



```
#include <stdlib.h>
#include <string.h>
#include <ctype.h>

#define MAXPAROLA 30
#define MAXRIGA 80

int main(int argc, char *argv[])
{
    int freq[MAXPAROLA]; /* vettore di contatori
delle frequenze delle lunghezze delle parole */
    char riga[MAXRIGA];
    int i, inizio, lunghezza;
    FILE *f;

    for(i=0; i<MAXPAROLA; i++)
        freq[i]=0;

    if(argc != 2)
    {
        printf(stderr, "ERRORE, serve un parametro con il nome del file\n");
        exit(1);
    }
    f = fopen(argv[1], "r");
    if(f==NULL)
    {
        printf(stderr, "ERRORE, impossibile aprire il file %s\n", argv[1]);
        exit(1);
    }

    while( fgets( riga, MAXRIGA, f ) != NULL )
```

UNIX/Linux Environment

UNIX & Linux commands (Part A)

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Linux installation

- ❖ Many possibilities exist to setup a UNIX-like (Linux) environment
 - For detailed information search on the WWW the most common Linux versions
 - For example, <https://ubuntu.com/>
 - or the various keywords listed below

- ❖ Main keywords
 - Cygwin, Linux LIVE, multi-boot, Virtual Machine, Windows Linux Subsystem

Linux installation

❖ Cygwin

- Free software (GNU Open Source) originally developed by Cygnus Solutions in 1995
 - Simulates the terminal of Unix-like OSs in Microsoft Windows OSs
 - Allows the porting of POSIX-Linux applications (not all) on Microsoft Windows systems
- Installation
 - Download from <https://www.cygwin.com/> the installation file "setup.exe", and execute it.
 - In this way a minimal version of GNU packets is installed in Microsoft Windows.
- For other information visit <https://www.cygwin.com/> or search "cygwin"

Linux installation

❖ Linux LIVE version

- Practically any modern Linux distribution provides a "LIVE" modality, i.e., the possibility to execute the whole OS without the installation requirement
 - Features are reduced
 - Generally it is not possible to save the system configuration, as every bootstrap is executed from the original state
- In practice Linux is executed from a CD, or (better) a USB-key containing ".iso" and/or other files
- Search "Linux LIVE versions"

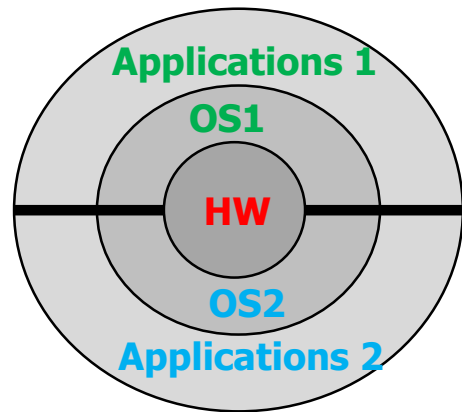
Linux installation

❖ Linux in a Multi-boot partition

- A disk can be partitioned, and each partition can contain a different OS
- Complex operation and potentially dangerous
- During the boot phase, a boot loader
 - GRUP (now **GRUB2**) in GNU Linux
 - NTLDR for Windows NT

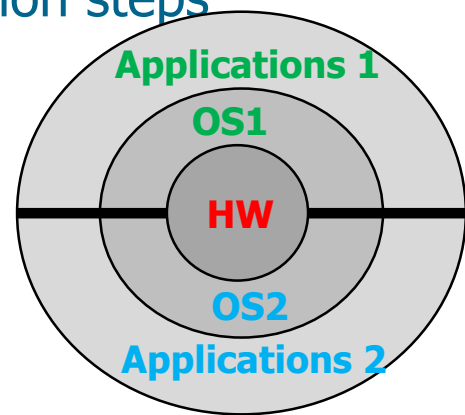
allows to decide with OS to use to bootstrap

- Search "GRUB" or "GRUB2"



