UNIX/LINUX Operating System

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The contribution to the content of these slides of current and previous colleagues is warmly acknowledged.

Lab texts and resources in

http://fmgroup.polito.it/loiacono/teaching/os/teaching.htm

Program

- Introduction to Linux
- Main commands
- **`vi`**: a text editor
- **`bash`**: Shell command interpreter
- Tools and command
- Shell scripts
- System administration

Setting a Linux OS for Windows users

- Download **`cygwin (Linux environments in Windows)`**
- Download a Linux distribution (**`iso`** file)
  - **`http://www.ubuntu.com/desktop/get-ubuntu/download`**
  - Use the **`iso`** file to create a bootable CD or USB pen drive

Alternatives

- Run and use Ubuntu from CD or pen drive
- Install in a new partition
- Install in a virtual machine (Virtualbox, VMware, Qemu)

Session

- Session begin:
  `login:`
  `Password:`
- End of session:
  `CTRL-d` `exit` `logout`

Unix is case sensitive

Connection to a System: Virtual Terminal

- Through TCP/IP:
  - `telnet <hostname>`
  - `ssh [-l <username>] <hostname>`

Main characteristics

- Multiuser:
  - username
  - uid
  - gid
  - Password

Privileged or superuser "root"

- Multitask:

  Try the command: `ps -aux`

UNIX Commands

- Syntax of UNIX commands
  `command [-options] [arguments]`
- Commands can be continued on the next line using "\" as last character of the line
- The sequential operator ";" allows several commands to be given on the same line

  `command1 ; command2 ; ...`
  will be executed in the given order

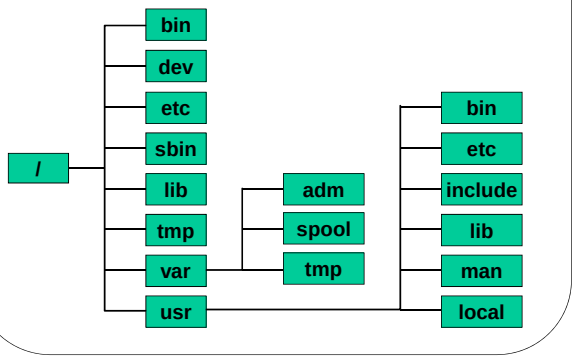
Online Help

- Unix commands are documented on line
  - `man <command>`
  - `apropos <term>`
  - `whatis <command>`
  - `<command> --help`
- Some systems offer graphical (xman) or hypertextual presentations
- `info`
- `/usr/doc/…`

UNIX File System

- Characteristics :
  - Hierarchical (parent-child relation)
  - Directory organization
  - Uniformity of notation (disks, directory, file, terminals)
  - no extension or version
  - *hard link* (same file with different names)
  - *soft link* (a file that is an indirect link to another file)
  - protection

File System Hierarchy



File System Hierarchy

- For every directory
- Its (other) name is `"."` (dot)
- Its parent directory is `".."` (dot dot)

File Names

- A file name can be composed of a string of characters
- UNIX does not manage directly file extensions and versions
- It's a good practice to give "standard" extensions such as:

```
.c .f .p .o .a .so a.out core
```

- A file name beginning by `"."` is a hidden file because it is not normally listed

`ls –a` lists all the files in the current directory, including the hidden ones

File Names (cont.)

- Since the following characters have special meaning for the command interpreter, it is not wise to use them in file names

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

- The space character can be used, (but be careful, it need be "escaped")
- A file is identified by means of its
  - absolute pathname: `/dir1/dir2/file`
  - relative pathname: `subdir1/subdir2/file`

Files: Classification

- Only one physical file type:
  - byte stream (sequence of bytes)
- Four logical file types:
  - Regular file: text files, executable files, etc…
  - Directory: associates names to data blocks
  - Link: a pointer to another file
  - Special file: entry point for an I/O device

File Access Protection

- Access modes or permissions
- Three main controls:
  - read (r) read permission
  - write (w) write permission
  - execute (x) execute permission
- Three user categories:
  - user (u) owner
  - group (g) group
  - others (o) others

