The Unix and GNU / Linux command line

Michael Opdenacker
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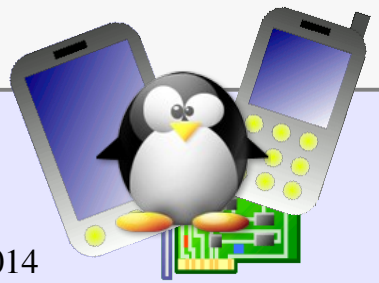

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Document sources, updates and translations:
http://free-electrons.com/training/intro_unix_linux

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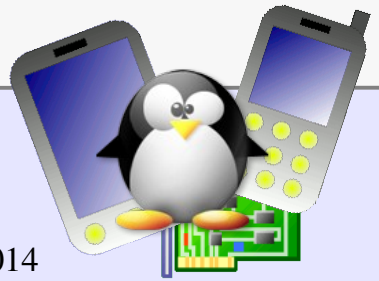

Training Contents (1)

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

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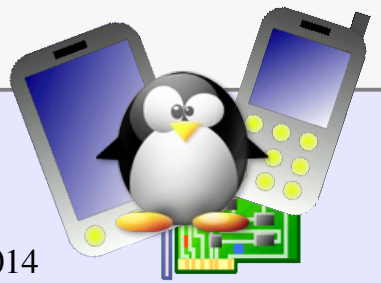

Training contents (2)

Standard I/O, redirections, pipes

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

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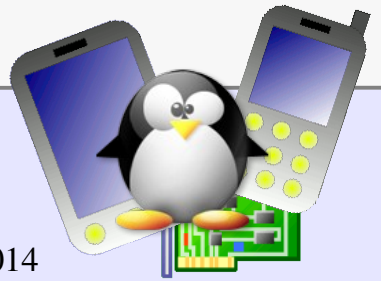

Training Contents (3)

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

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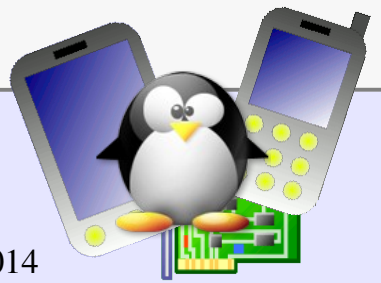
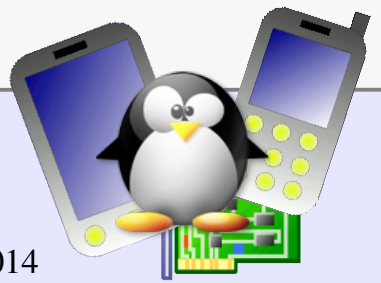


Training contents (4)

Miscellaneous

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



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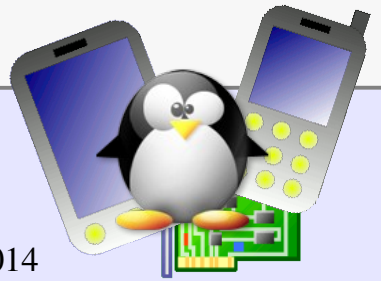
Training contents (5)

System administration basics

- File ownership
- Setting up networking
- Filesystems: creating and mounting

Going further

- Getting help, accessing manual pages
- Searching the Internet for resources



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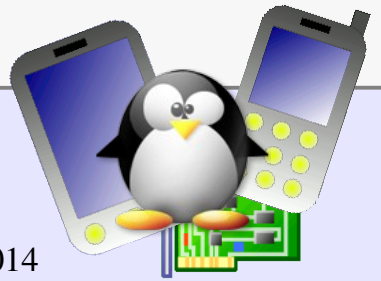
GNU / Linux and Free Software

- This presentation included an introduction to Free Software and Open Source: operating systems, applications, key projects and rules for success.
- It is now available as a separate presentation: http://free-electrons.com/articles/freesw



