The Unix and GNU/Linux command line

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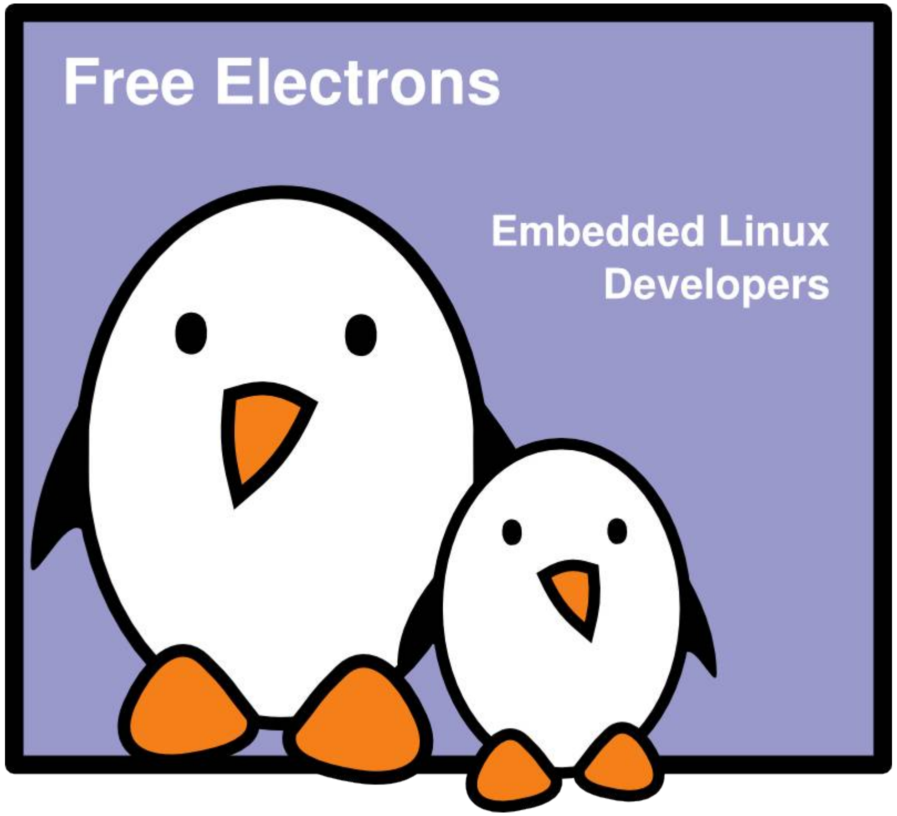


Command memento sheet

It is a useful companion to this presentation.

Examples for the most useful commands are given in just one sheet.

Suggestions for use

Stick this sheet on your wall, use it as desktop wallpaper, make it a mouse mat, print it on clothing, slice it into bookmarks...

Caution

Store away from mice!

Get it on
http://free-electrons.com/docs/command-line

Training Contents (1)

Shells, filesystem and file handling

- Everything is a file
- GNU / Linux filesystem structure
- Command line interpreters
- Handling files and directories
- Displaying, scanning and sorting files
- Symbolic and hard link
- File access rights

Training contents (2)

Standard I/O, redirections, pipes

- Standard input and output, redirecting to files
- Pipes: redirecting standard output to other commands
- Standard error

Training Contents (3)

Task control

- Full control on tasks
- Executing in background, suspending, resuming and aborting
- List of active tasks
- Killing processes
- Environment variables
- PATH environment variables
- Shell aliases, .bashrc file

Training contents (4)

Miscellaneous

- Text editors
- Compressing and archiving
- Printing files
- Comparing files and directories
- Looking for files
- Getting information about users

Unix filesystem

Everything is a file

Almost everything in Unix is a file!

- Regular files
- Directories
  Directories are just files listing a set of files
- Symbolic links
  Files referring to the name of another file
- Devices and peripherals
  Read and write from devices as with regular files
- Pipes
  Used to cascade programs
  `cat *.log | grep error`
- Sockets
  Inter process communication

File names

File name features since the beginning of Unix

- Case sensitive
- No obvious length limit
- Can contain any character (including whitespace, except `/`). File types stored in the file ("magic numbers"). File name extensions not needed and not interpreted. Just used for user convenience.
- File name examples:

```
README      .bashrc      Windows Buglist
index.htm   index.html   index.html.old
```

File paths

A *path* is a sequence of nested directories with a file or directory at the end, separated by the `/` character

- Relative path: `documents/fun/microsoft_jokes.html`
  Relative to the current directory
- Absolute path:
  `/home/bill/bugs/crash9402031614568`
- `/` : *root directory*.
  Start of absolute paths for all files on the system (even for files on removable devices or network shared).

GNU / Linux filesystem structure (1)

Not imposed by the system. Can vary from one system to the other, even between two GNU/Linux installations!

`/`	Root directory
`/bin/`	Basic, essential system commands
`/boot/`	Kernel images, initrd and configuration files
`/dev/`	Files representing devices
	`/dev/hda`: first IDE hard disk
`/etc/`	System configuration files
`/home/`	User directories
`/lib/`	Basic system shared libraries

GNU / Linux filesystem structure (2)

`/lost+found`	Corrupt files the system tried to recover
`/media`	Mount points for removable media: `/media/usbdisk`, `/media/cdrom`
`/mnt/`	Mount points for temporarily mounted
filesystems	
`/opt/`	Specific tools installed by the sysadmin `/usr/local/` often used instead
`/proc/`	Access to system information `/proc/cpuinfo`, `/proc/version` ...
`/root/`	root user home directory
`/sbin/`	Administrator-only commands
`/sys/`	System and device controls (cpu frequency, device power, etc.)

GNU / Linux filesystem structure (3)

`/tmp/`	Temporary files
`/usr/`	Regular user tools (not essential to the system) `/usr/bin/`, `/usr/lib/`, `/usr/sbin`...
`/usr/local/`	Specific software installed by the sysadmin (often preferred to `/opt/`)
`/var/`	Data used by the system or system servers `/var/log/`, `/var/spool/mail` (incoming mail), `/var/spool/lpd` (print jobs)...

The Unix filesystem structure is defined
by the Filesystem Hierarchy Standard (FHS):
http://www.pathname.com/fhs/

The Unix and GNU / Linux command line

Shells and file handling

Command line interpreters

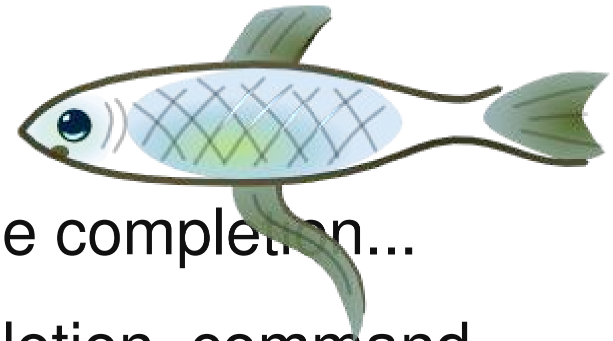
- Shells: tools to execute user commands
- Called “shells” because they hide the details on the underlying operating system under the shell's surface.
- Commands are input in a text terminal, either a window in a graphical environment or a text-only console.
- Results are also displayed on the terminal. No graphics are needed at all.
- Shells can be scripted: provide all the resources to write complex programs (variable, conditionals, iterations...)

Well known shells

Most famous and popular shells

- `sh`: The Bourne shell (obsolete)
  Traditional, basic shell found on Unix systems, by Steve Bourne.
- `csh`: The C shell (obsolete)
  Once popular shell with a C-like syntax
- `tcsh`: The TC shell (still very popular)
  A C shell compatible implementation with evolved features (command completion, history editing and more...)
- `bash`: The Bourne Again shell (most popular)
  An improved implementation of sh with lots of added features too.

fish: a great new shell



The Friendly Interactive SHell
http://www.fishshell.org/

- Standard features: history, command and file completion...
- Brand new features: command option completion, command completion with short description, syntax highlighting..
- Easier to any open files: `open` built-in command.
- Much simpler and consistent syntax (not POSIX compliant)
  Makes it easier to create shell scripts.

Command line beginners can learn much faster!
Even experienced users should find this shell very convenient.

ls command

Lists the files in the current directory, in alphanumeric order, except files starting with the "`.`" character.

- `ls -a` (all)
  Lists all the files (including `.*` files)
- `ls -l` (long)
  Long listing (type, date, size, owner, permissions)
- `ls -t` (time)
  Lists the most recent files first
- `ls -S` (size)
  Lists the biggest files first
- `ls -r` (reverse)
  Reverses the sort order
- `ls -ltr` (options can be combined)
  Long listing, most recent files at the end

File name pattern substitutions

Better introduced by examples!

- `ls *txt`
  The shell first replaces `*txt` by all the file and directory names ending by `txt` (including `.txt`), except those starting with `.`, and then executes the `ls` command line.
- `ls -d .*`
  Lists all the files and directories starting with `.`
  `-d` tells `ls` not to display the contents of directories.
- `cat ?.log`
  Displays all the files which names start by 1 character and end by `.log`

Special directories (1)

`./`

- The current directory. Useful for commands taking a directory argument. Also sometimes useful to run commands in the current directory (see later).
- So `./readme.txt` and `readme.txt` are equivalent.

`../`

- The parent (enclosing) directory. Always belongs to the `.` directory (see `ls -a`). Only reference to the parent directory.
- Typical usage:
  `cd ..`

Special directories (2)

`~/`

- Not a special directory indeed. Shells just substitute it by the home directory of the current user.
- Cannot be used in most programs, as it is not a real directory.

`~sydney/`

- Similarly, substituted by shells by the home directory of the `sydney` user.

The cd and pwd commands

- `cd <dir>`
  Changes the current directory to `<dir>`.
- `cd -`
  Gets back to the previous current directory.
- `pwd`
  Displays the current directory ("working directory").

The cp command

- `cp <source_file> <target_file>`
  Copies the source file to the target.
- `cp file1 file2 file3 ... dir`
  Copies the files to the target directory (last argument).
- `cp -i` (interactive)
  Asks for user confirmation if the target file already exists
- `cp -r <source_dir> <target_dir>` (recursive)
  Copies the whole directory.

mv and rm commands

- `mv <old_name> <new_name>` (move)
  Renames the given file or directory.
- `mv -i` (interactive)
  If the new file already exits, asks for user confirm
- `rm file1 file2 file3 ...` (remove)
  Removes the given files.
- `rm -i` (interactive)
  Always ask for user confirm.
- `rm -r dir1 dir2 dir3` (recursive)
  Removes the given directories with all their contents.

Creating and removing directories

- `mkdir dir1 dir2 dir3 ...` (make dir)
  Creates directories with the given names.
- `rmdir dir1 dir2 dir3 ...` (remove dir)
  Removes the given directories
  Safe: only works when directories and empty.
  Alternative: `rm -r` (doesn't need empty directories).

Displaying file contents

Several ways of displaying the contents of files.

- `cat file1 file2 file3 ...` (concatenate)
  Concatenates and outputs the contents of the given files.
- `more file1 file2 file3 ...`
  After each page, asks the user to hit a key to continue.
  Can also jump to the first occurrence of a keyword
  (`/` command).
- `less file1 file2 file3 ...`
  Does more than `more` with less.
  Doesn't read the whole file before starting.
  Supports backward movement in the file (`?` command).

The head and tail commands

- `head [-<n>] <file>`
  Displays the first <n> lines (or 10 by default) of the given file.
  Doesn't have to open the whole file to do this!
- `tail [-<n>] <file>`
  Displays the last <n> lines (or 10 by default) of the given file.
  No need to load the whole file in RAM! Very useful for huge files.
- `tail -f <file>` (follow)
  Displays the last 10 lines of the given file and continues to display new lines when they are appended to the file.
  Very useful to follow the changes in a log file, for example.
- Examples

```
head windows_bugs.txt
tail -f outlook_vulnerabilities.txt
```

The grep command

- `grep <pattern> <files>`
  Scans the given files and displays the lines which match the given pattern.
- `grep error *.log`
  Displays all the lines containing `error` in the `*.log` files
- `grep -i error *.log`
  Same, but case insensitive
- `grep -ri error .`
  Same, but recursively in all the files in `.` and its subdirectories
- `grep -v info *.log`
  Outputs all the lines in the files except those containing `info`.

The sort command

- `sort <file>`
  Sorts the lines in the given file in character order and outputs them.
- `sort -r <file>`
  Same, but in reverse order.
- `sort -ru <file>`
  `u`: unique. Same, but just outputs identical lines once.
- More possibilities described later!

The sed command

- `sed` is a `S`tream `ED`itor
- It parses text files and implements a programming language to apply transformations on the text.
- One of the most common usage of sed is text replacement, which relies on regular expressions
  - `sed -e 's/abc/def/' testfile` will replace every string “abc” by “def” in the file testfile and display the result on the standard output.
  - `sed 's/^[ \t]*//' testfile` will remove any tabulation or space at the beginning of a line
  - `sed 's/^|\([^|]*\)|\([^|]*\)|$/\1 -> \2/' testfile`
    replace lines like `|string1|string2|`
    by `string1 -> string2`

sed : regular expressions

- Regular expressions are useful in many Unix tools, not only sed. They allow to match the input text against an expression.
  - `.` matches any character
  - `[ ]` matches any character listed inside the brackets
  - `[^ ]` matches any character not listed inside the brackets
  - `^` matches the beginning of the line
  - `$` matches the end of the line
  - `*` matches the previous element zero or more times, + matches the previous element one or more times, ? matches the previous element zero or one time
  - `\( \)` defines a sub-expression that can be later recalled by using \n, where n is the number of the sub-expression in the regular expression
  - More at http://www.regular-expressions.info/

Symbolic links

A symbolic link is a special file which is just a reference to the name of another one (file or directory):

- Useful to reduce disk usage and complexity when 2 files have the same content.
- Example:
  `anakin_skywalker_biography -> darth_vador_biography`
- How to identify symbolic links:
  - `ls -l` displays -> and the linked file name.
  - GNU `ls` displays links with a different color.

Creating symbolic links

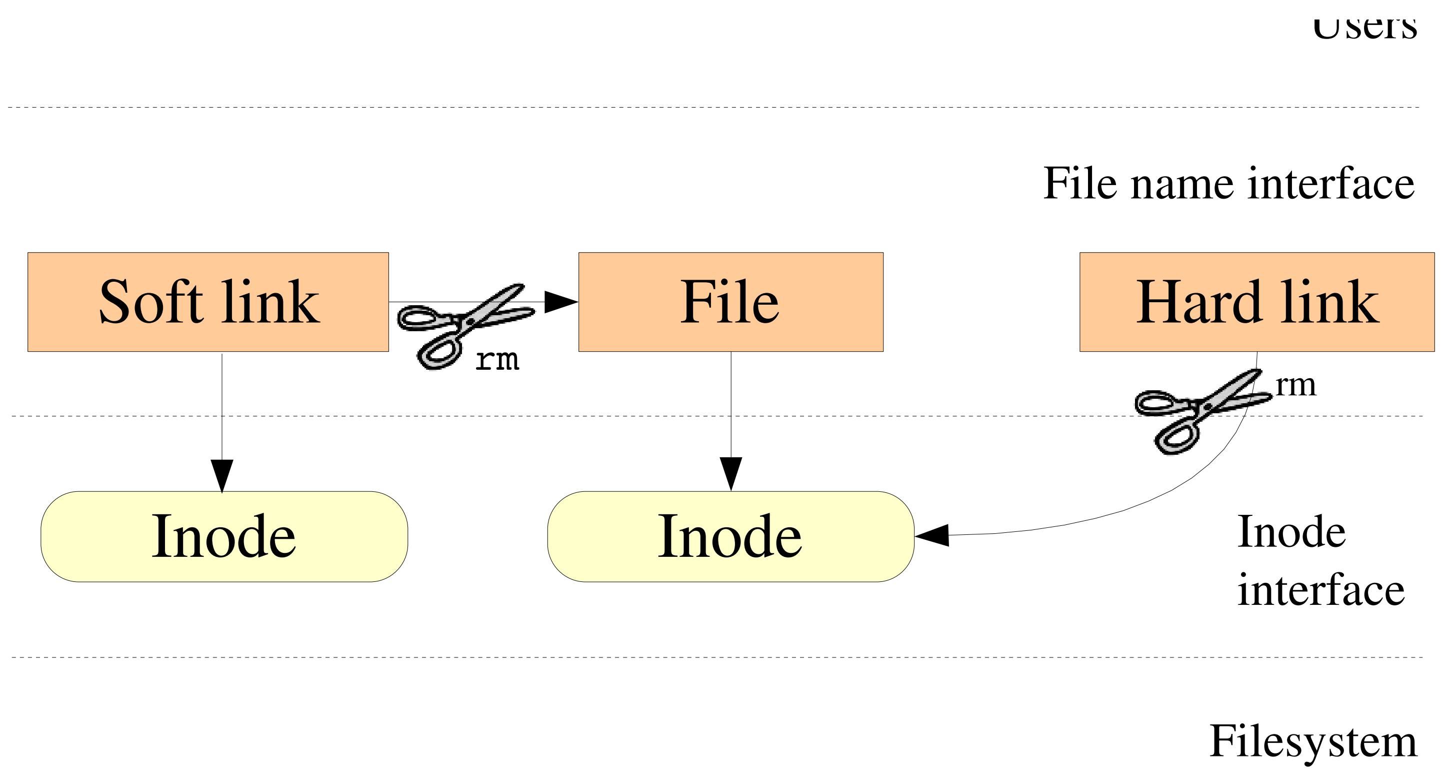
- To create a symbolic link (same order as in `cp`):
  ```
  ln -s file_name link_name
  ```
- To create a link with to a file in another directory, with the same name:
  ```
  ln -s ../README.txt
  ```
- To create multiple links at once in a given directory:
  ```
  ln -s file1 file2 file3 ... dir
  ```
- To remove a link:
  ```
  rm link_name
  ```
  Of course, this doesn't remove the linked file!

