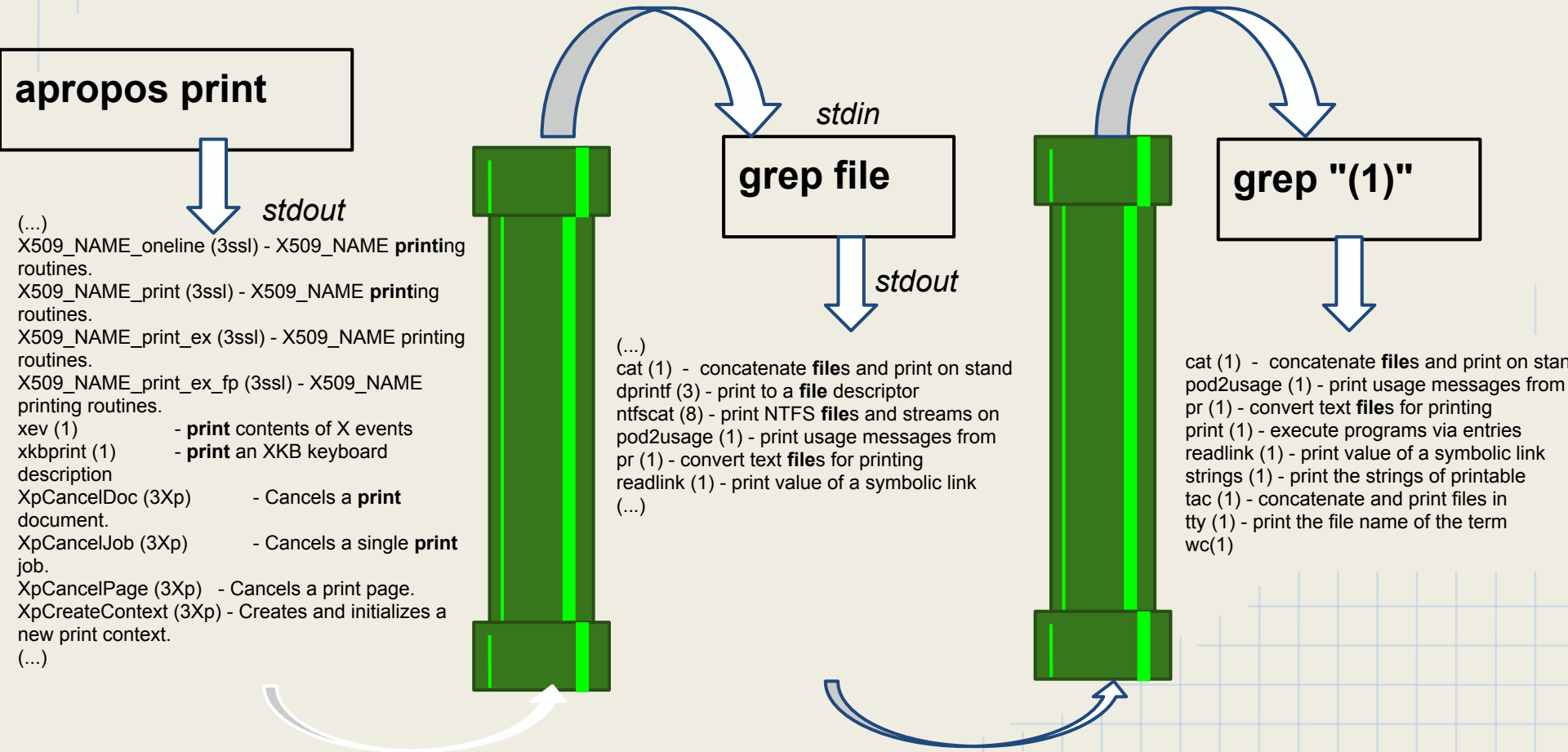
- All Linux and Mac OS X come with a pseudo-terminal
- You can open it like any other application
- Easy selection, copy-paste from web, go back in history using scroller, ...



