Project 1

Supplementary info + Q&A

Project 1 supplementary info

- Your shell must support the ***cd*** built-in command !
- However, *ls* is just a normal command
- No other built-ins than cd are required as of now
  - Tough, remember I hate *copy-pasting*

The Shell

Useful commands

Variables

```
% n=5
% echo $n
5
% h="Hello you"
% echo "The equivalent for $h in french is Salut toi"
The equivalent for Hello you in french is Salut toi
% echo "${n}Bits"
5Bits
```

Terminal

Environment variables

```
% echo $HOME
/home/tom
% echo $PATH
/usr/local/sbin:/usr/local/bin:/usr/sbin:/usr/bin:/sbin:/bin:/usr/games:/usr/local/games:/...
% echo $[TAB]
dirstack        HISTFILE                        LOGNAME         prompt_themes
-               dis_aliases     history                         MACHTYPE        PS1
!               dis_builtins    history_color                   MAIL            PS2
?               dis_functions   history_prompt1                 MAILCHECK       ...
```

Terminal

Math

```
% echo $((5 * 10))
50
% n=5
% echo $((n * 10))
50
% echo $(( (n * 10) % 5))
0
```

Terminal

From stdin :

```
% echo "5 * 10" | bc
50
```

Terminal

seq, sort, shuf

```
% seq 5
1
2
3
4
5
```

Terminal

```
% seq 5 | shuf
3
2
1
4
5
```

Terminal

```
% seq 5 | shuf | sort
1
2
3
4
5
```

Terminal

uniq

```
% echo $((RANDOM % 5)) >> rands.txt
% echo $((RANDOM % 5)) >> rands.txt
% echo $((RANDOM % 5)) >> rands.txt
% echo $((RANDOM % 5)) >> rands.txt
% echo $((RANDOM % 5)) >> rands.txt
% cat rands.txt
0
0
1
0
4
```