Linux installation

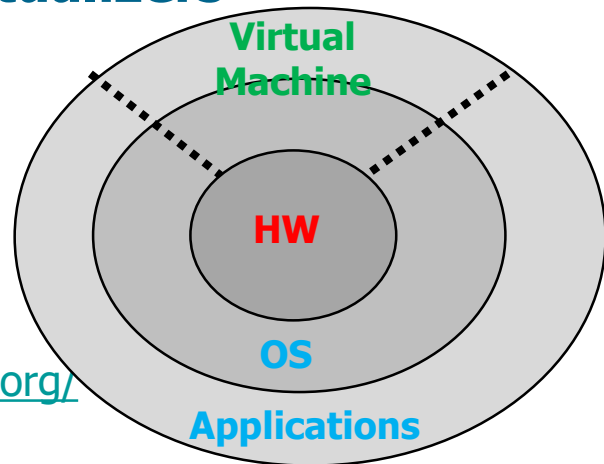
- ❖ Linux in a Multi-boot partition
 - Practically all "Linux LIVE" version provides the possibility to install permanently the Linux distribution in the harddisk
 - In this case the bootloader (i.e., GRUB or GRUB2) is automatically installed in the PC
 - without any need to configure it
 - You have just to follow the installation steps



Linux installation

❖ Linux inside a Virtual Machine

- There are some applications that allow hardware emulation
- These applications are called **virtualizers**
- The most important
 - Virtualbox
 - For AMD64 and Intel64
 - Available for Windows, Linux, MAC OS X, Solaris
 - WWW: <https://www.virtualbox.org/>
 - WMWare
 - Qemu
 - Virtual Machine Microsoft
 - Virsh (CentOS)



Linux installation

- ❖ A virtual machine creates the illusion of the availability of multiple personal computers, each with its own processor and memory
- ❖ Attention
 - Verify that the PC/laptop allows virtualization
 - It can be checked in the bios
 - With VirtualBox, after installing Linux, it is recommended to install the "Guest Addition"
 - Search: "VirtualBox"

Linux installation

- ❖ Windows Subsystem for Linux (WSL)
- ❖ Originally named “bash on Ubuntu on Windows” or “LXSS, Linux Windows Subsystem”
- ❖ This is not virtualization, because Microsoft has implemented a subsystem which exhibits the same Application Programming Interface (API) of a Linux kernel
- ❖ It is likely more efficient and requires less resources than virtualization
- ❖ Requirements:
 - **Windows 10**
 - From Windows 10 1607 Anniversary Update (i.e., from 2016)
 - 64 bit version

Linux installation

❖ Windows Subsystem for Linux (WSL)

➤ Installation procedure

- Follow the following or others installation guides
- <https://docs.microsoft.com/it-it/windows/wsl/install-win10>
- The missing software must be explicitly installed, e.g., for Ubuntu you can use:
 - `sudo apt install <packageName>`

➤ Search: "WLS on Windows 10"

Which linux?

❖ Mint or Ubuntu

- Ubuntu in Nguni Bantu language means "humanity" or "I am because we are"
- A new version released each 6 months
- A new LTS (Long Term Support) version released each 24 months (supported for 5 years)
 - 2010 10.04 LTS Lucid Lynx
 - 2012 12.04 LTS Precise Pangolin
 - 2014 14.04 LTS Trusty Tahr
 - 2016 16.04 LTS Xenial Xerus
 - 2018 18.04 LTS Bionic Beaver

Updates from April, with different subversion (e.g., 18.04.1, ...)

GNU GPL (General Public Library) license

❖ Session opening

- login: <username>
- password: <password>

Linux is case sensitive

❖ Remote connection

- ssh <username@hostname> (command line interface; -X option for redirect graphical content)
- ssh -X <username@hostname> (for the redirection of graphical content)
- putty (graphical interface)

both use a secure encrypted connection protocol

❖ Session termination

- exit
- logout
- ctrl-d

Help manual

❖ All commands are documented in manual pages

- `man <command>`

➤ Related commands

- `apropos <command>`
- `whatis <command >`
- `whereis <command >`

➤ Many commands allow the help option

- `command --help`
and the "version" option
- `command --version`

e.g.,
`man ln`
`man wc`
...