Chaining | commands

```
$ apropos print | grep file | grep (1)
```
Terminal

3 process created, output chained to inputs using so-called *pipes*



One shell to rule them all?

- By default, it is bash nearly everywhere
- **ZSH** (sudo apt-get install zsh && chsh) is just better
  - More intelligent autocompletion with TAB
    - E.g type “ls /home/t” and TAB will propose “ls /home/tom”
  - I said, just better !

- You can personalize all, changing your configuration in ~/.bashrc for bash and ~/.zshrc for ZSH
- An older version of mine at http://queen.run.montefiore.ulg.ac.be/~barbette/tag/zshrc/

- At least add some aliases in your rc file :
  - alias i=”sudo apt-get install” → “i program” to install program instead of typing the whole “sudo apt-get install program” every time

- **You can save a lot of time !**

Linux fundamentals

Linux

- Is the name of the ***Kernel***
  - Made by Linus Torvalds

- By extension, also the name of the *distributions* that uses it
  - In general Linux distributions put binaries in the /bin folder, and programs in /usr, though the Linux kernel has nothing to do with that

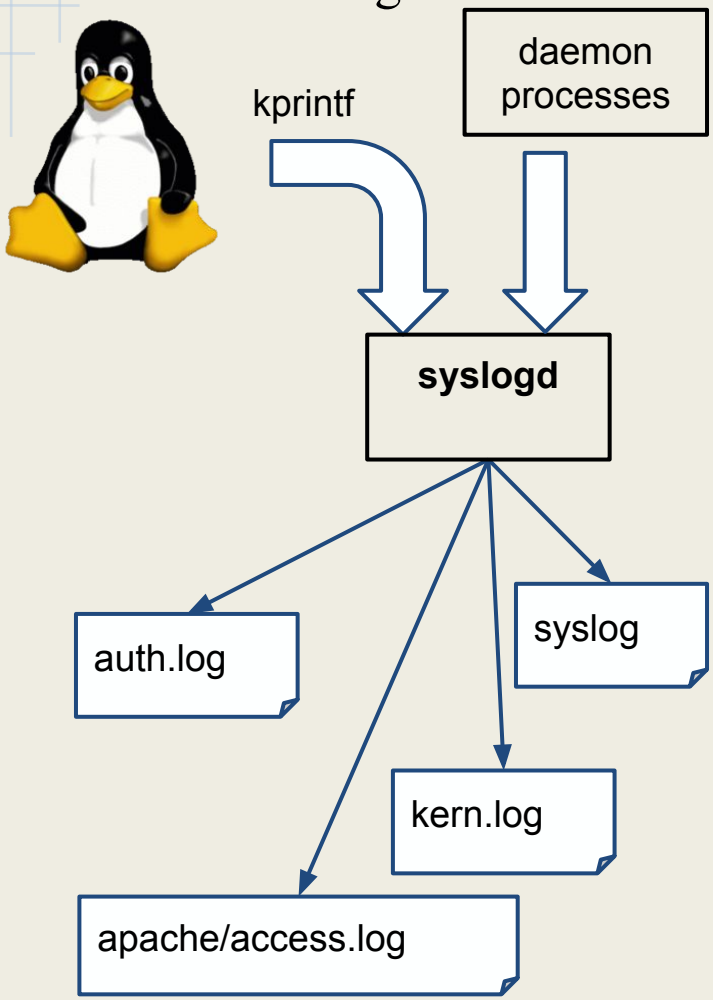
- Today : Linux-based Operating Systems general ideas
- Next week : Interactions with the Linux Kernel itself

Folders

- /bin
  - Software binaries (system/basic ones)
    - bash, ls, zip, tar , ...
- /sbin
  - Super-user binaries
    - fdisk, gparted, ...
- /dev, /proc, /sys access to kernel interaction (next week)
- /home
  - Users files
- /usr
  - Program installed by users
- /mnt, /media
  - Mount points (USB keys, network, …)
- /var
  - Software data (web root, caches, SQL database, …)
- /etc
  - Configuration files

/var/log

A place where the logs are collected



- **less /var/log/syslog** navigate through past events (/ to enter a regexp to search, n to hop to the next match, q to quit)
- **tail -f /var/log/auth.log &** will report bad users.