File Management

- `ls [-altrRdi] [file1 file2 …]`
  - List the content of the arguments or of the current directory
- `cp [-fir] src1 src2 ... dest`
  - Copies one or more files (possibly in a directory)
- `rm [-fir] file1 file2 …`
  - Delete the list of files
- `mv [-fi] file1 file2 ... dest`
  - rename (move) one or more file, (possibly in a directory)

File Management

- Options:
  - -f forced
  - -i asks confirmation for every file
  - -r operates recursively on all the subdirectories files

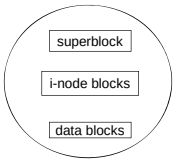
Directory management

- `cd <dir>`
  - Changes the current working directory to `<dir>`
- `pwd`
  - Prints the current working directory
- `mkdir <dir>`
  - Creates a new directory
- `rmdir <dir>`
  - Removes the directory `<dir>` (`<dir>` must be empty)

Links

- `ln source alias`
  - Creates a hard link
  - hard link: a name (in a directory) that points to a file descriptor called i-node
- `ln -s source alias`
  - Creates a soft link
  - soft link (symbolic link): a special file that contains the name of another file

Disk partition with a file system



- The superblock describes the characteristics of the file system
- An i-node is the file descriptor that allows the association of the file name (listed in a directory file) to its actual data (stored in data blocks)
- The data blocks of a file are accessed through some fields of its i-node

I-node Example

```
Owner:                  laface
Group:                  laface
Type:                   regular file
Permission mask:        rwxr-xr-x
Link-number             1
Accessed:               October 3 2004   h: 8:15
Modified:               October 3 2004   h: 10:30
I-node:                 October 4 2004   h: 13:30
Dimension:              3050 bytes
Block data addresses    (13 pointers)
```

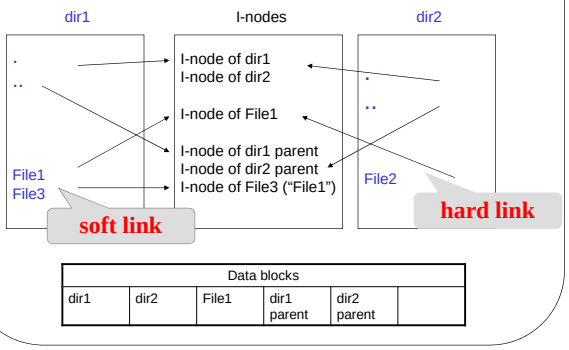
Directory Example

This command list all files in the current directory

```
ls -lai
```

```
I-node  Perms     link# owner group  bytes   date       name
109967 drwxr-xr-x  7   laface laface 4096 Jan  3 20:36 ./
109966 drwxr-xr-x  4   laface laface 4096 Aug  3 21:38 ../
736913 lrwxrwxrwx  1   laface laface   90 Jan  3 20:36 pap -> pippo
480699 -rw-r--r--  2   laface laface    6 Sep 27 17:56 pep
480699 -rw-r--r--  2   laface laface    6 Sep 27 17:56 pippo
480700 drwxr-xr-x  2   laface laface 4096 Sep 27 17:57 pluto/
```


Directory, I-node, File Name, and Links



Links

Hard links

- It is not possible to create hard links to files belonging to a different file system
- A file is deleted only when all its hard links have been removed

Special Modes

- Two special modes (for executable files):
  - setuid (s) : this file is run with the privileges of root (root PID)
  - setgid (S) : this file is run with the privileges of root group (root GID)

Directory Modes

- The permissions for directories have a special meaning
  - x allows crossing the directory
  - r allows reading the directory
  - w allows the creation and the deletion of files

Mode Change

- To change the permission mask of a list of files

```
chmod [-R] permission file1 file2 ….
```

- The permissions can be specified by means of symbols or using a three (four) digit octal number

```
system   user     group     others
4 2 1   4 2 1     4 2 1     4 2 1
s S t   r w x     r w x     r w x
```

Mode Change

- Permissions specified by symbols
  - A three characters string
  - `u(ser), g(roup), o(ther), a(ll)`
    `+, -, =`
    `s, S, t, r, w, x`