Commands

❖ Unix-like command syntax

`command [options] [arguments]`

- ❖ The name of the command is associated to the action performed
- ❖ The options (optional, 0 or more) have conventionally two formats
 - The character '-' followed by only another character
 - `-ch1 -ch2 ...`
 - The two characters "--" followed by a string
 - `--str1 --str2 ...`
- ❖ Arguments are optional

Or also
`-ch1 ch2 ch3`

Commands

❖ Available

- Automatic command completion (Tab)
- Up-down arrows for retrieving previously submitted commands

❖ Command parsing

- Long commands can be continued on the next line using ' \ ' as the last character of the current line
- Two or more commands can be given on the same line, separated by ' ; '
 - `command1 ; command2 ; ...`
 - Commands on the same line are executed **sequentially**

Filenames

❖ A filename can include any character sequence

- Filenames are case-sensitive
- Typically include
 - Letters, digits, points '.', underscores '_'
- Some characters should not be used

Space / \ " ' * ; ? [] () ~ ! \$ { } < > #
@ & |

- The character '\' is reserved as a separator (for directories in paths)

Filenames

- Formally a file has not extension and version
- Some meaningful extension are often used
 - `.c`, `.cpp`, `.sh`, `.o`, `.a`, `.so`, `.awk`, `.tar`,
`.gz`, `.tgz`, `a.out`, `core`
- ❖ A filename beginning by `.'` corresponds to an **hidden** file, i.e., a file that is not normally visible listing the content of a directory
- ❖ The length of a name is often limited to 255 characters
- ❖ A name must be unique within a directory
- ❖ Obsolete files (for example those created by autosave) are often automatically renamed by postponing the character `~` to the name

- ❖ The Linux filesystem is
 - Hierarchic
 - Organized by means of tree directories
 - The root tree directory is ' / ' (slash)
 - The current directory is indicated by ' . ' (dot)
 - The parent directory is indicated by ' . . ' (dot dot)
 - Directories are separated by means of a ' / ' (slash)
 - Uniform notation (disks, directories, files, special files, ...)

- ❖ A file is specified by its pathname
 - Absolute pathname
 - From the filesystem root
 - `/dir1/dir2/file`
 - Relative pathname
 - From the current working directory
 - `./subdir1/subdir2/file`
 - `subdir1/subdir2/file`

Regular file management: ls

- ❖ Command **ls** provides information about a file according to the specified options. If pathname is a directory, **ls** lists the files and subdirectories contained in that directory (i.e., the 'entries' of a directory)

```
ls [-options] [file ...]
```

➤ Options

- --help
 - in-line help
- --all, -a
 - Shows also hidden files (filenames beginning with '.')
- -l
 - Long list format (extended output)

Regular file management: ls

- `--group-directories-first, -g`
 - Included group info before those related to files
- `-t`
 - Sort files by date (newest first)
- `--reverse, -r`
 - Reverse order (alphabetic/date)
- `--recursive, -R`
 - Recursive (includes files in subdirectories)

Example

List of type
"long-list-format"
for "all-files"

```
$ ls -la
total 72
drwxr-xr-x  8 user1 group1 4096  Oct  7  2013 .
drwxr-xr-x 34 user1 group1 4096  Oct  3  12:37 ..
drwxr-xr-x  2 user1 group1 4096  Oct 15  2009 file
-rw-r--r--  1 user1 group1 17715 Oct  7  2013 index.htm
drwxr-xr-x  2 user1 group1 4096  Mar 22  2013 misc
drwxr-xr-x  2 user1 group1 4096  Jun 25  2009 paper
drwxr-xr-x  3 user1 group1 4096  May 30  2012 research
-rw-r--r--  1 user1 group1 18074 Apr 28  2005 stq.jpg
drwxr-xr-x 10 user1 group1 4096  Jun  5  14:56 teaching
drwxr-xr-x  2 user1 group1 4096  Jun  2  20:49 tmp
```

The "ls" command would
provide only the list of
files in the directory

Example

Total Number of Blocks
(default size 1024 bytes)