? *Can you tell when the system was last re-booted ? Which file was used as boot_image ?*

sudo vi /etc/passwd

- **/etc** stores all the machine's config
- (mostly as text files)
- **sudo** allows some users to *act as system administrator* (root) for *one command*.
- If you prefer, **nano** is installed in the Virtual Machine we'll use.

? *Can you change the machine's hostname in the configuration ?*

Installing programs

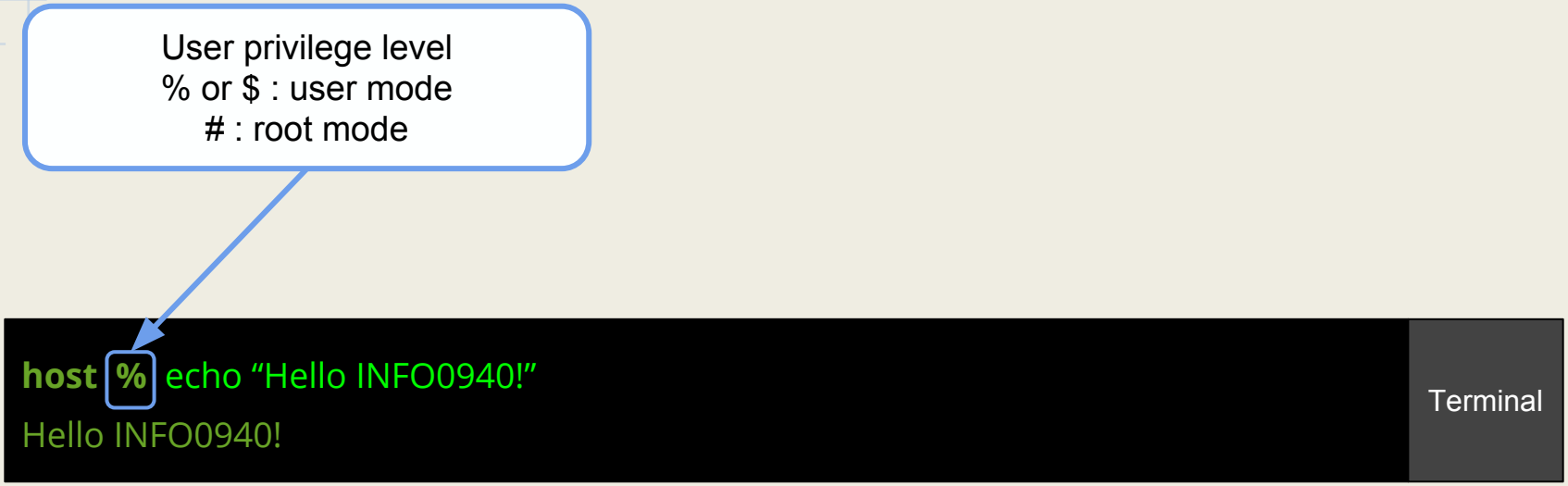
- **apt-cache search “XXX”**
- **sudo apt-get install XXX**

```
student $ apt-cache search jed
(...)
jed - Éditeur pour programmeur
jed-common - Fichiers d'exécution S-lang compilés pour jed et xjed
slang-gdbm - l'accès aux bases de données GDBM depuis S-Lang
xjed - éditeur pour programmeurs (version x11)

student $ sudo apt-get install jed
Lecture des listes de paquets... Fait
Construction de l'arbre des dépendances
Lecture des informations d'état... Fait
(...)
0 mis à jour, 4 nouvellement installés, 0 à enlever et 83 non mis à jour.
Il est nécessaire de prendre 821 ko dans les archives.
Après cette opération, 3.064 ko d'espace disque supplémentaires seront utilisés.
Souhaitez-vous continuer [O/n] ? o
(...)
```

Terminal

User vs Root



WARNING

No link with the CPU privilege mode, SYSCALL mechanism, ... Root is still in "user" context and is absolutely not tied to kernel mode !