Terminal

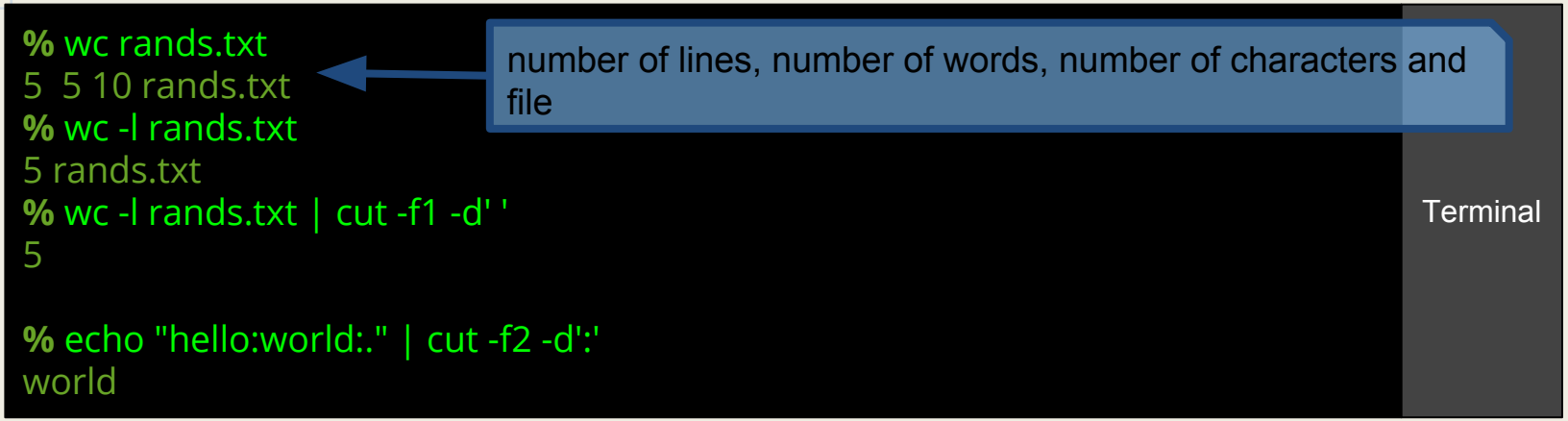
```
% cat rands.txt | uniq
0
1
0
4
```

Terminal

```
% cat rands.txt | sort | uniq
0
1
4
```

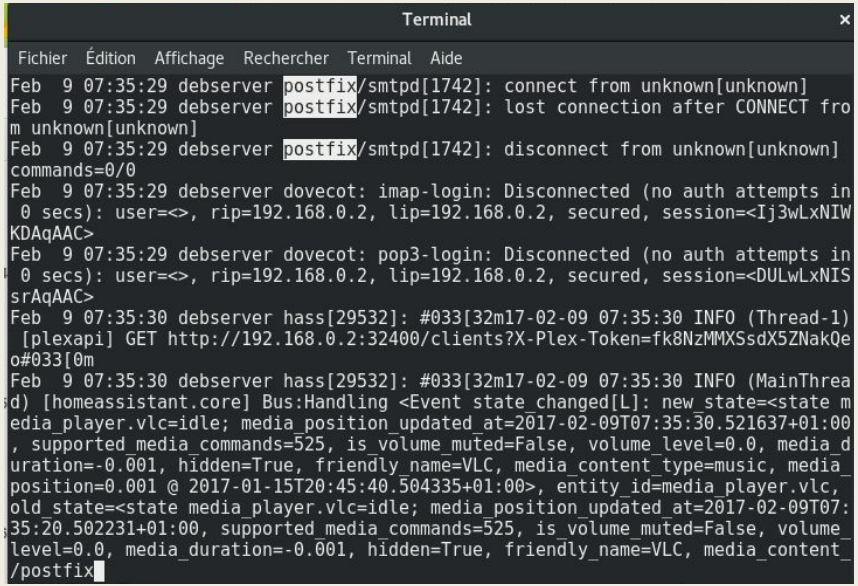
Terminal

wc, cut


% wc rands.txt
5 5 10 rands.txt
% wc -l rands.txt
5 rands.txt
% wc -l rands.txt | cut -f1 -d' '
5
% echo "hello:world:." | cut -f2 -d':'
world
number of lines, number of words, number of characters and file
Terminal

More, Less, Most

- Scroll through the content of a file or a pipe
- Search in it using a pattern (vim-like, type / then the pattern)



head, tail

```
% seq 5 > seqs.txt
% head -n 2 seqs.txt
1
2
% tail -n 2 seqs.txt
4
5
```

Terminal

```
% sudo tail -n 50 -f /var/log/syslog
[50 last lines of syslog]
[does not return and watch for more content !]
```

Terminal

grep

- The most important of all
- By default, show the lines matching a certain pattern
- Useful parameters :
  - grep -E “[a-z]+” → Regex
  - grep -oE “[a-z]+” → Regex and show only the matching part
  - grep -oiE “[a-z]+” → Idem, case insensitive

```
% sudo cat /var/log/syslog | grep -oE "[0-9]{1,3}([.][0-9]{1,3}){3}" | sort | uniq
109.88.217.64
188.189.92.184
192.168.0.1
192.168.0.2
```

Terminal

Command substitution

```
% n=$(seq 5)
% echo $n
1
2
3
4
5
% ip=$(sudo cat /var/log/syslog | grep -oE "[0-9]{1,3}([.][0-9]{1,3}){3}" | sort | uniq
| head -n 1)
% ping $ip
PING 109.88.217.64 56(84) bytes of data.
64 bytes from ams16s30-in-f3.1e100.net (1109.88.217.64): icmp_seq=1 ttl=51
time=7.83 ms
```

Terminal

Strings, filenames

```
% h="Hello you ."
% echo ${#h)
11
% echo ${h/you/him}
Hello him .
% echo ${h##*lo}
 him .
% echo ${h%lo*}
Hel
```

Remove longest match from the beginning

Remove longest match from the end

Terminal

```
% h="/home/tom/file.txt"
% basename $h
file.txt
% dirname $h
/home/tom
% echo ${h##*.}
txt
% echo ${$(basename $h)%.*}
file
```

Terminal

Find

```
% find .
[all objects in all subfolders]
% find . -type f
[all files in all subfolders]
% find . -maxdepth 2 -type f
[all files in this folder and one level deeper]
% find . -maxdepth 2 -type f | xargs echo
[all files in this folder and one level deeper on one line]
% find . -mindepth 1 -maxdepth 1 -type d | xargs ls
[display content of all directories in this folder]
% find . -maxdepth 1 -type f -exec wc {} \;
[launch wc on all files of the current folder]
```

Terminal

Chain of commands

```
% echo "hello" ; echo "you"
hello
you
% echo "hello" && echo "you"
hello
you
% echo "hello you" > file.txt
% grep "hello" file.txt &>/dev/null && echo "Found hello"
Found hello
% grep "hello" file.txt &>/dev/null || echo "Could not find hello in file.txt"
Could not find hello in file
```

Terminal

You can also put a program in background

```
% sudo tail -f /var/log/messages &
% fg
```

Terminal

```
% sudo tail -f /var/log/messages
[CTRL-Z]
bg
```

Terminal

Exercices

1. Write 6 random numbers between 0 and 9 in a file named *randoms* then display them in a sorted way on the screen.
2. Display only the unique numbers of the file on the screen.
3. Add the string : "*This is a string*" at the end of the file. What will return the command *wc {your file}* ?
4. You have h="Hello you. Do you enjoyed this course ?". In one line display : I enjoyed this course.