Example:
- `chmod 777 filename`

Standard Permissions

- `umask`
  - Shows the protection mask (octal number)
    - **the permissions that are denied** when a file is created

  Example:
  If umask is 022 and a file has been created with mode 666, its protection mask will be `666 & ~022 = 644`

```
  022 = 000010010
  666 = 110110110 &
~022 = 111101101
       110100100
```

- `umask mask`
  - Defines the protection mask

Owner Change

- Changes the group identifier of the files:
  `chgrp [-R] group file1 file2 …`
- Changes the owner (possibly the group) of the files
  `chown [-R] user[:group] file1 file2`
- Option `-R` applies recursively the change on all the subdirectory files

ls Command

- Output a list of files and their properties

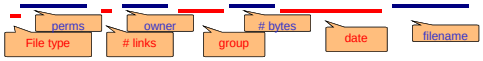
  ls [-options] [file ...]

- Options:

-a: (all)	shows hidden files ("." files)
-l: (long)	output using extended format
-t: (time)	lists the files ordered by date
-r: (reverse)	reverse order (alphabetic / temporal)
-R: (recursive)	lists the files in all the subdirectories

ls - Example

```
# ls -al ~/tmp
total 84
drwx------  6 laface staff    512 Sep  1 16:14 .
drwxr-xr-x 19 laface staff   1024 Sep  6 09:06 ..
-rw-r--r--  1 laface staff   1240 Jan 21  1992 AA.readme
drwxr-x---  2 laface staff    512 May 22 14:08 examples
-rw-------  1 laface staff   2416 Jun 30 15:24 gendata.c
-rw-------  1 laface staff    332 Jun 18 15:29 local.c
drwxr-xr-x  2 laface staff    512 May 22 14:08 man
-rw-r-----  1 laface staff  27930 Mar 12 23:19 new.tex
-rw-------  1 laface staff  28077 Mar 12 22:52 numer.tex
-rw-r-----  1 laface staff     70 Jun  2 18:00 pro.tex
-rw-r-----  1 laface staff   1364 May  6 14:20 random.c
-rw-r-----  1 laface staff     62 May  6 14:21 random.h
drwx------  2 laface staff    512 May 25 14:36 testprof
```



Output of a file content

- By means of an editor
  - **vi, gvim, emacs, …**
- **cat file1 file2 …**
  - Concatenates the argument files and send their content to the standard output
- **head [-n] file …**
  - Shows the first **n** lines, example:

    head -5 test.dat

Output of a file content

- **`tail [-n] [+n] [-rf] file …`**
  - Shows:
    - **`-n`** the last **`n`** lines
    - **`+n`** every line except the first **`n`** lines
    - **`-r`** shows the file lines in reverse order
    - **`-f`** continuously re-read the file

Pagers

- **`more file ...`**
- **`less file ...`**
- **`pg file ...`**

Pagers

- Commands:
  - **`space`** next page
  - **`enter`** next line
  - **`b`** previous page
  - **`/pattern`** next page including pattern
  - **`?pattern`** previous page including pattern
  - **`q`** end pager

Disk statistics

- **`df [partition ...]`**
  - Gives information about the partitions blocks (used or available)
- **`du [-as] directory…`**
  - Shows the number of blocks used by a directory and all its subdirectories
  - **`-a`** blocks used by each file
  - **`-s`** summary only

File search

- **`find directory expression`**
  - Visits the **`directory`** tree and performs the action that make true the **`expression`**
- Example:
  - **`find /users -name core`**

File compare

- **`cmp file1 file2`**
  - Shows the byte and the line where the files are different
- **`diff [-options] file1 file2`**
  - Shows the lines that are different, (a) added, (d) deleted, or (c) changed
- **`diff [-options] dir1 dir2`**
  - The comparison is performed between the couple of files with the same name in the two directories

File compare

- Options:
  - `-b` ignores spaces at the end of the line, collapses the others
  - `-i` ignores upper/lower case difference
  - `-w` ignores the spacing characters