Root

Root = Super User = SU

- The root user has access to all files
- In Unix, everything is a file
  - Your Terminal is /dev/tty
  - Your USB device is /dev/usb*
  - Kernel parameters are in /proc
  - ...

→ Root has access to everything in Unix…

(A good *syllogisme* example)

? *How to become root?*

Become the master

```
% make sandwich
You have to be root !
```
Terminal

First method with su

```
% su
Password : [Type root password]
# make sandwich
Your sandwich is ready !
#
```
Terminal

Second method with sudo :

```
% sudo make sandwich
Password : [Type your user password]
Your sandwich is ready !
%
```
Preferred !

Terminal

sudo -s allows you to mimic “su” but giving your own password (like sudo su)

Linux fundamentals Really?

Most of theses commands are distribution-specific

- “apt-get” is for debian-based distributions, like Ubuntu. You’ll use “yum” in fedora or red-hat

- /var/log/syslog is for debian-based, but it’s /var/log/messages in redhat-based…

- …

We’ll use **Ubuntu** for its popularity

Project 1

Deadline 21/02 23:59

Project #1

Implement a simple shell in C

- You will implement a simple shell, which uses exclusively **execv** and **fork** for sub-process.
  - Fork duplicates the process
  - Execv replace the current process by another one

- It must support launching programs with arguments, and return to the prompt when the program terminates, but no other concepts such as variable, substitution, pipes, chaining, …

- It will exit upon typing "exit" or CTRL+D (EOF)

- Command line can be limited to 255 arguments, while each arguments may be limited to 255 characters.

- The first prompt must be "> ",then "RET> " where RET is the return code of the last command. If there was no command when pressing enter, "> " is shown

Example

```
$ gcc -std=gnu99 -o shell shell.c && ./shell
> /bin/ls
shell  shell.c       shell.c~  shell.tar.gz

0> /bin/ls -al
total 32
drwxr-xr-x. 2 tom tom 4096  9 fév 12:23 .
drwxr-xr-x. 3 tom tom 4096  9 fév 11:28 ..
-rwxr-xr-x. 1 tom tom 9032  9 fév 12:23 shell
-rw-r--r--. 1 tom tom 1133  9 fév 12:23 shell.c
-rw-r--r--. 1 tom tom 1134  9 fév 12:23 shell.c~
-rw-r--r--. 1 tom tom  208  9 fév 11:41 shell.tar.gz

0>
```

Terminal

PATH support

- Look in the folders of $PATH (separated by :) in order to find the program to launch
- This should avoid to type "/bin/ls", as bin should be in the path, typing ls should be enough

DO NOT USE exec*p variants that do that themselves, only support it manually

/bin/chsh

Will you dare trust your own shell?

Submission

- You must submit a file named shell.c using the submission platform (https://submit.montefiore.ulg.ac.be)
- Currently, only compile test and a few input/output comparisons
- **Per group of 2** that you will keep the whole semester

Bring your laptop next week !

- Please have a Linux ready for next week with either :
  - Linux (maybe in dual boot)
  - Windows/Mac OS with a Linux in VirtualBox
  - Windows/Mac OS connecting to ms8xx machines using Putty/SSH
    - http://www.student.montefiore.ulg.ac.be/accounts.php
    - Please arrange that before the course !
- Do not hesitate to e-mail me

Putty (SSH on Windows) :
http://www.chiark.greenend.org.uk/~sgtatham/putty/latest.html

Windows 10 Bash is also a good solution for SSH to ms8xx :
http://www.howtogeek.com/249966/how-to-install-and-use-the-linux-bash-shell-on-windows-10/