Hard links

- The default behavior for `ln` is to create *hard links*
- A *hard link* to a file is a regular file with exactly the same physical contents
- While they still save space, hard links can't be distinguished from the original files.
- If you remove the original file, there is no impact on the hard link contents.
- The contents are removed when there are no more files (hard links) to them.

Files names and inodes

Makes hard and symbolic (soft) links easier to understand!



Command documentation

Command help

Some Unix commands and most GNU / Linux commands offer at least one help argument:

- `-h`
  (`-` is mostly used to introduce 1-character options)
- `--help`
  (`--` is always used to introduce the corresponding “long” option name, which makes scripts easier to understand)

You also often get a short summary of options when you input an invalid argument.

Manual pages

`man <keyword>`
Displays one or several manual pages for `<keyword>`

- `man man`

Most available manual pages are about Unix commands, but some are also about C functions, headers or data structures, or even about system configuration files!

- `man stdio.h`
- `man fstab` (for `/etc/fstab`)

Manual page files are looked for in the directories specified by the `MANPATH` environment variable.

Info pages

- In GNU, man pages are being replaced by info pages. Some manual pages even tell to refer to info pages instead.

```
info <command>
```

- `info` features:
  - Documentation structured in sections (“nodes”) and subsections (“subnodes”)
  - Possibility to navigate in this structure: top, next, prev, up
  - Info pages generated from the same texinfo source as the HTML documentation pages

Searching the Internet for resources (2)

Looking for documentation

- Look for `<tool>` or `<tool> page` to find the tool or project home page and then find the latest documentation resources.
- Look for `<tool> documentation` or `<tool> manual` in your favorite search engine.

Looking for generic technical information

- WikiPedia: http://wikipedia.org
  Lots of useful definitions in computer science. A real encyclopedia! Open to anyone's contributions.

Searching the Internet for resources (1)

Investigating issues

- Most forums and mailing list archives are public, and are indexed on a very frequent basis by Google.
- If you investigate an error message, copy it verbatim in the search form, enclosed in double quotes (“error message”). Lots of chances that somebody else already faced the same issue.
- Don't forget to use Google Groups:
  http://groups.google.com/
  This site indexes more than 20 years of newsgroups messages.

Users and permissions

File access rights

Use `ls -l` to check file access rights

3 types of access rights

- Read access (`r`)
- Write access (`w`)
- Execute rights (`x`)

3 types of access levels

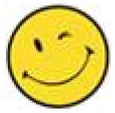
- User (`u`): for the owner of the file
- Group (`g`): each file also has a “group” attribute, corresponding to a given list of users
- Others (`o`): for all other users

Access right constraints

- `x` is sufficient to execute binaries
  Both `x` and `r` and required for shell scripts.
- Both `r` and `x` permissions needed in practice for directories:
  `r` to list the contents, `x` to access the contents.
- You can't rename, remove, copy files in a directory if you don't have `w` access to this directory.
- If you have `w` access to a directory, you CAN remove a file even if you don't have write access to this file (remember that a directory is just a file describing a list of files). This even lets you modify (remove + recreate) a file even without `w` access to it.

Access rights examples

- `-rw-r--r--`
  Readable and writable for file owner, only readable for others
- `-rw-r-----`
  Readable and writable for file owner, only readable for users belonging to the file group.
- `drwx------`
  Directory only accessible by its owner
- `-------r-x`
  File executable by others but neither by your friends nor by yourself. Nice protections for a trap...



chmod: changing permissions

- `chmod <permissions> <files>`
  2 formats for permissions:
- Octal format (abc):
  `a,b,c = r*4+w*2+x` (`r`, `w`, `x`: booleans)
  Example: `chmod 644 <file>`
  (`rw` for `u`, `r` for `g` and `o`)
- Or symbolic format. Easy to understand by examples:
  `chmod go+r`: add read permissions to group and others.
  `chmod u-w`: remove write permissions from user.
  `chmod a-x`: (`a`: all) remove execute permission from all.

More chmod (1)

```
chmod -R a+rX linux/
```

Makes `linux` and everything in it available to everyone!

- `R`: apply changes recursively
- `X`: `x`, but only for directories and files already executable
  Very useful to open recursive access to directories, without adding execution rights to all files.

More chmod (2)

`chmod a+t /tmp`

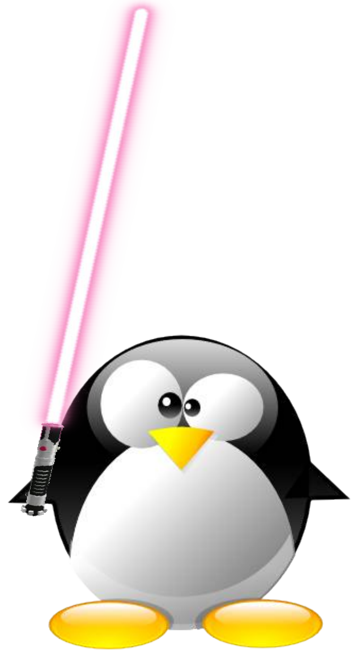
- `t`: (sticky). Special permission for directories, allowing only the directory and file owner to delete a file in a directory.
- Useful for directories with write access to anyone, like `/tmp`.
- Displayed by `ls -l` with a `t` character.

File ownership

Particularly useful in (embedded) system development when you create files for another system.

- `chown -R sco /home/linux/src` (`-R`: recursive)
  Makes user `sco` the new owner of all the files in `/home/linux/src`.
- `chgrp -R empire /home/askywalker`
  Makes `empire` the new group of everything in `/home/askywalker`.
- `chown -R borg:aliens usss_entreprise/`
  `chown` can be used to change the owner and group at the same time.

Beware of the dark side of root



- `root` user privileges are only needed for very specific tasks with security risks: mounting, creating device files, loading drivers, starting networking, changing file ownership, package upgrades...
- Even if you have the `root` password, your regular account should be sufficient for 99.9 % of your tasks (unless you are a system administrator).
- In a training session, it is acceptable to use `root`. In real life, you may not even have access to this account, or put your systems and data at risk if you do.

Using the root account

In case you really want to use `root`...

- If you have the `root` password:
  `su -` (**s**witch **u**ser)
- In modern distributions, the `sudo` command gives you access to some `root` privileges with your own user password.
  Example: `sudo mount /dev/hda4 /home`

Standard I/O, redirections, pipes

Standard output

More about command output

- All the commands outputting text on your terminal do it by writing to their *standard output*.
- Standard output can be written (redirected) to a file using the > symbol
- Standard output can be appended to an existing file using the >> symbol

Standard output redirection examples

- `ls ~saddam/* > ~gwb/weapons_mass_destruction.txt`

-
  ```
  cat obiwan_kenobi.txt > starwars_biographies.txt
  cat han_solo.txt >> starwars_biographies.txt
  ```
- `echo “README: No such file or directory” > README`
  Useful way of creating a file without a text editor.
  Nice Unix joke too in this case.

Standard input

More about command input

- Lots of commands, when not given input arguments, can take their input from *standard input*.

-
  ```
  sort
  windows
  linux
  [Ctrl][D]
  linux
  windows
  ```
  `sort` takes its input from the standard input: in this case, what you type in the terminal (ended by `[Ctrl][D]`)
- `sort < participants.txt`
  The standard input of sort is taken from the given file.

Pipes

- Unix pipes are very useful to redirect the standard output of a command to the standard input of another one.
- Examples
  - `cat *.log | grep -i error | sort`
  - `grep -ri error . | grep -v “ignored” | sort -u \`
    `> serious_errors.log`
  - `cat /home/*/homework.txt | grep mark | more`
- This one of the most powerful features in Unix shells!

The tee command

```
tee [-a] file
```

- The `tee` command can be used to send standard output to the screen and to a file simultaneously.
- `make | tee build.log`
  Runs the `make` command and stores its output to `build.log`.
- `make install | tee -a build.log`
  Runs the `make install` command and appends its output to `build.log`.

Standard error

- Error messages are usually output (if the program is well written) to *standard error* instead of standard output.
- Standard error can be redirected through `2>` or `2>>`
- Example:
  `cat f1 f2 nofile > newfile 2> errfile`
- Note: `1` is the descriptor for standard output, so `1>` is equivalent to `>`.
- Can redirect both standard output and standard error to the same file using `&>` :
  `cat f1 f2 nofile &> wholefile`

The yes command

Useful to fill standard input with always the same string.

- `yes <string> | <command>`
  Keeps filling the standard input of `<command>` with `<string>` (`y` by default).
- Examples

```
yes | rm -r dir/
bank> yes no | credit_applicant
yes "" | make oldconfig
```

  (equivalent to hitting `[Enter]` to accept all default settings)

Special devices (1)

Device files with a special behavior or contents

- `/dev/null`
  The data sink! Discards all data written to this file.
  Useful to get rid of unwanted output, typically log information:
  `mplayer black_adder_4th.avi &> /dev/null`
- `/dev/zero`
  Reads from this file always return `\0` characters
  Useful to create a file filled with zeros:
  `dd if=/dev/zero of=disk.img bs=1k count=2048`

See `man null` or `man zero` for details

Special devices (2)

- `/dev/random`
  Returns random bytes when read. Mainly used by cryptographic programs. Uses interrupts from some device drivers as sources of true randomness (“entropy”).
  Reads can be blocked until enough entropy is gathered.
- `/dev/urandom`
  For programs for which pseudo random numbers are fine.
  Always generates random bytes, even if not enough entropy is available (in which case it is possible, though still difficult, to predict future byte sequences from past ones).

See `man random` for details.

Special devices (3)

- `/dev/full`
  Mimics a full device.
  Useful to check that your application properly handles this kind of situation.

See `man full` for details.

Task control

Full control on tasks

- Since the beginning, Unix supports true preemptive multitasking.
- Ability to run many tasks in parallel, and abort them even if they corrupt their own state and data.
- Ability to choose which programs you run.
- Ability to choose which input your programs takes, and where their output goes.

Processes

“Everything in Unix is a file
Everything in Unix that is not a file is a process”

<u>Processes</u>

- Instances of a running programs
- Several instances of the same program can run at the same time
- Data associated to processes:
  Open files, allocated memory, stack, process id, parent, priority, state...

Running jobs in background

Same usage throughout all the shells

- Useful
  - For command line jobs which output can be examined later, especially for time consuming ones.
  - To start graphical applications from the command line and then continue with the mouse.
- Starting a task: add `&` at the end of your line:

```
find_prince_charming --cute --clever --rich &
```

Background job control

- `jobs`
  Returns the list of background jobs from the same shell

```
[1]-  Running ~/bin/find_meaning_of_life --without-god &
[2]+  Running make mistakes &
```

- `fg`
  `fg %<n>`
  Puts the last / nth background job in foreground mode
- Moving the current task in background mode:
  `[Ctrl] Z`
  `bg`
- `kill %<n>`
  Aborts the nth job.

Job control example

```
> jobs
[1]-  Running ~/bin/find_meaning_of_life --without-god &
[2]+  Running make mistakes &

> fg
make mistakes

> [Ctrl] Z
[2]+  Stopped make mistakes

> bg
[2]+ make mistakes &

> kill %1
[1]+  Terminated ~/bin/find_meaning_of_life --without-god
```

Listing all processes

... whatever shell, script or process they are started from

- `ps -ux`
  Lists all the processes belonging to the current user
- `ps -aux` (Note: `ps -edf` on System V systems)
  Lists all the processes running on the system
-

```
ps -aux | grep bart | grep bash
USER       PID %CPU %MEM   VSZ  RSS TTY      STAT START   TIME COMMAND
bart      3039  0.0  0.2  5916 1380 pts/2    S    14:35   0:00 /bin/bash
bart      3134  0.0  0.2  5388 1380 pts/3    S    14:36   0:00 /bin/bash
bart      3190  0.0  0.2  6368 1360 pts/4    S    14:37   0:00 /bin/bash
bart      3416  0.0  0.0     0    0 pts/2    RW   15:07   0:00 [bash]
```

-

PID:	Process id
VSZ:	Virtual process size (code + data + stack)
RSS:	Process resident size: number of KB currently in RAM
TTY:	Terminal
STAT:	Status: R (Runnable), S (Sleep), W (paging), Z (Zombie)...

Live process activity

- `top` – Displays most important processes, sorted by cpu percentage

```
top - 15:44:33 up  1:11,  5 users,  load average: 0.98, 0.61, 0.59
Tasks:  81 total,   5 running,  76 sleeping,   0 stopped,   0 zombie
Cpu(s): 92.7% us,  5.3% sy,  0.0% ni,  0.0% id,  1.7% wa,  0.3% hi,  0.0% si
Mem:    515344k total,   512384k used,     2960k free,    20464k buffers
Swap:  1044184k total,        0k used,  1044184k free,   277660k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
3809 jdoe      25   0  6256 3932 1312 R 93.8  0.8   0:21.49 bunzip2
2769 root      16   0  157m  80m  90m R  2.7 16.0   5:21.01 X
3006 jdoe      15   0 30928  15m  27m S  0.3  3.0   0:22.40 kdeinit
3008 jdoe      16   0  5624  892 4468 S  0.3  0.2   0:06.59 autorun
3034 jdoe      15   0 26764  12m  24m S  0.3  2.5   0:12.68 kscd
3810 jdoe      16   0  2892  916 1620 R  0.3  0.2   0:00.06 top
```

- You can change the sorting order by typing
  `M`: Memory usage, `P`: %CPU, `T`: Time.
- You can kill a task by typing `k` and the process id.

Killing processes (1)

- `kill <pids>`
  Sends an abort signal to the given processes. Lets processes save data and exit by themselves. Should be used first. Example:
  `kill 3039 3134 3190 3416`
- `kill -9 <pids>`
  Sends an immediate termination signal. The system itself terminates the processes. Useful when a process is really stuck (doesn't answer to `kill -1`).
- `kill -9 -1`
  Kills all the processes of the current user. `-1`: means all processes.

Killing processes (2)

- `killall [-<signal>] <command>`
  Kills all the jobs running `<command>`. Example:
  `killall bash`
- `xkill`
  Lets you kill a graphical application by clicking on it!
  Very quick! Convenient when you don't know the application command name.

Recovering from stuck graphics

- If your graphical session is stuck and you can no longer type in your terminals, don't reboot!
- It is very likely that your system is still fine. Try to access a text console by pressing the `[Ctrl][Alt][F1]` keys (or `[F2]`,`[F3]` for more text consoles)
- In the text console, you can try to kill the guilty application.
- Once this is done, you can go back to the graphic session by pressing `[Ctrl][Alt][F5]` or `[Ctrl][Alt][F7]` (depending on your distribution)
- If you can't identify the stuck program, you can also kill all your processes: `kill -9 -1`
  You are then brought back to the login screen.

Sequential commands

- Can type the next command in your terminal even when the current one is not over.
- Can separate commands with the `;` symbol:

```
echo “I love thee”; sleep 10;  echo “ not”
```

- Conditionals: use `||` (or) or `&&` (and):

```
more God || echo “Sorry, God doesn't exist”
```

Runs `echo` only if the first command fails

```
ls ~sd6 && cat ~sd6/* > ~sydney/recipes.txt
```

Only cats the directory contents if the `ls` command succeeds (means read access).

Quoting (1)

Double (") quotes can be used to prevent the shell from interpreting spaces as argument separators, as well as to prevent file name pattern expansion.

```
> echo "Hello World"
  Hello World

> echo "You are logged as $USER"
  You are logged as bgates

> echo *.log
  find_prince_charming.log cosmetic_buys.log

> echo "*.log"
  *.log
```

Quoting (2)

Single quotes bring a similar functionality, but what is between quotes is never substituted

```
> echo 'You are logged as $USER'
  You are logged as $USER
```

Back quotes (\`) can be used to call a command within another

```
> cd /lib/modules/`uname -r`; pwd
  /lib/modules/2.6.9-1.6_FC2
```

Back quotes can be used within double quotes

```
> echo "You are using Linux `uname -r`"
  You are using Linux 2.6.9-1.6_FC2
```

Measuring elapsed time

- `time find_expensive_housing --near`

```
<...command output...>
real     0m2.304s  (actual elapsed time)
user     0m0.449s  (CPU time running program code)
sys      0m0.106s  (CPU time running system calls)
```

real = user + sys + *waiting*

waiting = I/O waiting time + idle time (running other tasks)

Environment variables

- Shells let the user define *variables*.
  They can be reused in shell commands.
  Convention: lower case names
- You can also define *environment variables*:
  variables that are also visible within scripts or executables called from the shell.
  Convention: upper case names.
- `env`
  Lists all defined environment variables and their value.

Shell variables examples

Shell variables (bash)

- `projdir=/home/marshall/coolstuff`
  `ls -la $projdir; cd $projdir`

Environment variables (bash)

- `cd $HOME`
- `export DEBUG=1`
  `./find_extraterrestrial_life`
  (displays debug information if `DEBUG` is set)

Main standard environment variables

Used by lots of applications!