Shell Scripts

You can make little scripts to avoid retyping all commands. Just create a file which starts by ***#!/bin/bash*** and simply puts your commands one by line. Example :

```
#!/bin/sh

cd /target
make
make install
```

Shell Script

script.sh

```
% chmod +x script.sh
% ./script.sh
...
```

Terminal

Condition

```
#!/bin/sh

if grep "salut" file.txt ; then
        echo “Salut is present !”
endif
```

If uses the return code, not stdout !

Shell Script

script.sh

```
#!/bin/sh

grep "salut" file.txt 2>&1 /dev/null
if [ $? -eq 0 ] ; then
        echo “Salut is present !”
endif
```

$? is the return code of the last cmd

Shell Script

script.sh

```
#!/bin/sh

number=7
if [ $number -lt 10 ] ; then
        echo "$number is smaller than 10"
endif
```

Shell Script

script.sh

Condition

[thing] is just a shortcut for *test thing*

```
% man test
[...]
    ( EXPRESSION )
          EXPRESSION is true

     ! EXPRESSION
          EXPRESSION is false

     EXPRESSION1 -a EXPRESSION2
          both EXPRESSION1 and EXPRESSION2 are true

     EXPRESSION1 -o EXPRESSION2
          either EXPRESSION1 or EXPRESSION2 is true

     -n STRING
          the length of STRING is nonzero

     STRING equivalent to -n STRING
...
```

Terminal

Loops

```
#!/bin/sh

n=0
while [ $n -lt 10 ] ; do
        echo "$n"
        n=$((n + 1))
done
```

Shell Script

script.sh

```
#!/bin/sh

for n in $(seq 10) ; do
        echo "$n"
done
```

Shell Script

script.sh

```
#!/bin/sh

for file in ./* ; do
        stat --printf="%s\n" $file
done
```

Shell Script

script.sh

Exercise

Build a shell script to compute the total size of the files in a folder specified as the first argument of the script using a loop to sum the total size

Supplementary exercises

1. Write a bash script which will print all the file that contains a specific string
2. Write a bash script that compute the result of the operation given in argument

Kernel Interaction

What is the Kernel

- A very big program, but still, a program
- Kernel vs OS
  - Linux is the Kernel of Linux distributions
  - XNU is Mac OS's kernel
  - Windows NT's kernel is kind of Windows NT's kernel, and makes the difference harder as the window manager is part of the kernel (hybrid kernel)
- So that explains a lot of problem in wordings (last's weeks "Linux fundamentals" slides is in fact the tools part while today we could say we'll speak about Linux fundamentals, the kernel part.

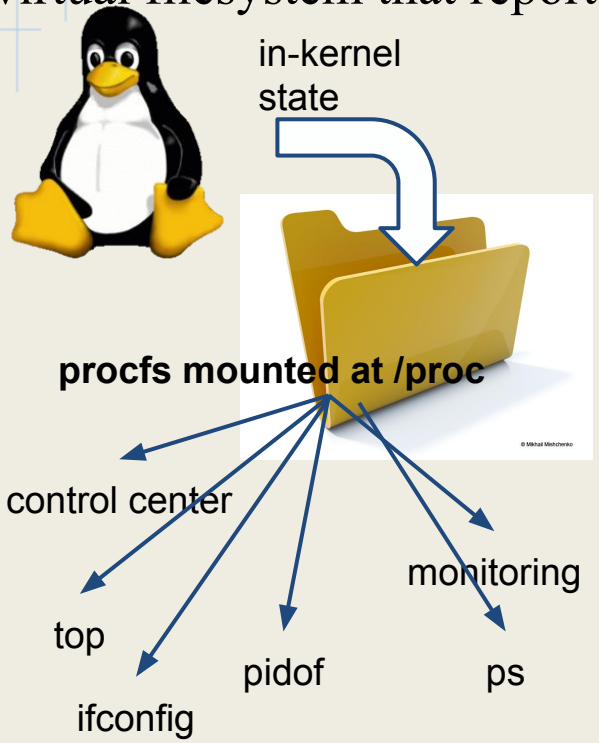
Kernel Entry

- Interrupts
- System calls
  - Why not a simple library/function call?
  - Cost?
- (Memory mappings)

- How to read this "big program" 's state

/proc

A virtual filesystem that reports kernel's internal state



- **ls /proc** list most the general state.
- **cat /proc/cpuinfo** is all you need about your CPU
- **/proc/{number}** holds info about process #{number}