User (owner)
name

Owner
group

Entry name

```

$ ls -la
total 72
drwxr-xr-x  8 user1 group1 4096  Oct  7  2013 .
drwxr-xr-x 34 user1 group1 4096  Oct  3 12:37 ..
drwxr-xr-x  2 user1 group1 4096  Oct 15  2009 file
-rw-r--r--  1 user1 group1 17715 Oct  7  2013 index.htm
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drwxr-xr-x  2 user1 group1 4096  Jun  2 20:49 tmp

```

Type &
permissions

Number of links

Size (in byte)

Last modification
date

Example

File type

- Normal file
- d Directory
- s Socket file
- l Link file

Three users types

- u user (owner)
- g group
- o others other users

```

...
-rw-r--r-- 1 user1 group1 17715 Oct 7 2013 index.htm
drwxr-xr-x 2 user1 group1 4096 Mar 22 2013 misc
...

```

Three base permissions

- r read
- w write
- x execute

Example

Permission can be defined as an octal value

rwX rwX rwX	→	777
rw- rw- rw-	→	666
rwX --X ---	→	710

```
...  
-rw-r--r--  1 user1 group 17715 Oct  7  2013 index.htm  
drwxr-xr-x  2 user1 group 14096 Mar 22  2013 misc  
...
```

Alternatively by means of

- a letter: u(ser), g(roup), o(ther), a(ll)
- a symbol: +, -, = (add, subtract, untouched)
- a character: r, w, x (read, write, execute)

(see chmod command)

Regular file management

❖ Copy a file

- `cp [options] src1 src2 ... dest`
- Example
 - `cp file1 file2 file3 ... dir`

❖ Remove a file

- `rm [options] file1 file2 ...`

❖ Move (rename) a file

- `mv [options] file1 file2 ... dest`

Regular file management

❖ Options

- --help
 - in-line help
- --force, -f
 - does not ask confirmation (force)
- --interactive, -i
 - ask confirmation for each file (interactive)
- --recursive, -r, -R
 - Apply command recursively on all the subdirectory files

rm over objects
without write
rights requires
confirmation

❖ Directories can often be managed as regular files

Directory management

- ❖ Change current directory
 - `cd dir`
- ❖ Print working directory
 - `pwd`
- ❖ Create a directory
 - `mkdir dir`
- ❖ Remove a directory
 - `rmdir dir`
 - A directory can be removed only if it is empty, unless the options `-rf` are used with command
 - `rm -rf dir`

Permissions for directories

- ❖ The meaning of the permission "rwx" is different between files and directories

➤ File

- r
 - Read permission (of the file)
- W
 - Write permission (of the content of the file)
- X
 - Execution permission (the file can be executed)

`cp file1 file2`
fails if file1 has not read
permissions or if file2 has not
write permissions

Permissions for directories

❖ The meaning of the permission characters is different for directories.

➤ Directory

- r
 - Directory content can be listed
- w
 - Create, rename, or delete files within the directory
- x
 - Directory can be crossed or **cd** command can be performed (to access it, not to list)

cd dir
fails if dir has not
execution permissions

Permission management

- ❖ It is possible to change file permissions if you have the rights, i.e., if you are the owner of the file
- ❖ There are commands to change personal generalities (i.e., the user) of files on a UNIX system
 - To become a different user
 - `su username`
 - The password of the new user is requested
 - To run commands as a superuser (or other user)
 - `sudo command`
 - The password of the root user is required
 - To know which user you are
 - `whoami`

The super-user do the command:
`sudo -u user command`

Permission management

- ❖ It is possible to change file permissions
 - `chmod [options] permissions file`
- ❖ Permissions can be specified in different ways
 - Absolute, by means of three octal digits
 - `chmod 775 filename`
 - Symbolic, by means of a string of three (or more) characters
 - `chmod g+r filename`
 - `chmod +x filename`
 - `chmod +xw filename`
 - `chmod uo+rx filename`

u (user)		r		+
g (group)	→	w	→	-
o (other)		x		=
a (all)				