- `LD_LIBRARY_PATH`
  Shared library search path
- `DISPLAY`
  Screen id to display X (graphical) applications on.
- `EDITOR`
  Default editor (vi, emacs...)
- `HOME`
  Current user home directory
- `HOSTNAME`
  Name of the local machine
- `MANPATH`
  Manual page search path
- `PATH`
  Command search path
- `PRINTER`
  Default printer name
- `SHELL`
  Current shell name
- `TERM`
  Current terminal type
- `USER`
  Current user name

PATH environment variables

- `PATH`
  Specifies the shell search order for commands

```
/
home/acox/bin:/usr/local/bin:/usr/kerberos/bin:
/usr/bin:/bin:/usr/X11R6/bin:/bin:/usr/bin
```

- `LD_LIBRARY_PATH`
  Specifies the shared library (binary code libraries shared by applications, like the C library) search order for `ld`

```
/usr/local/lib:/usr/lib:/lib:/usr/X11R6/lib
```

- `MANPATH`
  Specifies the search order for manual pages

```
/usr/local/man:/usr/share/man
```

PATH usage warning

It is strongly recommended not to have the "`.`" directory in your `PATH` environment variable, in particular not at the beginning:

- A cracker could place a malicious `ls` file in your directories. It would get executed when you run `ls` in this directory and could do naughty things to your data.
- If you have an executable file called `test` in a directory, this will override the default `test` program and some scripts will stop working properly.
- Each time you `cd` to a new directory, the shell will waste time updating its list of available commands.

Call your local commands as follows: `./test`

Alias

Shells let you define command *aliases*: shortcuts for commands you use very frequently.

Examples

- `alias ls='ls -la'`
  Useful to always run commands with default arguments.
- `alias rm='rm -i'`
  Useful to make `rm` always ask for confirmation.
- `alias frd='find_rambaldi_device --asap --risky'`
  Useful to replace very long and frequent commands.
- `alias cia='. /home/sydney/env/cia.sh'`
  Useful to set an environment in a quick way
  (`.` is a shell command to execute the content of a shell script).

The which command

Before you run a command, `which` tells you where it is found

-
  ```
  bash> which ls
  alias ls='ls --color=tty'
          /bin/ls
  ```

-
  ```
  tcsh> which ls
  ls:      aliased to ls --color=tty
  ```

-
  ```
  bash> which alias
  /usr/bin/which: no alias in
  (/usr/local/bin:/usr/bin:/bin:/usr/X11R6/bin)
  ```

-
  ```
  tcsh> which alias
  alias: shell built-in command.
  ```

~/.bashrc file

- `~/.bashrc`
  Shell script read each time a `bash` shell is started
- You can use this file to define
  - Your default environment variables (`PATH`, `EDITOR`...).
  - Your aliases.
  - Your prompt (see the `bash` manual for details).
  - A greeting message.

Command editing

- You can use the left and right arrow keys to move the cursor in the current command.
- You can use `[Ctrl][a]` to go to the beginning of the line, and `[Ctrl][e]` to go to the end.
- You can use the up and down arrows to select earlier commands.
- You can use `[Ctrl][r]` to search inside the history of previous commands.

Command history (1)

- `history`
  Displays the latest commands that you ran and their number. You can copy and paste command strings.
- You can recall the latest command:
  `!!`
- You can recall a command by its number
  `!1003`
- You can recall the latest command matching a starting string:
  `!cat`

Command history (2)

- You can make substitutions on the latest command:
  `^more^less`
- You can run another command with the same arguments:
  `more !*`

Miscellaneous

Text editors

Text editors

Graphical text editors

Fine for most needs

- nedit
- Emacs, Xemacs
- Kate, Gedit

Text-only text editors

Often needed for sysadmins and great for power users

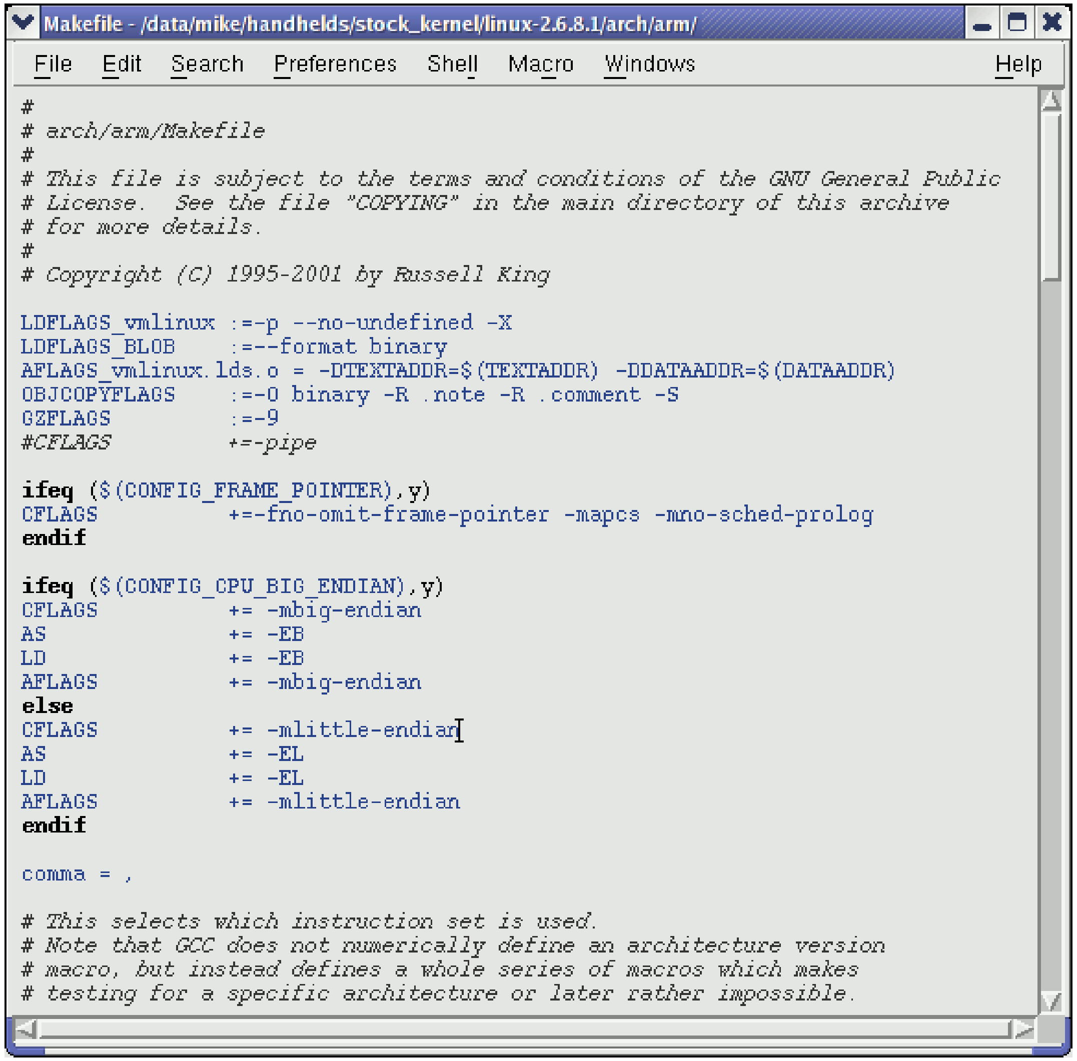
- vi, vim
- nano

The nedit text editor

http://www.nedit.org/

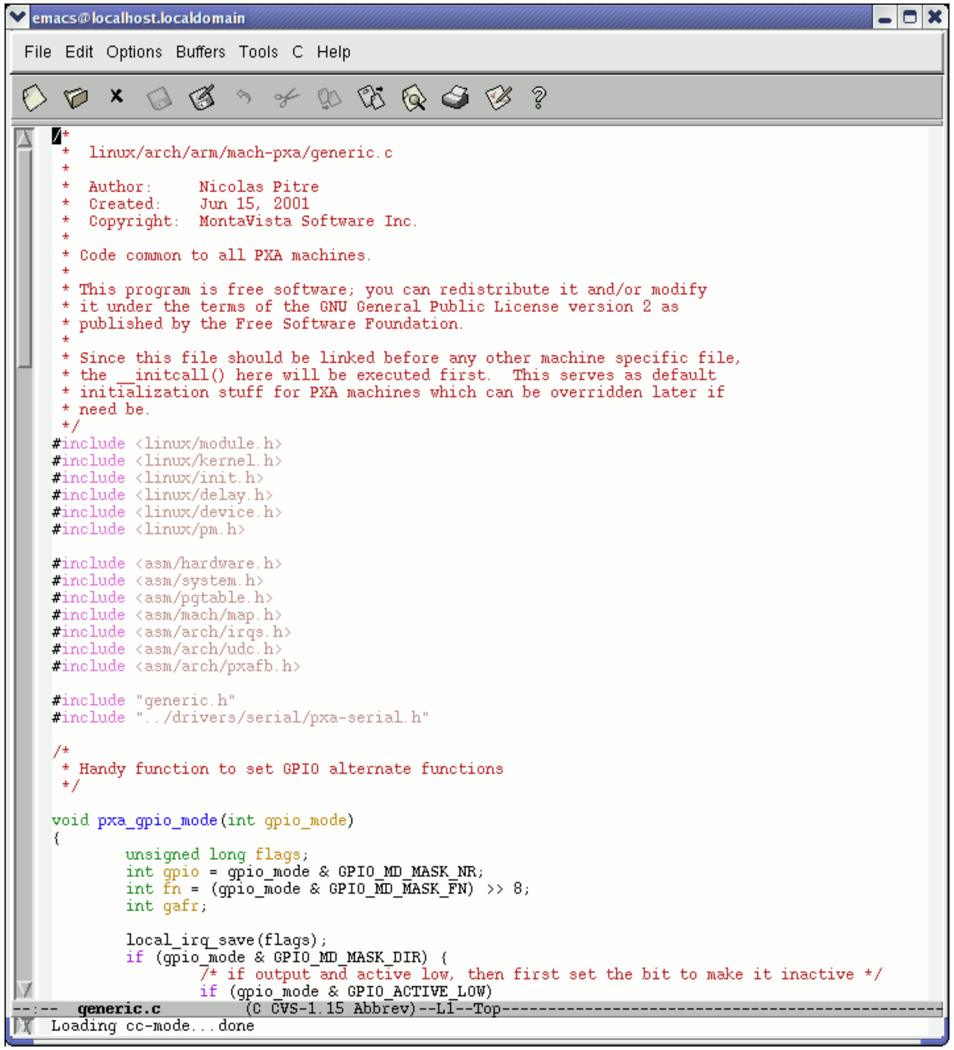
- Best text editor for non vi or emacs experts
- Feature highlights:
  - Very easy text selection and moving
  - Syntax highlighting for most languages and formats. Can be tailored for your own log files, to highlight particular errors and warnings.
  - Easy to customize through menus
- Not installed by default by all distributions

nedit screenshot


Makefile - /data/mike/handhelds/stock_kernel/linux-2.6.8.1/arch/arm/
File Edit Search Preferences Shell Macro Windows Help

```
#
# arch/arm/Makefile
#
# This file is subject to the terms and conditions of the GNU General Public
# License.  See the file "COPYING" in the main directory of this archive
# for more details.
#
# Copyright (C) 1995-2001 by Russell King

LDFLAGS_vmlinux :=-p --no-undefined -X
LDFLAGS_BLOB    :=--format binary
AFLAGS_vmlinux.lds.o = -DTEXTADDR=$(TEXTADDR) -DDATAADDR=$(DATAADDR)
OBJCOPYFLAGS    :=-O binary -R .note -R .comment -S
GZFLAGS         :=-9
#CFLAGS         +=-pipe

ifeq ($(CONFIG_FRAME_POINTER),y)
CFLAGS          +=-fno-omit-frame-pointer -mapcs -mno-sched-prolog
endif

ifeq ($(CONFIG_CPU_BIG_ENDIAN),y)
CFLAGS          += -mbig-endian
AS              += -EB
LD              += -EB
AFLAGS          += -mbig-endian
else
CFLAGS          += -mlittle-endian
AS              += -EL
LD              += -EL
AFLAGS          += -mlittle-endian
endif

comma = ,

# This selects which instruction set is used.
# Note that GCC does not numerically define an architecture version
# macro, but instead defines a whole series of macros which makes
# testing for a specific architecture or later rather impossible.
```

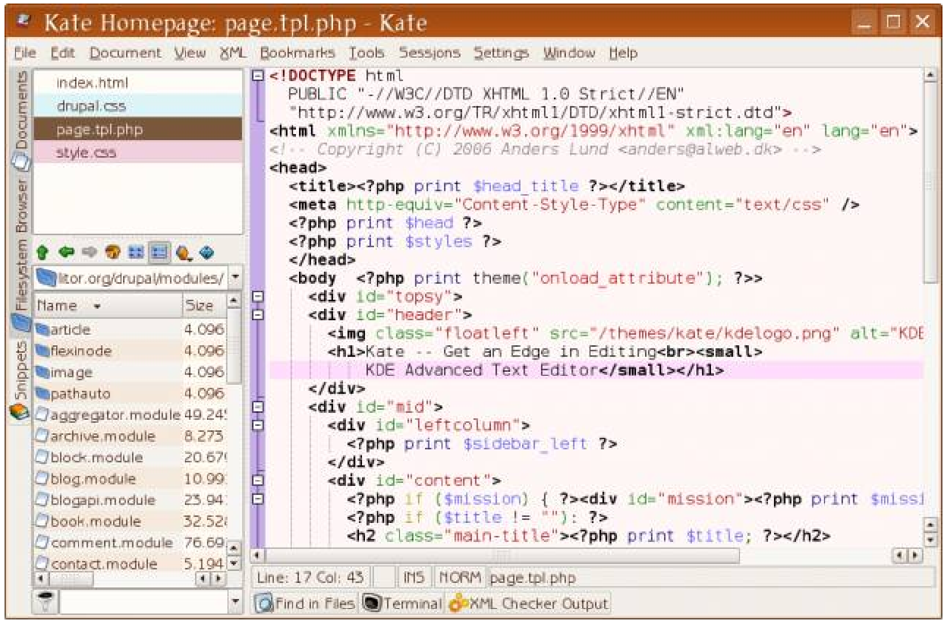
Emacs / Xemacs


emacs@localhost.localdomain
File Edit Options Buffers Tools C Help

```
/*
 *  linux/arch/arm/mach-pxa/generic.c
 *
 *  Author:     Nicolas Pitre
 *  Created:    Jun 15, 2001
 *  Copyright:  MontaVista Software Inc.
 *
 * Code common to all PXA machines.
 *
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License version 2 as
 * published by the Free Software Foundation.
 *
 * Since this file should be linked before any other machine specific file,
 * the __initcall() here will be executed first.  This serves as default
 * initialization stuff for PXA machines which can be overridden later if
 * need be.
 */
#include <linux/module.h>
#include <linux/kernel.h>
#include <linux/init.h>
#include <linux/delay.h>
#include <linux/device.h>
#include <linux/pm.h>

#include <asm/hardware.h>
#include <asm/system.h>
#include <asm/pgtable.h>
#include <asm/mach/map.h>
#include <asm/arch/irqs.h>
#include <asm/arch/udc.h>
#include <asm/arch/pxafb.h>

#include "generic.h"
#include "../drivers/serial/pxa-serial.h"

/*
 * Handy function to set GPIO alternate functions
 */

void pxa_gpio_mode(int gpio_mode)
{
        unsigned long flags;
        int gpio = gpio_mode & GPIO_MD_MASK_NR;
        int fn = (gpio_mode & GPIO_MD_MASK_FN) >> 8;
        int gafr;

        local_irq_save(flags);
        if (gpio_mode & GPIO_MD_MASK_DIR) {
                /* if output and active low, then first set the bit to make it inactive */
                if (gpio_mode & GPIO_ACTIVE_LOW)
--:--  generic.c         (C CVS-1.15 Abbrev)--L1--Top------------------------------------
Loading cc-mode...done
```

- Emacs and Xemacs are pretty similar (up to your preference)
- Extremely powerful text editor features
- Great for power users
- Less ergonomic than nedit
- Non standard shortcuts
- Much more than a text editor (games, e-mail, shell, browser).
- Some power commands have to be learnt.