/proc/1/status

```
 cat /proc/1/status]
Name:   systemd
State:  S (sleeping)
Tgid:   1
Ngid:   0
Pid:    1
PPid:   0
TracerPid:      0
Uid:    0       0       0       0
Gid:    0       0       0       0
FDSize: 256
Groups:
NStgid: 1
NSpid:  1
NSpgid: 1
NSsid:  1
VmPeak:   251112 kB
VmSize:   185788 kB
VmLck:         0 kB
VmPin:         0 kB
VmHWM:      6452 kB
VmRSS:      4912 kB
VmData:   149540 kB
VmStk:       136 kB
VmExe:      1392 kB
```

```
1475 struct task_struct {
1483         volatile long state;    /* -1 unrunnable, 0 runnable, >0 stopped */
1484         void *stack;
1485         atomic_t usage;
1486         unsigned int flags;     /* per process flags, defined below */
1487         unsigned int ptrace;
1488
1489 #ifdef CONFIG_SMP
1490         struct llist_node wake_entry;
1491         int on_cpu;
1492 #ifdef CONFIG_THREAD_INFO_IN_TASK
1493         unsigned int cpu;       /* current CPU */
1494 #endif
1495         unsigned int wakee_flips;
1496         unsigned long wakee_flip_decay_ts;
1497         struct task_struct *last_wakee;
1498
1499         int wake_cpu;
1500 #endif
1501         int on_rq;
1502
1503         int prio, static_prio, normal_prio;
1504         unsigned int rt_priority;
1505         const struct sched_class *sched_class;
1506         struct sched_entity se;
```

/sys

- /proc is for process-related things
- /sys is for the whole system
- So why cpuinfo etc are in /proc?
  - Like everything else in Linux : it's a mess
- /sys/module : Modules parameters
- /sys/bus : Access devices per-bus

```
student $ ls /sys/bus/usb/devices
1-0:1.0  1-1.3     1-1.6:1.0  2-1     2-1.6.1     2-1.6.1:1.1  usb1  usb4
1-1      1-1.3:1.0  1-1.6:1.1  2-1:1.0  2-1.6:1.0   3-0:1.0      usb2
1-1:1.0  1-1.6     2-0:1.0    2-1.6   2-1.6.1:1.0  4-0:1.0      usb3
```

Terminal

What's behind sys and proc?

- They are "fake" (virtual) file systems
- When read is called, it finds some handlers registered by kernel parts, eg :
  - "hey I'm a usb device handler, call fnt_usb_read() when a read is made on usb/deviceXXX/status"
- So at the end, it relies on the *open*/*read* **system calls**

What's behind network configuration

- Set IP address
  - Manual
    - Set the IP
      - ifconfig eth0 IP netmask MASK
      - ip addr add IP/CIDR dev eth0
    - Set the DNS
      - vi /etc/resolv.conf
  - dhcp
    - dhclient eth0

Nearly just a syscall wrapper

Some userspace parts

Does not directly involves the kernel

System call example : set eth0 ip address

int socket(int domain, int type, int protocol);
→ Creates a socket
→ Return a File Descriptor (FD). man 2 socket for more informations

int ioctl(unsigned int fd, unsigned int cmd, unsigned long arg);
→ Call some command with some arguments on a file descriptor (here, we pass the socket fd)

Filesystem

- Create partitions
  - fdisk /dev/sda
  - gparted /dev/sda
- Format partitions
  - mkfs.ext4 /dev/sda1
- Mount partition
  - mount /dev/sda1 /mnt/disk
- Unmount partition
  - umount /mnt/disk

Nearly just a syscall wrapper

Some userspace parts

Does not directly involves the kernel

Practical Course

Part 2

Google ❤

https://goo.gl/qdE3jS

Project 2 (08/03 23h59)

- You will add a "sys" built-in to your shell
  - sys hostname → Gives the hostname without using a system call
  - sys cpu model→ Gives the CPU model
  - sys cpu freq N → Gives the CPU number N frequency
  - sys cpu freq N X -> Set the frequency of the CPU N to X (in HZ)
    - Prints nothing
  - sys ip addr DEV -> Get the ip and mask of the interface DEV
    - a.b.c.d e.f.g.h
  - sys ip addr DEV IP MASK -> Set the ip of the interface DEV to IP/MASK
- Built-in must return error code like real software
- Support variables along with $? and $! replacement

Project 2 advices

- You are (or should be) good programmers
  - No copy-pasting, use functions !
  - Pay attention to style and indentation
  - Be clean and efficient
  - Don't forget previous courses
  - C → beware of memory leaks !

- Project will have different importance, though P1 and P2 are of equivalent importance (next projects won't)