`uo+rx`: Add (+) to user (u) and other (o) the read (r) and execute (x) permissions

Permission management

- ❖ Changing the owner of a directory entry
 - `chown [options] user entry`
- ❖ Changing the group of a directory entry
 - `chgrp [options] group entry`
- ❖ These command can be combined
 - `chown [options] user[:group] entry`
 - `chown [options] uid[:gid] entry`
- Options
 - `--recursive, -R`
 - Performed recursively on all entries of the directory tree

Output the content of a file

❖ Output and concatenate files

- `cat filename1 filename2 ...`

❖ Output the first **num** lines of a file

- `head [options] filename ...`

Default num=10

❖ Output the last **num** lines of a file

- `tail [options] filename ...`

`tail -n 2 file`
prints the last two lines of file
Compact version: `tail -2 file`

➤ Options

- `--lines num, -n num`
 - print first (head) / last (tail) num lines
- `--follow, -f`
 - outputs appended data as the file grows (i.e., the file is continuously re-read)

Output the content of a file

❖ Additional output commands

- `pg [options] filename ...`
 - "browse page-wise through text file"
- `more [options] filename ...`
 - to view a text file
- `less [options] filename ...`
 - Like the previous command but allows the use of arrows to move in the text (advanced version of more)

Output the content of a file

- Some commands when a file is opened with less or more commands
 - space Next page
 - return Next line
 - b Previous page
 - /str Find next occurrence of string str
 - ?str Find previous occurrence of string str
 - q Quit

File comparison

- ❖ Difference between two files
 - `diff [options] file1 file2`
 - Lists the line number of the lines
 - a
 - added
 - d
 - deleted
 - c
 - changed
- ❖ Difference between two directories
 - `diff [options] dir1 dir2`

File comparison

➤ Options

- `--brief, -q`
 - Reports only when files differ (default)
- `--ignore-space-change, -b`
 - Ignores spaces at the end of the line, merges the others
- `--ignore-case, -i`
 - Case insensitive
- `--ignore-all-space, -w`
 - Ignores completely all white spaces
- `--ignore-blank-lines, -B`
 - Ignores all blank lines

❖ Outputs the number of lines, words, and bytes of a file

- `wc [options] [file...]`

➤ Options

- `--lines, -l`
 - Outputs only the number of lines
- `--words, -w`
 - Outputs only the number of words
- `--bytes, -c`
 - Outputs only the number of bytes
- `--chars, -m`
 - Outputs only the number of characters
 - Option typically not used

Warning: it also outputs the filename as its first line

Hard and Soft Link

❖ There are two types of links in UNIX

➤ Symbolic or soft link

- Particular type of file that simply contains a path (i.e., the name) of another object (file or directory)
- Allows references between different file-systems (partitions)
- If you remove the file the link remains pending

➤ Physical or hard link

- Association between an object name and its content (pointer from directory-entry to i-node)
- It is not possible to create hard links between different file-systems, or hard links to a directory
- The file is removed only when it is removed the last of its hard links

Hard and Symbolic Links

❖ Link creation

- In [options] source [destination]

➤ Default behavior

- Creates a hard link
- If the destination is not present, creates a link with the same filename on the working directory

Hard and Symbolic Links

➤ Options

- --help
 - in-line help
- --symbolic, -s
 - Creates a symbolic link (soft link)
- --force, -f
 - Force creation, removes file if already exist
- --directory, -f, -F
 - allow the superuser to attempt to create a hard link to a directories (note: will probably fail due to system restrictions, even for the superuser)

Hard and Symbolic Links

➤ Examples

- `ln source alias`
- `ln /home/scanzio/file`
 - Corresponds to `ln /home/scanzio/file .`
- `ln -s /home/foo/tmp/bar.exe /mnt/foo/bin/`

Symbolic link, possibly to a file in another filesystem

❖ Notice that

➤ Command **rm**

- Removes the data of a file only if its link number is equal to 0

➤ Command **mv**

- Performed as the sequence of commands **ln** followed by **rm**