Kate and gedit

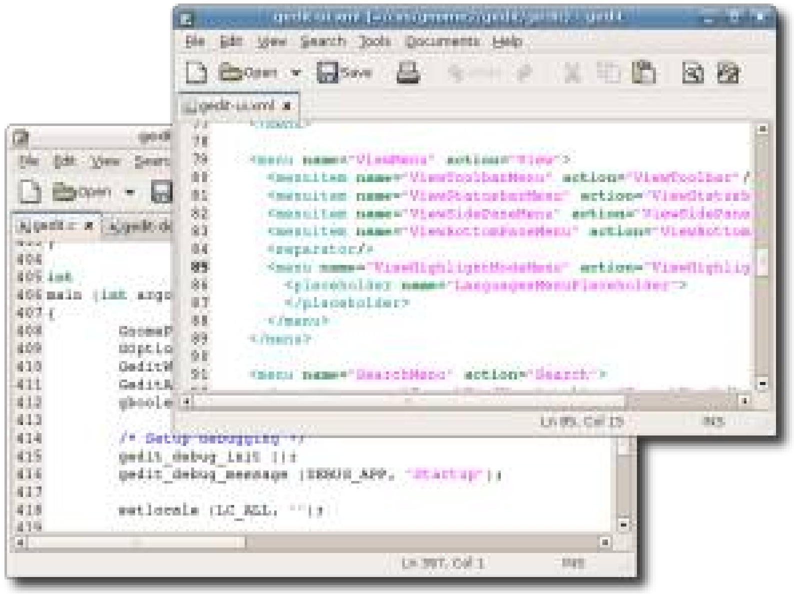


```
<!DOCTYPE html
  PUBLIC "-//W3C//DTD XHTML 1.0 Strict//EN"
  "http://www.w3.org/TR/xhtml1/DTD/xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml" xml:lang="en" lang="en">
<!-- Copyright (C) 2006 Anders Lund <anders@alweb.dk> -->
<head>
  <title><?php print $head_title ?></title>
  <meta http-equiv="Content-Style-Type" content="text/css" />
  <?php print $head ?>
  <?php print $styles ?>
  </head>
  <body  <?php print theme("onload_attribute"); ?>>
    <div id="topsy">
    <div id="header">
      <img class="floatleft" src="/themes/kate/kdelogo.png" alt="KDE
      <h1>Kate -- Get an Edge in Editing<br><small>
        KDE Advanced Text Editor</small></h1>
    </div>
    <div id="mid">
      <div id="leftcolumn">
        <?php print $sidebar_left ?>
      </div>
      <div id="content">
        <?php if ($mission) { ?><div id="mission"><?php print $missi
        <?php if ($title != ""): ?>
        <h2 class="main-title"><?php print $title; ?></h2>
```

Name	Size
article	4.096
flexinode	4.096
image	4.096
pathauto	4.096
aggregator.module	49.24
archive.module	8.273
block.module	20.67
blog.module	10.99
blogapi.module	25.94
book.module	32.52
comment.module	76.69
contact.module	5.194

```
Line: 17 Col: 43   INS  NORM  page.tpl.php
```

- Kate is a powerful text editor dedicated to programming activities, for KDE
  - http://kate.kde.org



```
  <menu name="ViewMenu" action="View">
    <menuitem name="ViewToolbarMenu" action="ViewToolbar"/
    <menuitem name="ViewStatusbarMenu" action="ViewStatusb
    <menuitem name="ViewSidePaneMenu" action="ViewSidePane
    <menuitem name="ViewBottomPaneMenu" action="ViewBottom
    <separator/>
    <menu name="ViewHighlightModeMenu" action="ViewHighlig
      <placeholder name="LanguagesMenuPlaceholder">
      </placeholder>
    </menu>
  </menu>

  <menu name="SearchMenu" action="Search">
```

```
int
main (int argc
{
        GnomeP
        GOptio
        GeditW
        GeditA
        gboole

        /* Setup debugging */
        gedit_debug_init ();
        gedit_debug_message (DEBUG_APP, "Startup");

        setlocale (LC_ALL, "");
```

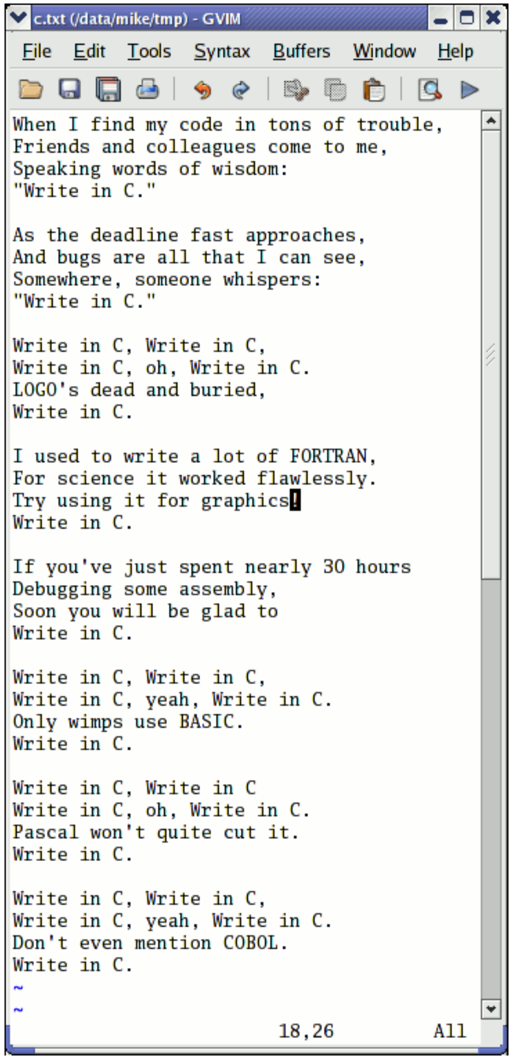
- Gedit is a text editor for the Gnome environment
  - http://projects.gnome.org/gedit/

vi

Text-mode text editor available in all Unix systems. Created before computers with mice appeared.

- Difficult to learn for beginners used to graphical text editors.
- Very productive for power users.
- Often can't be replaced to edit files in system administration or in Embedded Systems, when you just have a text console.

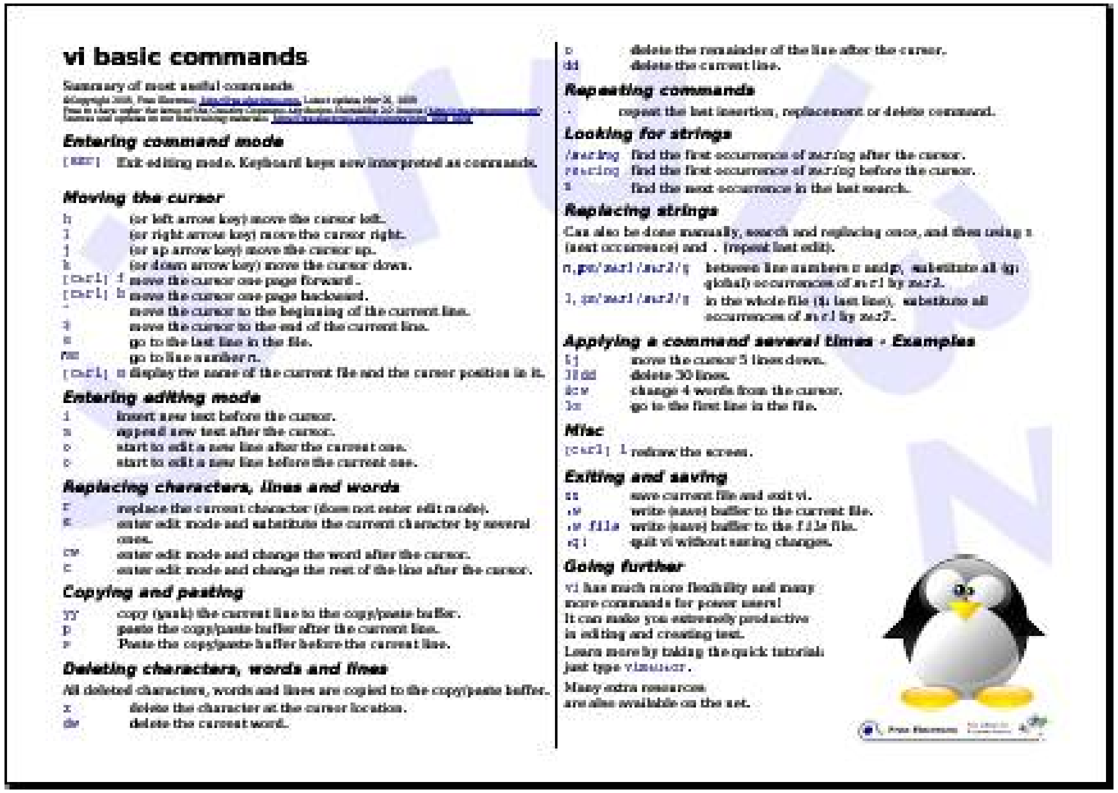
vim - vi improved


c.txt (/data/mike/tmp) - GVIM
File Edit Tools Syntax Buffers Window Help

```
When I find my code in tons of trouble,
Friends and colleagues come to me,
Speaking words of wisdom:
"Write in C."

As the deadline fast approaches,
And bugs are all that I can see,
Somewhere, someone whispers:
"Write in C."

Write in C, Write in C,
Write in C, oh, Write in C.
LOGO's dead and buried,
Write in C.

I used to write a lot of FORTRAN,
For science it worked flawlessly.
Try using it for graphics!
Write in C.

If you've just spent nearly 30 hours
Debugging some assembly,
Soon you will be glad to
Write in C.

Write in C, Write in C,
Write in C, yeah, Write in C.
Only wimps use BASIC.
Write in C.

Write in C, Write in C
Write in C, oh, Write in C.
Pascal won't quite cut it.
Write in C.

Write in C, Write in C,
Write in C, yeah, Write in C.
Don't even mention COBOL.
Write in C.
~
~
                         18,26          All
```

- `vi` implementation now found in most GNU / Linux host systems
- Implements lots of features available in modern editors: syntax highlighting, command history, help, unlimited undo and much much more.
- Cool feature example: can directly open compressed text files.
- Comes with a GTK graphical interface (`gvim`)
- Unfortunately, not free software (because of a small restriction in freedom to make changes)

vi basic commands



vi basic commands

Summary of most useful commands

[illegible]

Entering command mode

[ESC]	Exit editing mode. Keyboard keys now interpreted as commands.

Moving the cursor

h	(or left arrow key) move the cursor left.
l	(or right arrow key) move the cursor right.
k	(or up arrow key) move the cursor up.
j	(or down arrow key) move the cursor down.
[Ctrl] f	move the cursor one page forward.
[Ctrl] b	move the cursor one page backward.
^	move the cursor to the beginning of the current line.
$	move the cursor to the end of the current line.
G	go to the last line in the file.
nG	go to line number n.
[Ctrl] G	display the name of the current file and the cursor position in it.

Entering editing mode

i	insert new text before the cursor.
a	append new text after the cursor.
o	start to edit a new line after the current one.
O	start to edit a new line before the current one.

Replacing characters, lines and words

r	replace the current character (does not enter edit mode).
s	enter edit mode and substitute the current character by several ones.
cw	enter edit mode and change the word after the cursor.
C	enter edit mode and change the rest of the line after the cursor.

Copying and pasting

yy	copy (yank) the current line to the copy/paste buffer.
p	paste the copy/paste buffer after the current line.
P	Paste the copy/paste buffer before the current line.

Deleting characters, words and lines

All deleted characters, words and lines are copied to the copy/paste buffer.

x	delete the character at the cursor location.
dw	delete the current word.
D	delete the remainder of the line after the cursor.
dd	delete the current line.

Repeating commands

.	repeat the last insertion, replacement or delete command.

Looking for strings

/string	find the first occurrence of string after the cursor.
?string	find the first occurrence of string before the cursor.
n	find the next occurrence in the last search.

Replacing strings

Can also be done manually, search and replacing once, and then using n (next occurrence) and . (repeat last edit).

n,p s/str1/str2/g	between line numbers n and p, substitute all (g: global) occurrences of str1 by str2.
1,$ s/str1/str2/g	in the whole file ($: last line), substitute all occurrences of str1 by str2.

Applying a command several times - Examples

5j	move the cursor 5 lines down.
30dd	delete 30 lines.
4cw	change 4 words from the cursor.
1G	go to the first line in the file.

Misc

[Ctrl] l	redraw the screen.

Exiting and saving

ZZ	save current file and exit vi.
:w	write (save) buffer to the current file.
:w file	write (save) buffer to the file file.
:q!	quit vi without saving changes.

Going further

vi has much more flexibility and many more commands for power users!
It can make you extremely productive in editing and creating text.
Learn more by taking the quick tutorial: just type vimtutor.
Many extra resources are also available on the net.

Though vi is extremely powerful, its main 30 commands are easy to learn and are sufficient for 99% of everyone's needs!

You can also take the quick tutorial by running `vimtutor`.

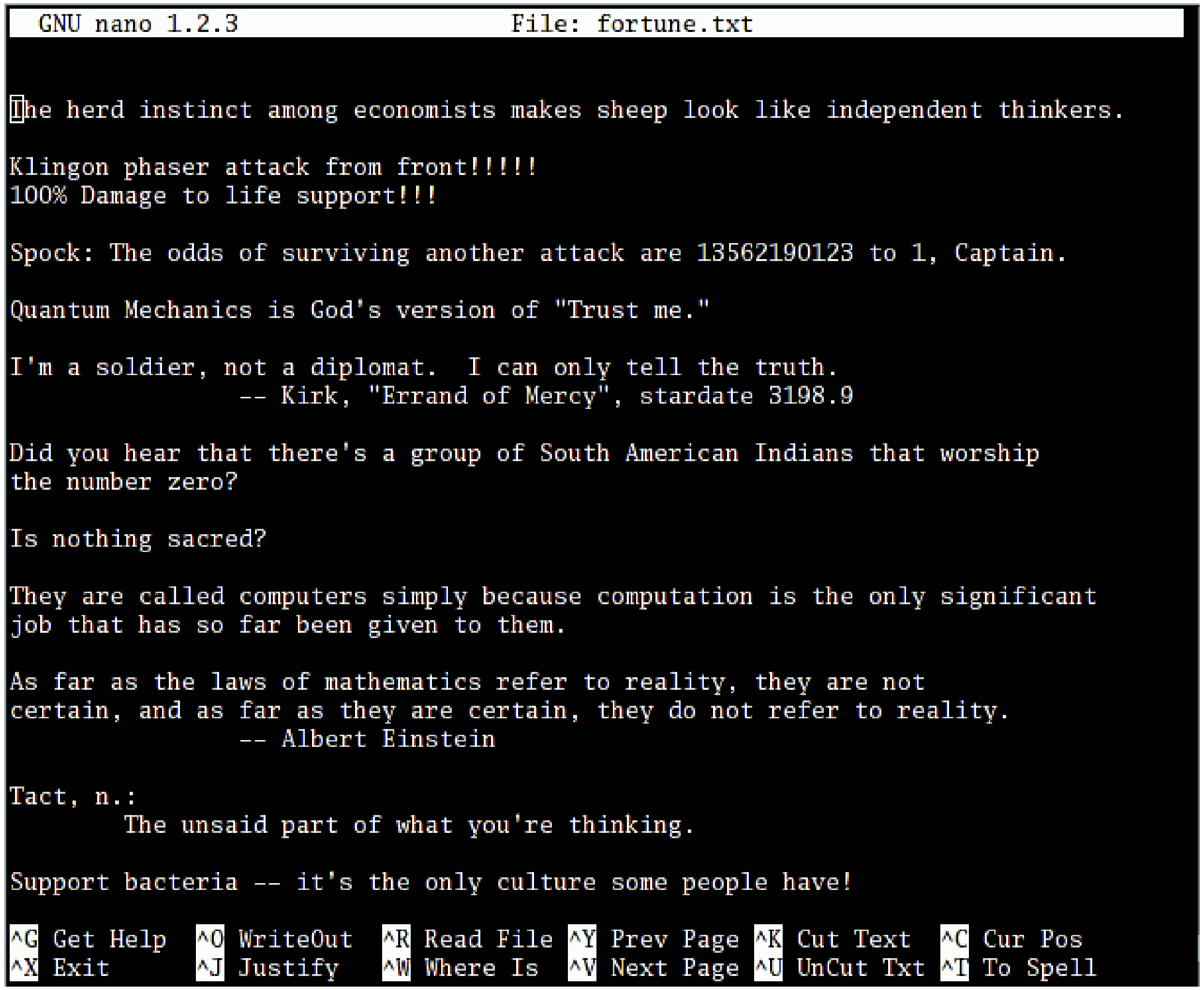
Get our vi memento sheet if you didn't get it with this course:
http://free-electrons.com/docs/command-line

GNU nano

http://www.nano-editor.org/

- Another small text-only, mouse free text editor.
- An enhanced Pico clone (non free editor in Pine)
- Friendly and easier to learn for beginners thanks to on screen command summaries.
- Available in binary packages for several platforms.
- An alternative to vi in embedded systems.
  However, not available as a busybox built-in.

GNU nano screenshot



```
  GNU nano 1.2.3                   File: fortune.txt


The herd instinct among economists makes sheep look like independent thinkers.

Klingon phaser attack from front!!!!!
100% Damage to life support!!!

Spock: The odds of surviving another attack are 13562190123 to 1, Captain.

Quantum Mechanics is God's version of "Trust me."

I'm a soldier, not a diplomat.  I can only tell the truth.
                -- Kirk, "Errand of Mercy", stardate 3198.9

Did you hear that there's a group of South American Indians that worship
the number zero?

Is nothing sacred?

They are called computers simply because computation is the only significant
job that has so far been given to them.

As far as the laws of mathematics refer to reality, they are not
certain, and as far as they are certain, they do not refer to reality.
                -- Albert Einstein

Tact, n.:
        The unsaid part of what you're thinking.

Support bacteria -- it's the only culture some people have!

^G Get Help  ^O WriteOut  ^R Read File ^Y Prev Page ^K Cut Text  ^C Cur Pos
^X Exit      ^J Justify   ^W Where Is  ^V Next Page ^U UnCut Txt ^T To Spell
```

Miscellaneous

Compressing and archiving

Measuring disk usage

Caution: different from file size!

- `du -h <file>` (disk usage)
  `-h`: returns size on disk of the given file, in human readable format: K (kilobytes), M (megabytes) or G (gigabytes), . Without `-h`, `du` returns the raw number of disk blocks used by the file (hard to read).
  Note that the `-h` option only exists in GNU `du`.
- `du -sh <dir>`
  `-s`: returns the sum of disk usage of all the files in the given directory.

Measuring disk space

- `df -h <dir>`
  Returns disk usage and free space for the filesystem containing the given directory.
  Similarly, the `-h` option only exists in GNU `df`.
- Example:

```
> df -h .
Filesystem            Size  Used Avail Use% Mounted on
/dev/hda5             9.2G  7.1G  1.8G  81% /
```

- `df -h`
  Returns disk space information for all filesystems available in the system. When errors happen, useful to look for full filesystems.

Compressing and decompressing

Very useful for shrinking huge files and saving space

- `g[un]zip <file>`
  GNU zip compression utility. Creates `.gz` files.
  Ordinary performance (similar to Zip).
- `b[un]zip2 <file>`
  More recent and effective compression utility.
  Creates `.bz2` files. Usually 20-25% better than gzip.
- `[un]lzma <file>`
  Much better compression ratio than bzip2 (up to 10 to 20%).
  Compatible command line options.

Archiving (1)

Useful to backup or release a set of files within 1 file

- `tar`: originally “tape archive”
- Creating an archive:
  ```
  tar cvf <archive> <files or directories>
  ```
  `c`: create
  `v`: verbose. Useful to follow archiving progress.
  `f`: file. Archive created in file (tape used otherwise).
- Example:
  ```
  tar cvf /backup/home.tar /home
  bzip2 /backup/home.tar
  ```

Archiving (2)

- Viewing the contents of an archive or integrity check:
  `tar tvf <archive>`
  `t`: test
- Extracting all the files from an archive:
  `tar xvf <archive>`
- Extracting just a few files from an archive:
  `tar xvf <archive> <files or directories>`
  Files or directories are given with paths relative to the archive root directory.

Extra options in GNU tar

`tar` = `gtar` = GNU `tar` on GNU / Linux
Can compress and uncompress archives on the fly.
Useful to avoid creating huge intermediate files
Much simpler to do than with `tar` and `bzip2`!

- `j` option: [un]compresses on the fly with `bzip2`
- `z` option: [un]compresses on the fly with `gzip`
- `--lzma` option: [un]compresses on the fly with `lzma`
- Examples (which one will you remember?)
  - `gtar jcvf bills_bugs.tar.bz2 bills_bugs`
  - `tar cvf - bills_bugs | bzip2 > bills_bugs.tar.bz2`

Checking file integrity

Very low cost solution to check file integrity

- `md5sum FC3-i386-disk*.iso > MD5SUM`
  Computes a MD5 (Message Digest Algorithm 5) 128 bit checksum of the given files. Usually redirected to a file.
- Example output:
  ```
  db8c7254beeb4f6b891d1ed3f689b412 FC3-i386-disc1.iso
  2c11674cf429fe570445afd9d5ff564e FC3-i386-disc2.iso
  f88f6ab5947ca41f3cf31db04487279b FC3-i386-disc3.iso
  6331c00aa3e8c088cc365eeb7ef230ea FC3-i386-disc4.iso
  ```
- `md5sum -c MD5SUM`
  Checks the integrity of the files in `MD5SUM` by comparing their actual MD5 checksum with their original one.

Miscellaneous

Printing

Unix printing

- Multi-user, multi-job, multi-client, multi-printer
  In Unix / Linux, printing commands don't really print. They send jobs to printing queues, possibly on the local machine, on network printing servers or on network printers.
- Printer independent system:
  Print servers only accept jobs in PostScript or text. Printer drivers on the server take care of the conversion to each printers own format.
- Robust system:
  Reboot a system, it will continue to print pending jobs.

Printing commands

- Useful environment variable: `PRINTER`
  Sets the default printer on the system. Example:
  `export PRINTER=lp`
- `lpr [-P<queue>] <files>`
  Sends the given files to the specified printing queue
  The files must be in text or PostScript format. Otherwise, you only print garbage.
- `a2ps [-P<queue>] <files>`
  "Any to PostScript" converts many formats to PostScript and send the output to the specified queue. Useful features: several pages / sheet, page numbering, info frame...

Print job control

- `lpq [-P<queue>]`
  Lists all the print jobs in the given or default queue.

```
lp is not ready
Rank    Owner   Job     File(s)                         Total Size
1st     asloane 84      nsa_windows_backdoors.ps        60416 bytes
2nd     amoore  85      gw_bush_iraq_mistakes.ps        65024000 bytes
```

- `cancel <job#> [<queue>]`
  Removes the given job number from the default queue.

Using PostScript and PDF files

Viewing a PostScript file

- PostScript viewers exist, but their quality is pretty poor.
- Better convert to PDF with `ps2pdf`:

```
ps2pdf decss_algorithm.ps
xpdf decss_algorithm.pdf &
```

Printing a PDF file

- You don't need to open a PDF reader!
- Better convert to PostScript with `pdf2ps`:

```
pdf2ps rambaldi_artifacts_for_dummies.pdf
lpr rambaldi_artifacts_for_dummies.ps
```

Miscellaneous

Synchronizing files

Smart directory copy with rsync

`rsync` (remote sync) has been designed to keep in sync directories on 2 machines with a low bandwidth connection.

- Only copies files that have changed. Files with the same size are compared by checksums.
- Only transfers the blocks that differ within a file!
- Can compress the transferred blocks
- Preserves symbolic links and file permissions: also very useful for copies on the same machine.
- Can work through ssh (secure remote shell). Very useful to update the contents of a website, for example.

rsync examples (1)

- `rsync -a /home/arvin/sd6_agents/ /home/sydney/misc/`

  `-a`: archive mode. Equivalent to `-rlptgoD`... easy way to tell you want recursion and want to preserve almost everything.

- `rsync -Pav --delete /home/steve/ideas/ /home/bill/my_ideas/`

  `-P`: `--partial` (keep partially transferred files) and `--progress` (show progress during transfer)

  `--delete`: delete files in the target which don't exist in the source.

Caution: directory names should end with `/` . Otherwise, you get a `my_ideas/ideas/` directory at the destination.

rsync examples (2)

- Copying to a remote machine

```
rsync -Pav /home/bill/legal/arguments/ \
bill@www.sco.com:/home/legal/arguments/
```

  User `bill` will be prompted for a password.

- Copying from a remote machine through ssh

```
rsync -Pav -e ssh
homer@tank.duff.com:/prod/beer/ \
fridge/homer/beer/
```

  User `homer` will be prompted for his ssh key password.

Miscellaneous

Comparing files and directories

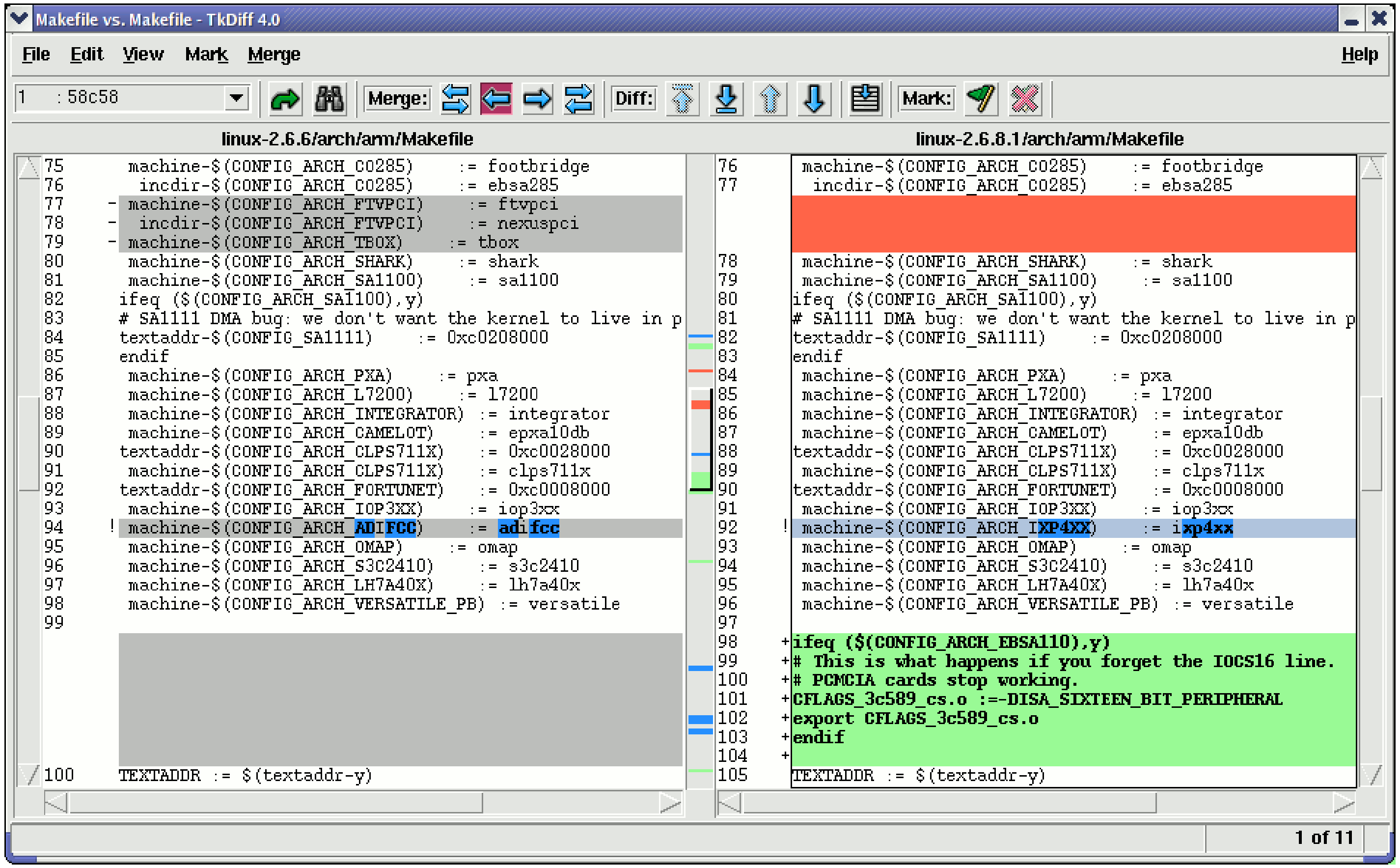
Comparing files and directories

- `diff file1 file2`
  Reports the differences between 2 files, or nothing if the files are identical.
- `diff -r dir1/ dir2/`
  Reports all the differences between files with the same name in the 2 directories.
- These differences can be saved in a file using the redirection, and then later re-applied using the `patch` command.
- To investigate differences in detail, better use graphical tools!

tkdiff

http://tkdiff.sourceforge.net/

Useful tool to compare files and merge differences


Makefile vs. Makefile - TkDiff 4.0
File
Edit
View
Mark
Merge
Help
1 : 58c58
Merge:
Diff:
Mark:
linux-2.6.6/arch/arm/Makefile
linux-2.6.8.1/arch/arm/Makefile
1 of 11

linux-2.6.6/arch/arm/Makefile

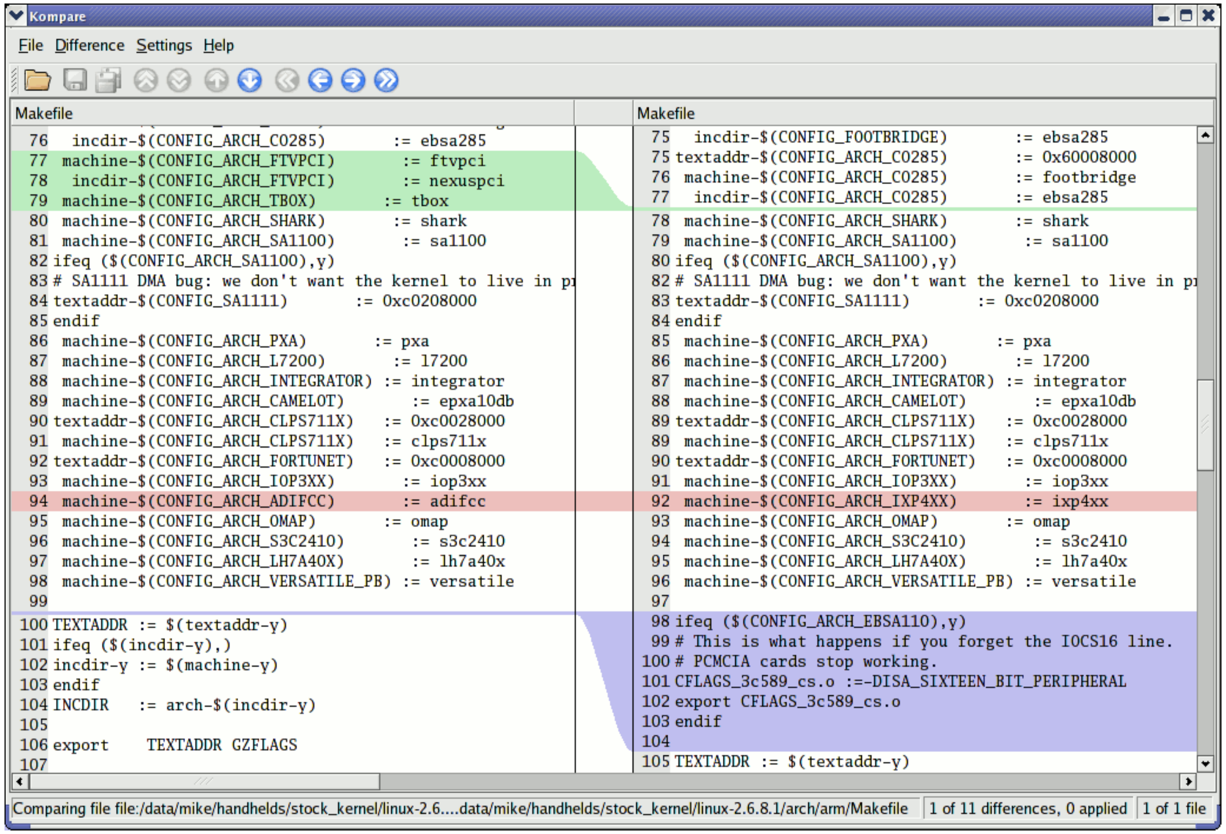
```
   machine-$(CONFIG_ARCH_CO285)     := footbridge
    incdir-$(CONFIG_ARCH_CO285)     := ebsa285
-  machine-$(CONFIG_ARCH_FTVPCI)     := ftvpci
-   incdir-$(CONFIG_ARCH_FTVPCI)     := nexuspci
-  machine-$(CONFIG_ARCH_TBOX)     := tbox
   machine-$(CONFIG_ARCH_SHARK)     := shark
   machine-$(CONFIG_ARCH_SA1100)     := sa1100
  ifeq ($(CONFIG_ARCH_SA1100),y)
  # SA1111 DMA bug: we don't want the kernel to live in p
  textaddr-$(CONFIG_SA1111)     := 0xc0208000
  endif
   machine-$(CONFIG_ARCH_PXA)     := pxa
   machine-$(CONFIG_ARCH_L7200)     := l7200
   machine-$(CONFIG_ARCH_INTEGRATOR)  := integrator
   machine-$(CONFIG_ARCH_CAMELOT)     := epxa10db
  textaddr-$(CONFIG_ARCH_CLPS711X)     := 0xc0028000
   machine-$(CONFIG_ARCH_CLPS711X)     := clps711x
  textaddr-$(CONFIG_ARCH_FORTUNET)     := 0xc0008000
   machine-$(CONFIG_ARCH_IOP3XX)     := iop3xx
!  machine-$(CONFIG_ARCH_ADIFCC)     := adifcc
   machine-$(CONFIG_ARCH_OMAP)     := omap
   machine-$(CONFIG_ARCH_S3C2410)     := s3c2410
   machine-$(CONFIG_ARCH_LH7A40X)     := lh7a40x
   machine-$(CONFIG_ARCH_VERSATILE_PB)  := versatile

  TEXTADDR := $(textaddr-y)
```

linux-2.6.8.1/arch/arm/Makefile

```
  machine-$(CONFIG_ARCH_CO285)     := footbridge
   incdir-$(CONFIG_ARCH_CO285)     := ebsa285
  machine-$(CONFIG_ARCH_SHARK)     := shark
  machine-$(CONFIG_ARCH_SA1100)     := sa1100
 ifeq ($(CONFIG_ARCH_SA1100),y)
 # SA1111 DMA bug: we don't want the kernel to live in p
 textaddr-$(CONFIG_SA1111)     := 0xc0208000
 endif
  machine-$(CONFIG_ARCH_PXA)     := pxa
  machine-$(CONFIG_ARCH_L7200)     := l7200
  machine-$(CONFIG_ARCH_INTEGRATOR)  := integrator
  machine-$(CONFIG_ARCH_CAMELOT)     := epxa10db
 textaddr-$(CONFIG_ARCH_CLPS711X)     := 0xc0028000
  machine-$(CONFIG_ARCH_CLPS711X)     := clps711x
 textaddr-$(CONFIG_ARCH_FORTUNET)     := 0xc0008000
  machine-$(CONFIG_ARCH_IOP3XX)     := iop3xx
! machine-$(CONFIG_ARCH_IXP4XX)     := ixp4xx
  machine-$(CONFIG_ARCH_OMAP)     := omap
  machine-$(CONFIG_ARCH_S3C2410)     := s3c2410
  machine-$(CONFIG_ARCH_LH7A40X)     := lh7a40x
  machine-$(CONFIG_ARCH_VERSATILE_PB)  := versatile

+ifeq ($(CONFIG_ARCH_EBSA110),y)
+# This is what happens if you forget the IOCS16 line.
+# PCMCIA cards stop working.
+CFLAGS_3c589_cs.o :=-DISA_SIXTEEN_BIT_PERIPHERAL
+export CFLAGS_3c589_cs.o
+endif
+
 TEXTADDR := $(textaddr-y)
```

kompare

Another nice tool to compare files and merge differences
Part of the `kdesdk` package (Fedora Core)



Makefile

```
  incdir-$(CONFIG_ARCH_CO285)        := ebsa285
 machine-$(CONFIG_ARCH_FTVPCI)        := ftvpci
  incdir-$(CONFIG_ARCH_FTVPCI)        := nexuspci
 machine-$(CONFIG_ARCH_TBOX)        := tbox
 machine-$(CONFIG_ARCH_SHARK)        := shark
 machine-$(CONFIG_ARCH_SA1100)        := sa1100
ifeq ($(CONFIG_ARCH_SA1100),y)
# SA1111 DMA bug: we don't want the kernel to live in pr
textaddr-$(CONFIG_SA1111)        := 0xc0208000
endif
 machine-$(CONFIG_ARCH_PXA)        := pxa
 machine-$(CONFIG_ARCH_L7200)        := l7200
 machine-$(CONFIG_ARCH_INTEGRATOR) := integrator
 machine-$(CONFIG_ARCH_CAMELOT)        := epxa10db
textaddr-$(CONFIG_ARCH_CLPS711X)    := 0xc0028000
 machine-$(CONFIG_ARCH_CLPS711X)    := clps711x
textaddr-$(CONFIG_ARCH_FORTUNET)    := 0xc0008000
 machine-$(CONFIG_ARCH_IOP3XX)        := iop3xx
 machine-$(CONFIG_ARCH_ADIFCC)        := adifcc
 machine-$(CONFIG_ARCH_OMAP)        := omap
 machine-$(CONFIG_ARCH_S3C2410)        := s3c2410
 machine-$(CONFIG_ARCH_LH7A40X)        := lh7a40x
 machine-$(CONFIG_ARCH_VERSATILE_PB) := versatile

TEXTADDR := $(textaddr-y)
ifeq ($(incdir-y),)
incdir-y := $(machine-y)
endif
INCDIR    := arch-$(incdir-y)

export    TEXTADDR GZFLAGS

```

Makefile

```
  incdir-$(CONFIG_FOOTBRIDGE)        := ebsa285
textaddr-$(CONFIG_ARCH_CO285)        := 0x60008000
 machine-$(CONFIG_ARCH_CO285)        := footbridge
  incdir-$(CONFIG_ARCH_CO285)        := ebsa285
 machine-$(CONFIG_ARCH_SHARK)        := shark
 machine-$(CONFIG_ARCH_SA1100)        := sa1100
ifeq ($(CONFIG_ARCH_SA1100),y)
# SA1111 DMA bug: we don't want the kernel to live in pr
textaddr-$(CONFIG_SA1111)        := 0xc0208000
endif
 machine-$(CONFIG_ARCH_PXA)        := pxa
 machine-$(CONFIG_ARCH_L7200)        := l7200
 machine-$(CONFIG_ARCH_INTEGRATOR) := integrator
 machine-$(CONFIG_ARCH_CAMELOT)        := epxa10db
textaddr-$(CONFIG_ARCH_CLPS711X)    := 0xc0028000
 machine-$(CONFIG_ARCH_CLPS711X)    := clps711x
textaddr-$(CONFIG_ARCH_FORTUNET)    := 0xc0008000
 machine-$(CONFIG_ARCH_IOP3XX)        := iop3xx
 machine-$(CONFIG_ARCH_IXP4XX)        := ixp4xx
 machine-$(CONFIG_ARCH_OMAP)        := omap
 machine-$(CONFIG_ARCH_S3C2410)        := s3c2410
 machine-$(CONFIG_ARCH_LH7A40X)        := lh7a40x
 machine-$(CONFIG_ARCH_VERSATILE_PB) := versatile

ifeq ($(CONFIG_ARCH_EBSA110),y)
# This is what happens if you forget the IOCS16 line.
# PCMCIA cards stop working.
CFLAGS_3c589_cs.o :=-DISA_SIXTEEN_BIT_PERIPHERAL
export CFLAGS_3c589_cs.o
endif

TEXTADDR := $(textaddr-y)
```

Comparing file file:/data/mike/handhelds/stock_kernel/linux-2.6....data/mike/handhelds/stock_kernel/linux-2.6.8.1/arch/arm/Makefile | 1 of 11 differences, 0 applied | 1 of 1 file

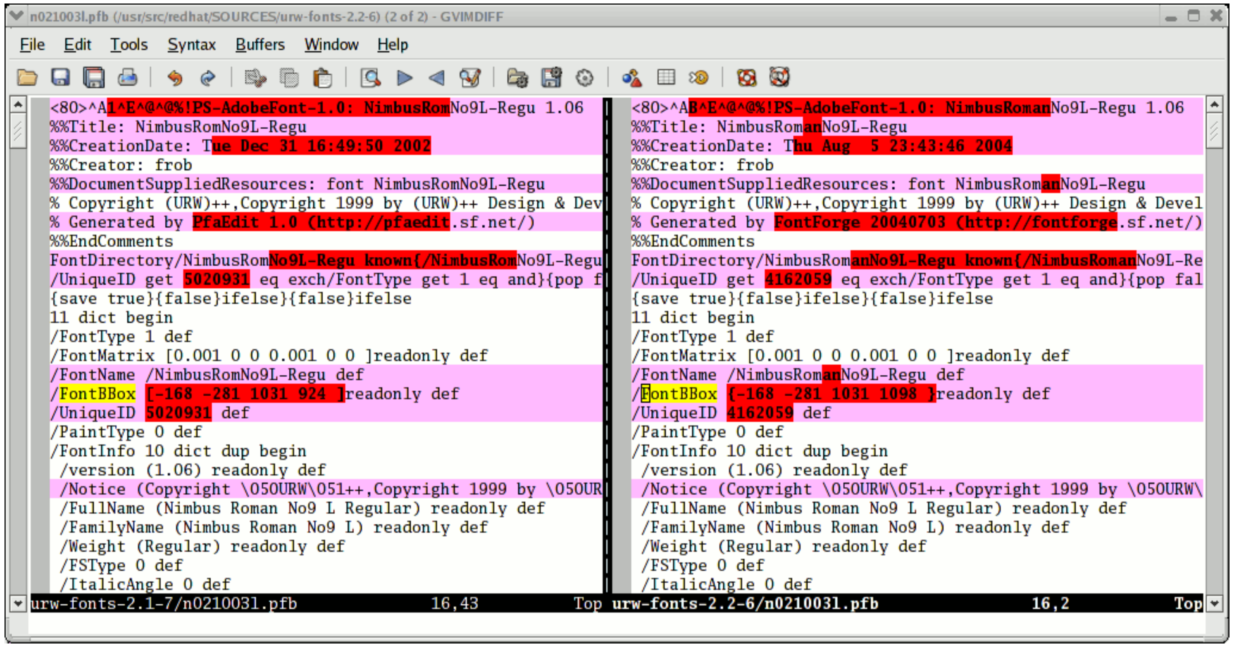
gvimdiff

Another nice tool to view differences in files

Available in most distributions with `gvim`

Apparently not using `diff`.

No issue with files with binary sections!


n021003l.pfb (/usr/src/redhat/SOURCES/urw-fonts-2.2-6) (2 of 2) - GVIMDIFF
File Edit Tools Syntax Buffers Window Help

```
<80>^A1^E^@^@%!PS-AdobeFont-1.0: NimbusRomNo9L-Regu 1.06
%%Title: NimbusRomNo9L-Regu
%%CreationDate: Tue Dec 31 16:49:50 2002
%%Creator: frob
%%DocumentSuppliedResources: font NimbusRomNo9L-Regu
% Copyright (URW)++,Copyright 1999 by (URW)++ Design & Dev
% Generated by PfaEdit 1.0 (http://pfaedit.sf.net/)
%%EndComments
FontDirectory/NimbusRomNo9L-Regu known{/NimbusRomNo9L-Regu
/UniqueID get 5020931 eq exch/FontType get 1 eq and}{pop f
{save true}{false}ifelse}{false}ifelse
11 dict begin
/FontType 1 def
/FontMatrix [0.001 0 0 0.001 0 0 ]readonly def
/FontName /NimbusRomNo9L-Regu def
/FontBBox [-168 -281 1031 924 ]readonly def
/UniqueID 5020931 def
/PaintType 0 def
/FontInfo 10 dict dup begin
 /version (1.06) readonly def
 /Notice (Copyright \050URW\051++,Copyright 1999 by \050UR
 /FullName (Nimbus Roman No9 L Regular) readonly def
 /FamilyName (Nimbus Roman No9 L) readonly def
 /Weight (Regular) readonly def
 /FSType 0 def
 /ItalicAngle 0 def
urw-fonts-2.1-7/n0210031.pfb                16,43          Top
```

```
<80>^AB^E^@^@%!PS-AdobeFont-1.0: NimbusRomanNo9L-Regu 1.06
%%Title: NimbusRomanNo9L-Regu
%%CreationDate: Thu Aug  5 23:43:46 2004
%%Creator: frob
%%DocumentSuppliedResources: font NimbusRomanNo9L-Regu
% Copyright (URW)++,Copyright 1999 by (URW)++ Design & Devel
% Generated by FontForge 20040703 (http://fontforge.sf.net/)
%%EndComments
FontDirectory/NimbusRomanNo9L-Regu known{/NimbusRomanNo9L-Re
/UniqueID get 4162059 eq exch/FontType get 1 eq and}{pop fal
{save true}{false}ifelse}{false}ifelse
11 dict begin
/FontType 1 def
/FontMatrix [0.001 0 0 0.001 0 0 ]readonly def
/FontName /NimbusRomanNo9L-Regu def
/FontBBox {-168 -281 1031 1098 }readonly def
/UniqueID 4162059 def
/PaintType 0 def
/FontInfo 10 dict dup begin
 /version (1.06) readonly def
 /Notice (Copyright \050URW\051++,Copyright 1999 by \050URW\
 /FullName (Nimbus Roman No9 L Regular) readonly def
 /FamilyName (Nimbus Roman No9 L) readonly def
 /Weight (Regular) readonly def
 /FSType 0 def
 /ItalicAngle 0 def
urw-fonts-2.2-6/n0210031.pfb                16,2           Top
```

Miscellaneous

Looking for files

The find command

Better explained by a few examples!

- `find . -name “*.pdf”`
  Lists all the `*.pdf` files in the current (`.`) directory or subdirectories. You need the double quotes to prevent the shell from expanding the `*` character.
- `find docs -name "*.pdf" -exec xpdf {} ';'`
  Finds all the `*.pdf` files in the `docs` directory and displays one after the other.
- Many more possibilities available! However, the above 2 examples cover most needs.

The locate command

Much faster regular expression search alternative to `find`

- `locate keys`
  Lists all the files on your system with `keys` in their name.
- `locate "*.pdf"`
  Lists all the `*.pdf` files available on the whole machine
- `locate "/home/fridge/*beer*"`
  Lists all the `*beer*` files in the given directory (absolute path)
- `locate` is much faster because it indexes all files in a dedicated database, which is updated on a regular basis.
- `find` is better to search through recently created files.

Miscellaneous

Various commands

Getting information about users

- `who`
  Lists all the users logged on the system.
- `whoami`
  Tells what user I am logged as.
- `groups`
  Tells which groups I belong to.
- `groups <user>`
  Tells which groups `<user>` belongs to.
- `finger <user>`
  Tells more details (real name, etc) about `<user>`
  Disabled in some systems (security reasons).

Changing users

You do not have to log out to log on another user account!

- `su hyde`
  (Rare) Change to the `hyde` account, but keeping the environment variable settings of the original user.
- `su - jekyll`
  (More frequent) Log on the `jekyll` account, with exactly the same settings as this new user.
- `su -`
  When no argument is given, it means the `root` user.

The wget command

Instead of downloading files from your browser, just copy and paste their URL and download them with `wget`!

`wget` main features

- http and ftp support
- Can resume interrupted downloads
- Can download entire sites or at least check for bad links
- Very useful in scripts or when no graphics are available (system administration, embedded systems)
- Proxy support (`http_proxy` and `ftp_proxy` env. variables)

wget examples

- `wget -c \`
  `http://microsoft.com/customers/dogs/winxp4dogs.zip`
  Continues an interrupted download.
- `wget -m http://lwn.net/`
  Mirrors a site.
- `wget -r -np http://www.xml.com/ldd/chapter/book/`
  Recursively downloads an on-line book for off-line access.
  `-np`: "no-parent". Only follows links in the current directory.

Misc commands (1)

- `sleep 60`
  Waits for 60 seconds
  (doesn't consume system resources).

- `wc report.txt` (word count)

  ```
  438  2115 18302 report.txt
  ```

  Counts the number of lines, words and characters in a file or in standard input.

Misc commands (2)

- `bc` ("basic calculator?")
  `bc` is a handy but full-featured calculator. Even includes a programming language! Use the `-l` option to have floating point support.
- `date`
  Returns the current date. Useful in scripts to record when commands started or completed.

Checksum commands

- *A checksum or hash sum is a fixed-size datum computed from an arbitrary block of digital data for the purpose of detecting accidental errors that may have been introduced during its transmissions or storage.*
  http://en.wikipedia.org/wiki/Checksum
- The MD5 hash algorithm is implemented in the `md5sum` command

```
$ md5sum patch-2.6.24.7.bz2
0c1c5d6d8cd82e18d62406d2f34d1d38  patch-2.6.24.7.bz2
```

- The SHA algorithm is implemented in the `shaXsum` (`sha1sum`, `sha256sum`, etc.)
- The integrity of several files can be verified against a file listing the checksums using the `-c` option.

System administration

See our presentation about system administration basics:

- Network setup
- Creating and mounting filesystems
- Accessing administrator (root) priviledges
- Package management

Also available on http://free-electrons.com/docs/command-line

Application development

Compiling simple applications

- The compiler used for all Linux systems is GCC
  http://gcc.gnu.org
- To compile a single-file application, developed in C :
  ```
  gcc -o test test.c
  ```
  - Will generate a test binary, from the test.c source file
- For C++ :
  ```
  g++ -o test test.cc
  ```
- The -Wall option enables more warnings
- To compile sources files to object files and link the application :
  ```
  gcc -c test1.c
  gcc -c test2.c
  gcc -o test test1.o test2.o
  ```
- `gcc` automatically calls the linker `ld`

Using libraries (1)

- On any Linux system, a C library is available and offers a large set of APIs for application development.
  - See http://www.gnu.org/software/libc/manual/
- Outside of the C library, thousands of other libraries are available for graphic programming, multimedia, networking, scientific computations, and moroe.
- Most libraries are already available as packages in your distribution, in general in two packages
  - **`libfoo`** is the package containing the library itself. This package is required to **execute** already compiled applications, but not sufficient to build new applications
  - **`libfoo-dev`** is the package containing the headers and other configurations files and tools needed to **build** new applications relying on libfoo.

Using libraries (2)

- In your source code, include the proper header files of the library
  - Usually `#include <foo.h>` or `#include <foo/foo.h>`
  - These headers are present in `/usr/include/`
  - Refer to the documentation of the library for details, available in `/usr/share/doc/<package>/`, on the Web... or in the header files !
- To compile your application with the library, the easiest solution is to use pkg-config, which is supported by most libraries today :

```
gcc -o test test.c $(pkg-config --cflags –libs)
```

- By default, the application are dynamically linked with the libraries
  - The libraries must be present in `/lib/` for the application to work
  - Use the `ldd` command to see which libraries are needed by an application

Make and Makefiles

- The compilation process can be automated using the make tool.
- make reads a file called Makefile from the current directory, and executes the rules described in this file
- Every rule is has a target name, a colon, and a list of dependencies, and the list of commands to generate the target from the dependencies

```
target: dep1 dep2
    command1
    command2
    command3
```

  - When simply running `make`, the default target that is generated is "`all`". A target is only re-generated if dependencies have changed.
- See http://www.gnu.org/software/make/manual/

Simple Makefile example

```
CFLAGS = -Wall

all: test

test: t1.o t2.o
   gcc -o $@ $^ $(CFLAGS)

clean:
   $(RM) -f test

install:
   $(CP) test /usr/bin
```

Variables can be defined and later expaneded with $(VARNAME)

The default target “all” simply depends on the “test” target.

The “test” target depends on t1.o and t2.o. Once these files are generated, the gcc command is executed.
`$@` is the target name
`$^`is the name of all dependencies.
The .o files are generated using implicit dependencies, known by `make`.

These targets are executed by running “make clean” and “make install”

Build systems

- Makefiles are nice, but they don't easily allow easy adaptation to the different build environment and different build options
- More elaborated build systems have been developed
  - Autotools (automake, autoconf), based on Makefiles and shell scripts. Even though they are old and a little bit difficult to understand, they are the most popular build system for free software packages.
  - CMake, a newer, cleaner build system
  - Sconcs and Waf, other build systems based on Python
- The typical steps to compile a autotools based package are

```
./configure
make
sudo make install
```

Debugging

- The official debugger that comes with the GNU development tools is `gdb`.
  - See http://sourceware.org/gdb/download/onlinedocs/gdb.html
- An application must be compiled with the `-g` option to be properly debugged. This option adds debugging information to the application binary

  ```
  gcc -o test test.c -g
  ```
- The application can then be run inside the `gdb` debugger :

  ```
  gdb test
  ```
- Or the debugger can be attached to the application while it is running :

  ```
  gdb test -p PID
  ```
  - Where PID is the process ID of the running application

Using gdb

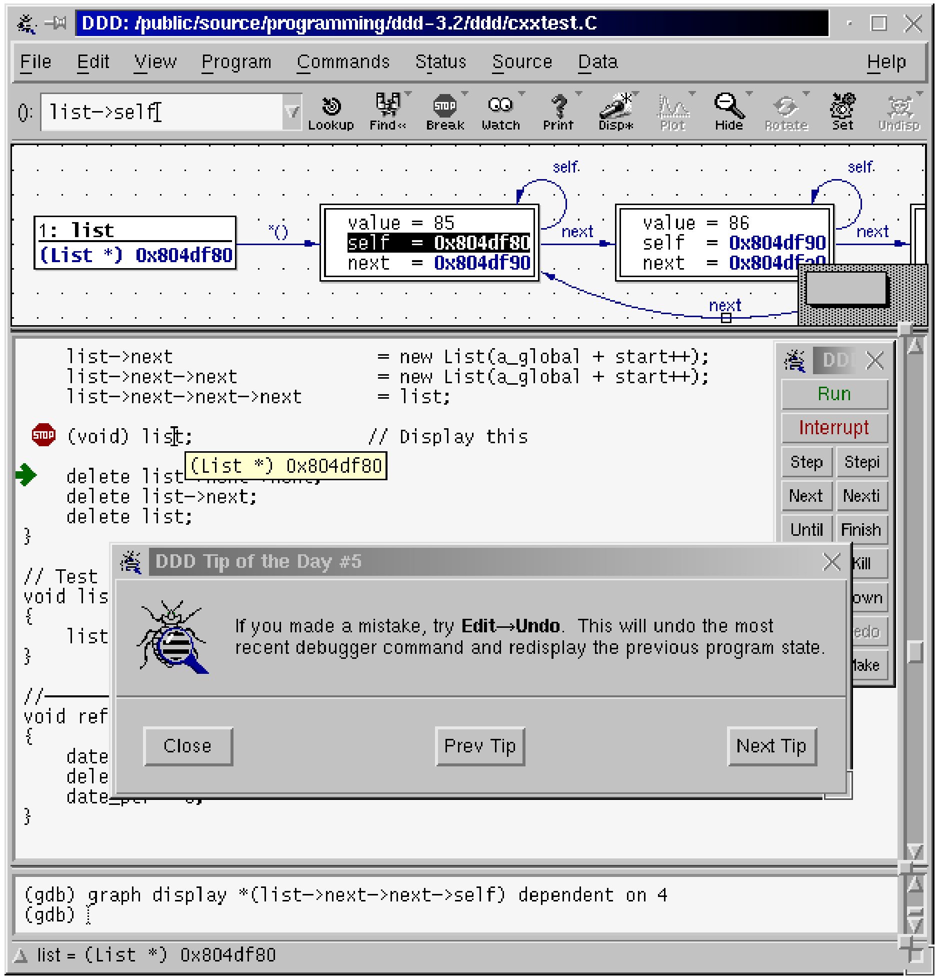
- **gdb** is a text-based debugger, with a command-line interface like a shell, providing dedicated commands. Some of the important commands are :
  - `break (b)` to set a breakpoint in the code. Can be used with a function name or a location in the source code, or an absolute memory address.
  - `print (p)` to print the value of a variable. Used with a variable name, even if it's a complex one (which involves dereferencing structures, for example)
  - `c` to continue the execution until the next breakpoint.
  - `next (n)` to execute only the next line of code (step *over* any function call) and `step (s)` to execute only the next line of code (step *into* any function call)
  - `backtrace (bt)` to display the function call stack

gdb sample session

```
thomas@surf:/tmp$ gcc -o test test.c -g
thomas@surf:/tmp$ gdb test
GNU gdb 6.8-debian
[...)
(gdb) break foo
Breakpoint 1 at 0x80483c7: file test.c, line 5.
(gdb) run
Starting program: /tmp/test2

Breakpoint 1, foo (a=2, b=3) at test.c:5
5       return a + b;
(gdb) p a
$1 = 2
(gdb) p b
$2 = 3
(gdb) c
Continuing.
foo=5

Program exited normally.
```

ddd, the graphical gdb

- There are several graphical front-ends to `gdb`. A popular one is **`ddd`.**
  - Allows to navigate in the source code while debugging
  - Allows to set break points, inspect and change variable value directly by looking at the source code
- http://www.gnu.org/software/ddd/


DDD: /public/source/programming/ddd-3.2/ddd/cxxtest.C
File Edit View Program Commands Status Source Data Help
(): list->self
Lookup Find« Break Watch Print Disp* Plot Hide Rotate Set Undisp
1: list
(List *) 0x804df80
*()
value = 85
self = 0x804df80
next = 0x804df90
self
next
value = 86
self = 0x804df90
next = 0x804dfa0
Run Interrupt Step Stepi Next Nexti Until Finish Kill Down Redo Make
DDD Tip of the Day #5
Close Prev Tip Next Tip

```
    list->next                  = new List(a_global + start++);
    list->next->next            = new List(a_global + start++);
    list->next->next->next      = list;

    (void) list;                // Display this

    delete list
    delete list->next;
    delete list;
}

// Test
void lis
{
    list
}

//
void ref
{
    date
    dele
    date
}
```

(List *) 0x804df80

If you made a mistake, try **Edit→Undo**. This will undo the most recent debugger command and redisplay the previous program state.

```
(gdb) graph display *(list->next->next->self) dependent on 4
(gdb)
```

list = (List *) 0x804df80

Version control system
CVS

Version control (1)

- Activity that consists in maintaining the full history of project files
- Every version of every file is recorded
- It allows to :
  - Create a knowledge database about the project codebase
  - Revert in case of mistake
  - Review the modifications introduced between two different versions
  - Work as a team on a single project
  - Create parallel development or release branches
  - Tag previous versions of a project

Version control (2)

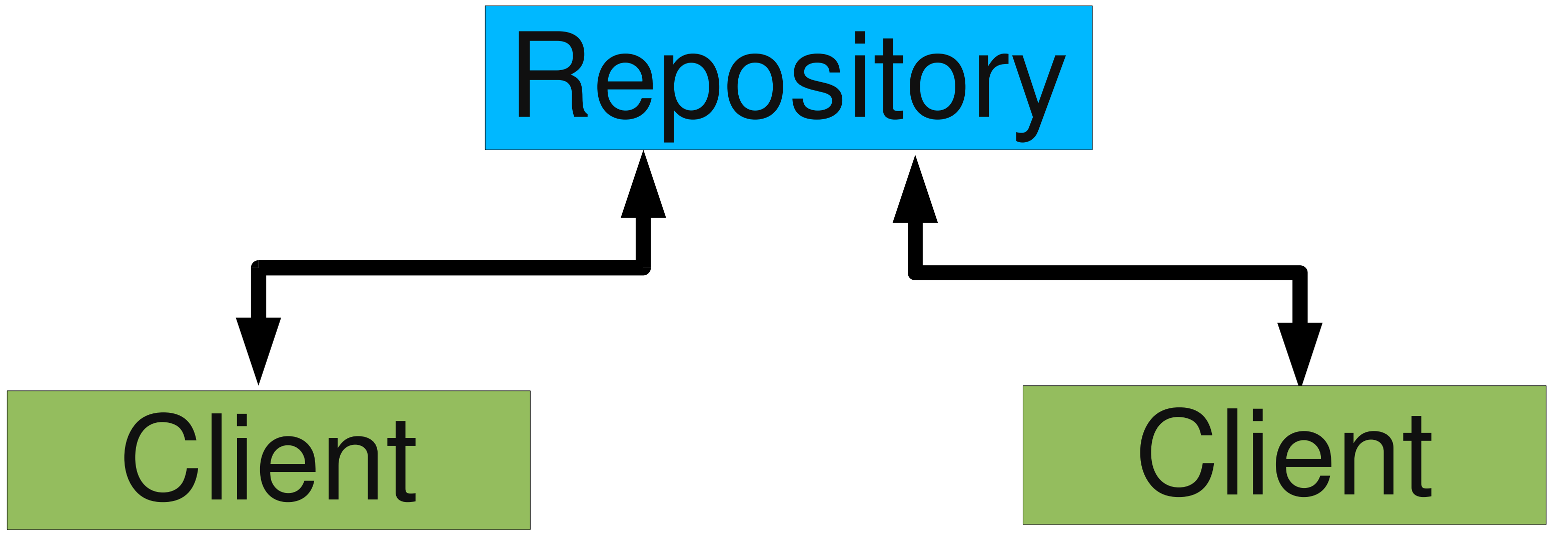
- Useful for :
  - Source code, of course
  - Documentation, translation strings, compilation scripts, configuration files, etc.
  - Binary data can be versioned, but the functionalities will be limited. Best to use text-only file formats.
- Generated files should never be versioned.
- Version control is absolutely necessary when working as a team on a project
  - Version control systems are one of the fundamental tools used for open source development
- Version control is still very useful when working alone on a project.

Tools and approaches

- A lot of version control systems available
  - Proprietary: Perforce, Synergy, StarTeam, BitKeeper, ClearCase
  - Free and open source: CVS, Subversion, Git, Mercurial, Arch, Monotone
- In the free/open solutions, two main approaches
  - The classical one, the centralized approach, implemented by CVS and Subversion
  - A newer one, the decentralized or distributed approach, implemented in Git, Mercurial, Arch or Monotone.

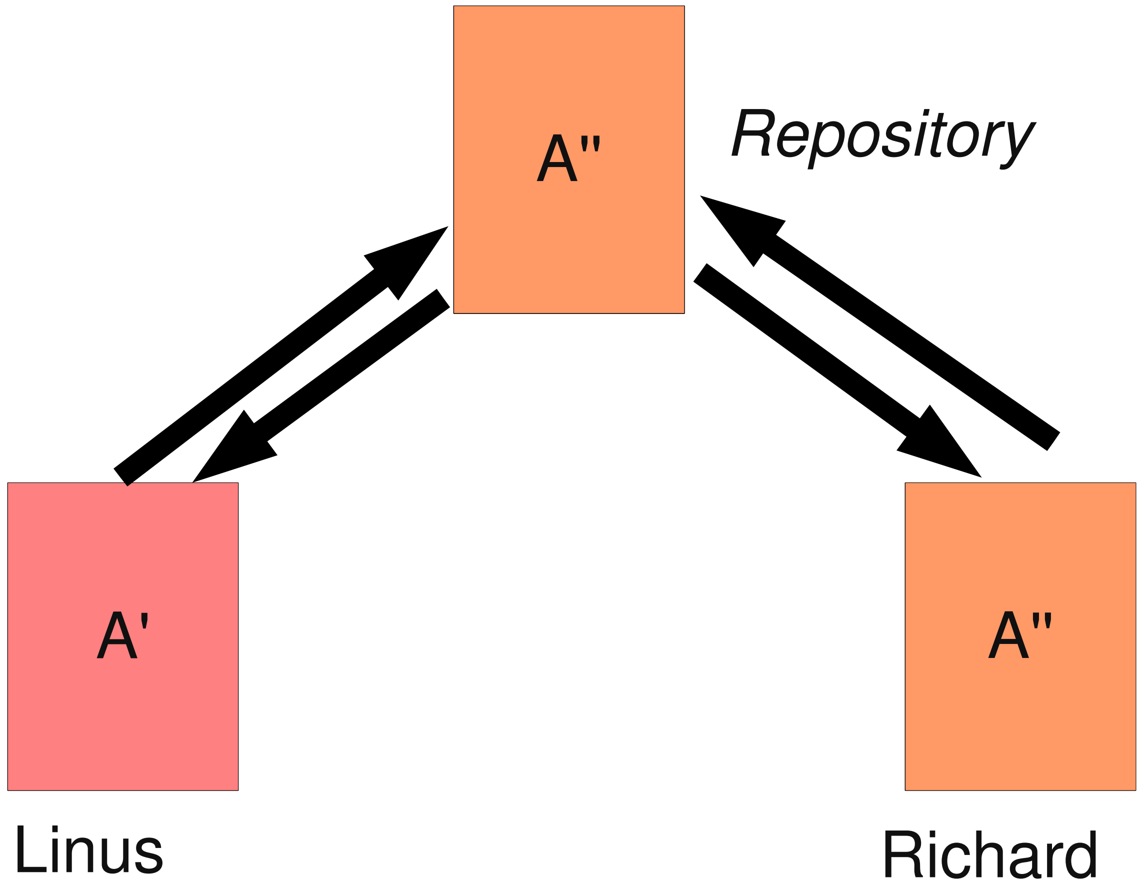
Centralized approach

- The centralized approach is based on the presence of a server hosting a **repository**.
- The repository contains the history of all files and acts as the reference for all participants in the project.
- Typical client/server approach.



Conflict management (1)

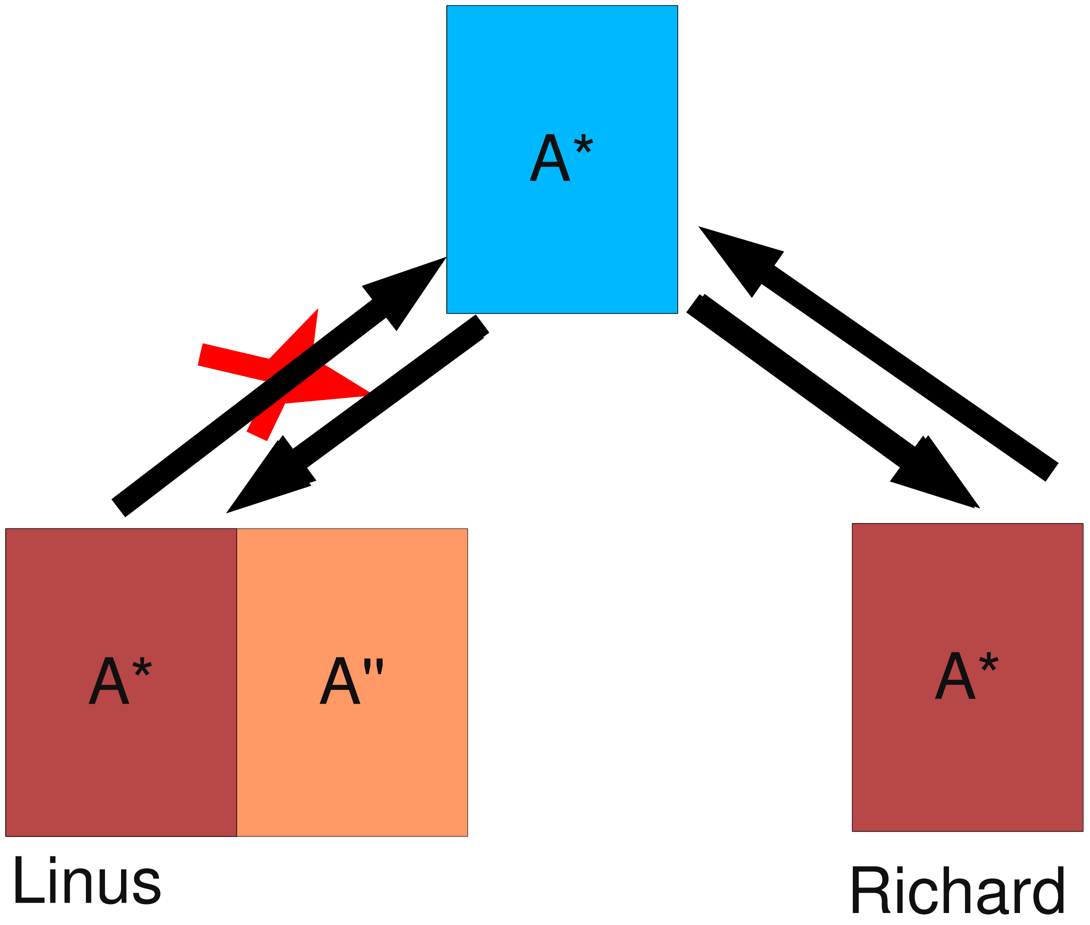
- When two persons are working at the same time on the same file, when the changes are sent to the server, a **conflict** can occur if the modifications are not « compatible ».



Conflict management (2)

- Two solutions to solve the conflict problem
  - The **locking** approach : preventing two developers to work on the same file.
  - The **merge** approach : the second developer sending his changes to the server is responsible for merging his changes with the other developers changes already present on the server.
- In the free/open source projects, the traditional model is the merge one. It avoids the burden of handling the locking and scales better with a bigger team.
- But CVS and Subversion both implement advisory locking : a developer must voluntarily lock the files he is going to work with.

Conflict resolution by fusion



CVS

- Free Software
- Used to be the most widely used free version control system. Now replaced by Subversion.
- Still used by big projects, but a lot of large projects (KDE, Apache, Eclipse) have moved to Subversion.
- Homepage : http://www.nongnu.org/cvs/
- Documentation : http://ximbiot.com/cvs/manual/

CVS usage

- The main client is a command-line one, implemented in the `cvs` command
  - `cvs help` gives the list of available commands
    - `add, admin, annotate, checkout, commit, diff, edit, editors, export, history, import, init, log, login, logout, ls, pserver, rannotate, rdiff, release, remove, rlog, rls, rtag, server, status, tag, unedit, update, version, watch, watchers`
  - `cvs --help command` gives the help of command.
- Graphical interfaces
  - Integration in Vim, Emacs, Anjuta, Dev-C++, Eclipse, Kdevelop, etc.
  - Graphical clients: Cervisia (for KDE), gcvs (for Gnome), CrossVC, etc.
  - Web clients: ViewVC, cvsweb, etc.

Create the working copy

- The first step to work on an existing project is to create a **working copy.** A working copy is a copy on the developer machine of the full tree of the project source code.
  - The developer will work on this copy of the source code, as usual (files are directly accessible and editable).
- `cvs -d repository-address checkout module`
  - Create in the current directory a working copy of the module `module` located in the given repository
- A repository address can be :
  - A local path, like `:local:/home/user/cvsrepo/`
  - The address of a CVS pserver, like `:pserver:user@host:/var/cvsrepo/`
  - Using SSH, by setting the environment variable `CVS_RSH` to `ssh`, and using an address like `:ext:user@host:/var/cvsrepo/`

Simple usage

- Working copy creation to be done once for all !
- **Modifications** of the project files
  - Files are modified directly, as usual, nothing special is necessary. CVS knows the contents of the original version of the files and is able to compute the list of modifications made by the developer.
  - Every directory contains a `CVS` directory that should not be modified.
- Send the modifications to the server : **commit**
  - `cvs commit`
  - Runs a text editor to write the message that describes the commit. This message will be preserved forever in the history. Very important to describe your change in details !
- Fetch the modifications made by other developers : **update**
  - `cvs update`

Example

```
$ cvs -d :local:/tmp/repo/ checkout project
cvs checkout: Updating project
U project/README
U project/a.c
U project/b.c
$ cd project/
project$ vi README
project$ cvs commit -m "Adding infos"
cvs commit: Examining .
/tmp/repo/project/README,v  <--  README
new revision: 1.3; previous revision: 1.2
project$ cvs update
cvs update: Updating .
U a.c
project$
```

File management

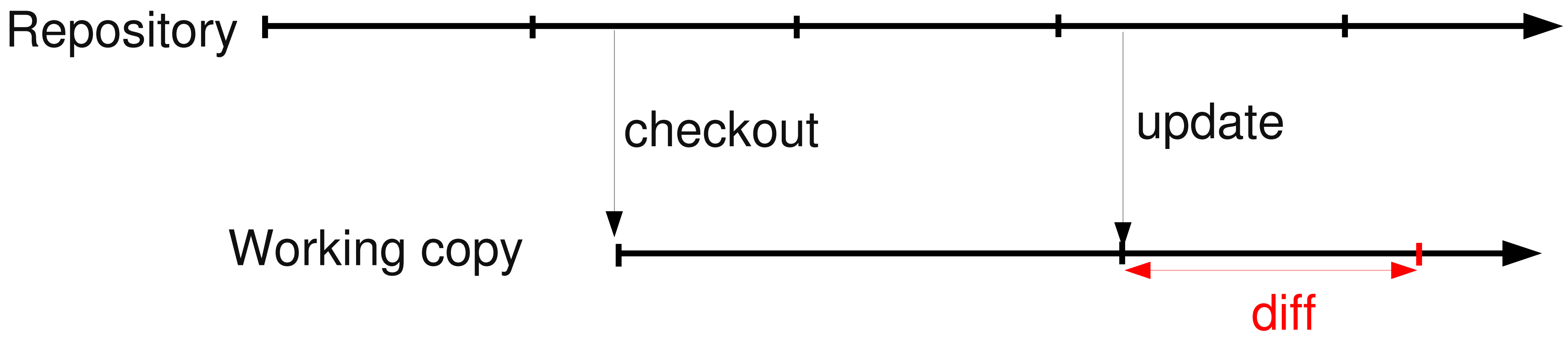
- When new files or directories are created inside the project, they are not automatically taken into account by CVS
- They must be explicitly added with the **add** command
  - `cvs add file1.c`
  - The new file is not propagated to the repository until the next commit
  - Same thing with directories
- Files and directories can be removed with the **remove** command
- Issues fixed in Subversion
  - Files and directories cannot be renamed without losing the history
  - Directory removal is badly handled in CVS

Example

```
project$ vi c.c
project$ cvs add c.c
cvs add: scheduling file `c.c' for addition
cvs add: use `cvs commit' to add this file permanently
project$ cvs commit -m "New file c.c"
cvs commit: Examining .
/tmp/repo/project/c.c,v  <--  c.c
initial revision: 1.1
project$ rm a.c
project$ cvs remove a.c
cvs remove: scheduling `a.c' for removal
cvs remove: use `cvs commit' to remove this file permanently
project$ cvs commit -m "Remove a.c"
cvs commit: Examining .
/tmp/repo/project/a.c,v  <--  a.c
new revision: delete; previous revision: 1.2
```

State of the working copy

- To get informations about the state of the working, use the **status** command
  - Will tell the version of the file, if they have been locally modified, etc.
- To see the modifications made to the project and not committed yet, use the **diff** command



Diff command example

```
project$ cvs diff
cvs diff: Diffing .
Index: c.c
===================================================================
RCS file: /tmp/repo/project/c.c,v
retrieving revision 1.1
diff -u -r1.1 c.c
--- c.c  28 Jan 2009 16:48:11 -0000 1.1
+++ c.c  28 Jan 2009 16:50:41 -0000
@@ -1 +1,2 @@
 Test.
+Test2.
```

Using the history

- See the commit messages
  - `cvs log`
  - `cvs log file.c`
- See the differences between two past revisions
  - `cvs diff -r 1.1 -r 1.2 file.c`
  - With CVS, the versioning is done on a per-file basis : a commit is not an entity that can be referred to once completed. It makes the usage of the history very complicated. This is fixed in Subversion.
- See who made a change
  - `cvs annotate`
- A graphical interface, either a graphical client or a web client, will be very useful to navigate and use the history efficiently

Conflict management in CVS (1)

- After changing a file, we try to commit the change to the server

```
$ cvs commit -m "Modification"
cvs commit: Examining .
cvs commit: Up-to-date check failed for `main.c'
cvs [commit aborted]: correct above errors first!
```

- The file has been modified on the server since our last update. So we must make merge the modifications we have done with the modifications of the other developers, by updating our working copy.

```
$ cvs update
cvs update: Updating .
RCS file: /tmp/repo/project/main.c,v
retrieving revision 1.1
retrieving revision 1.2
Merging differences between 1.1 and 1.2 into main.c
rcsmerge: warning: conflicts during merge
cvs update: conflicts found in main.c
C main.c
```

Conflict management in CVS (2)

- Inside main.c

```
#include <stdio.h>

int main(void) {
<<<<<<< main.c
    printf("Bonjour monde\n");
=======
    printf("Hola mundo\n");
>>>>>>> 1.2
    return 0;
}
```

Our modification !

The modification made by the other developer

Conflict resolution in CVS

- The conflict must be manually resolved by the developer, no automated tool can resolve such conflicts
- The conflict is resolved directly in the file by removing the markers and merging the modifications (either selecting one of them or creating a new version based on both modifications)
- Once resolved, the file can be committed as usual

```
project$ cvs commit -m "In French"
cvs commit: Examining .
/tmp/repo/project/main.c,v  <--  main.c
new revision: 1.3; previous revision: 1.2
```

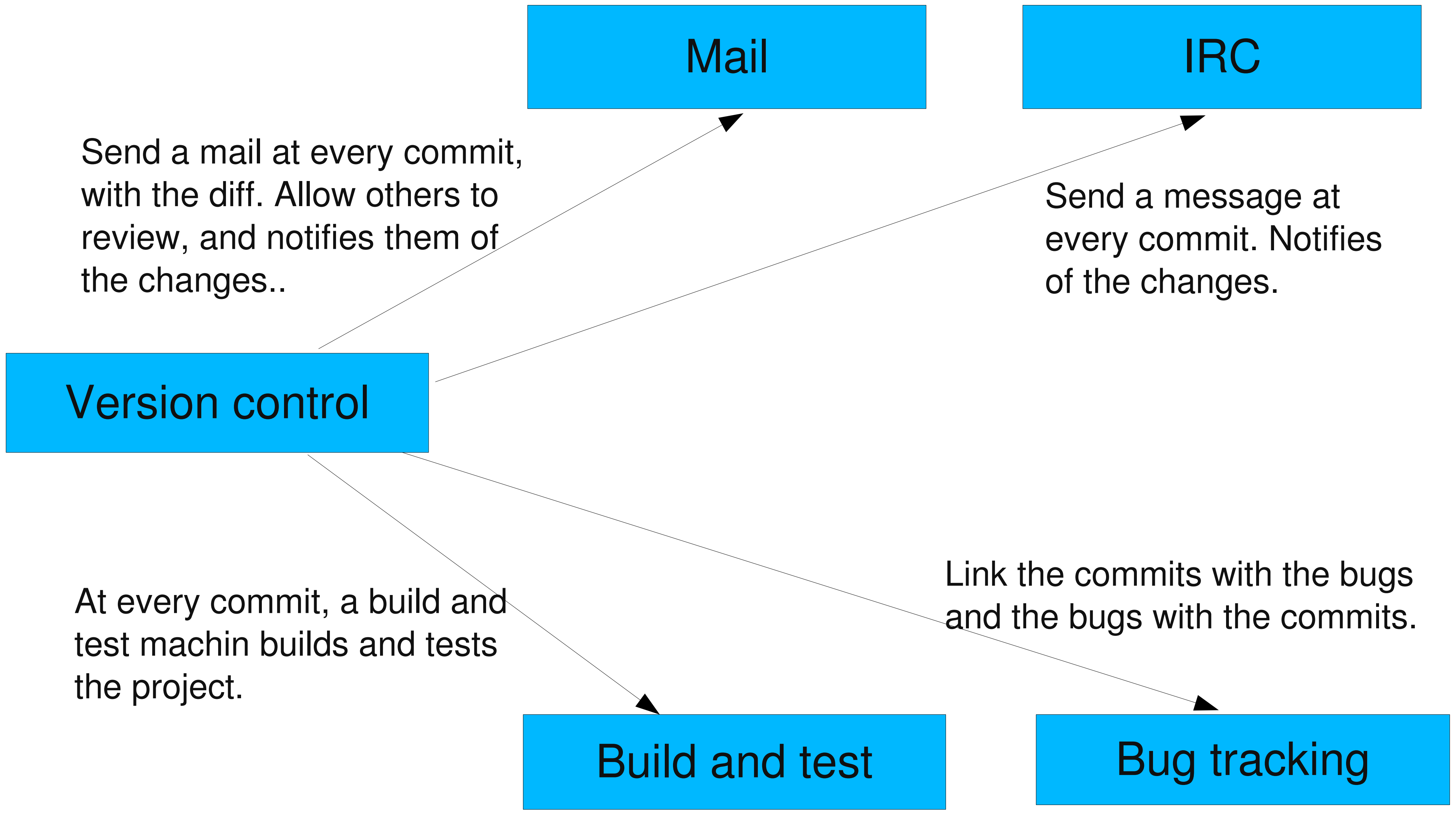
Repository initialization

- A repository must be initialized using the init command :
  - `mkdir /home/user/cvsrepo`
  - `cvs -d :local:/home/user/cvsrepo init`
- Once initialized, it can be accessed locally or remotely through SSH. Remote access through pserver will require additional configuration, see the CVS documentation.
- If already existing projects have to be imported in the repository, use the import command
  - `cd project`
  - `cvs -d :local:/home/user/cvsrepo import modulename vendortag releasetag`
    - `vendortag`, symbolic name for the branch
    - `releasetag`, symbolic name for the release

Tags and branches

- Tags allow to identify a given version of the project through a meaningful symbolic name
  - Useful for example if the version has been delivered to the test team or to a customer.
- Tags are created using the `cvs tag` command.
- Branches allow to create parallel flow of developments
  - Maintenance of a previous release
  - Development of experimental new features
- Created using the `-b` option of the `cvs tag` command
- Branching and merging is relatively complicated, and falls outside the scope of this training.

Connection with other tools



Send a mail at every commit, with the diff. Allow others to review, and notifies them of the changes..

Send a message at every commit. Notifies of the changes.

At every commit, a build and test machin builds and tests the project.

Link the commits with the bugs and the bugs with the commits.

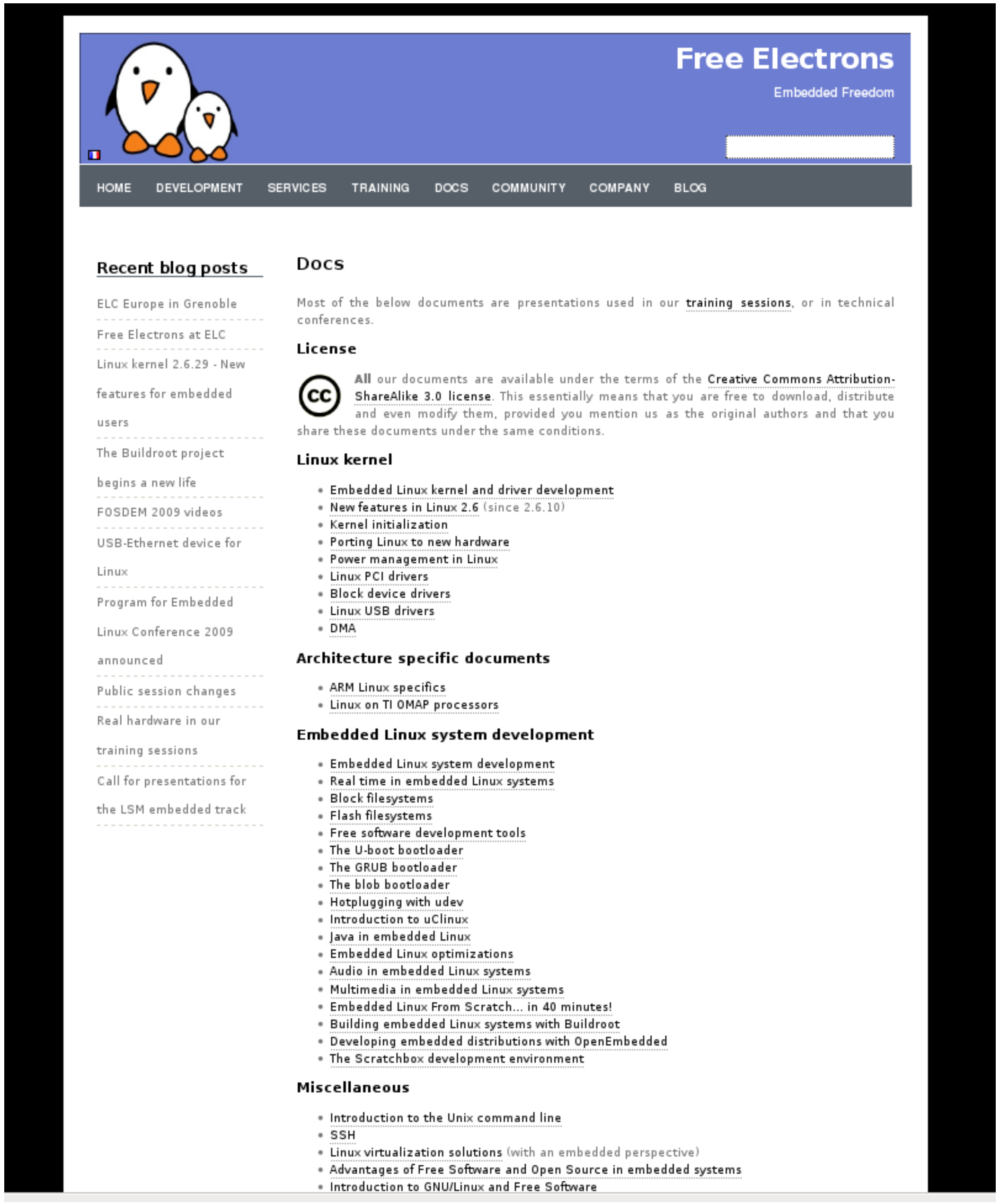
Why Subversion ?

- Because CVS has many drawbacks and short-coming
  - Not possible to simply rename files and directories while preserving the history
  - No atomic commits identifying the commit as a whole, making it difficult to navigate in the history, revert commits, and is the source of repository incoherency in case of crashes
  - Poor branching and merging capabilities
- In usage, Subversion is very similar to CVS : the commands are exactly the same.
  - Fixes all CVS short comings
  - And provides interesting branching and merging features such as merge-tracking.
  - Many large-scale projects already made the switch.

Distributed version control systems

- Since a few years, a new generation of version control systems
- Distributed version control instead of a centralized approach
- Principles
  - No technically-central repository, every copy is a repository
  - All developers can create local branches, share these branches with other developers without asking a central authority.
  - Advanced branching and merging capabilities.
- More and more commonly used in free software projects (Linux kernel, X.org, etc.)
- Most commonly used tools : Git, Mercurial

Related documents



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