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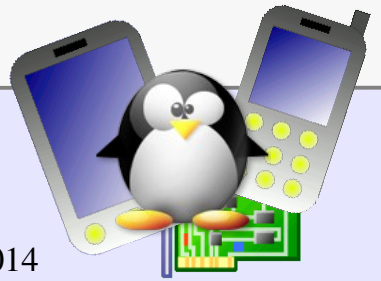
Unix filesystem



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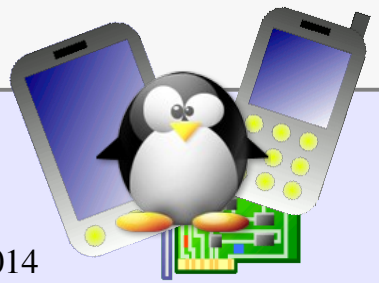
Everything is a file

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



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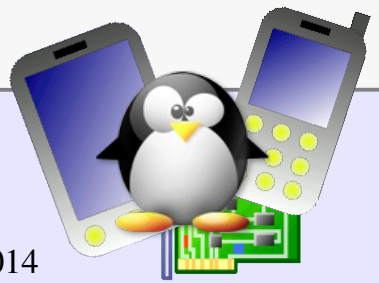
File names

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
```



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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).

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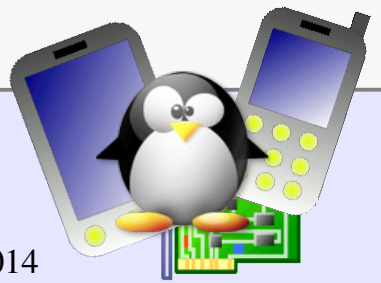

GNU / Linux filesystem structure (1)

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 binaries
`/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

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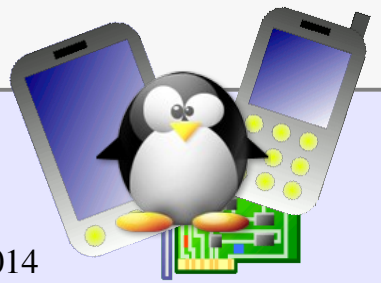
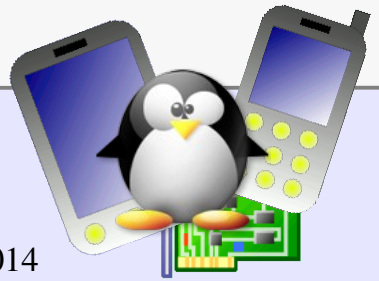


GNU / Linux filesystem structure (2)

`/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.)



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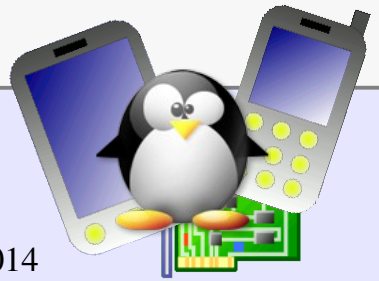
GNU / Linux filesystem structure (3)

`/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/



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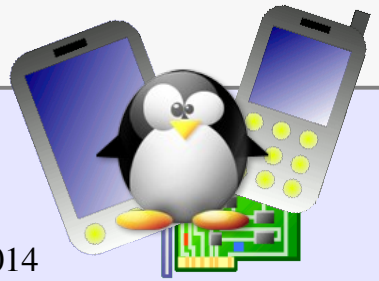
Shells and file handling



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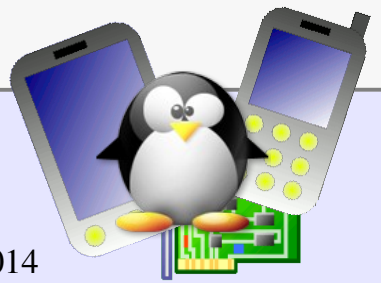
Command line interpreters

- 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...)



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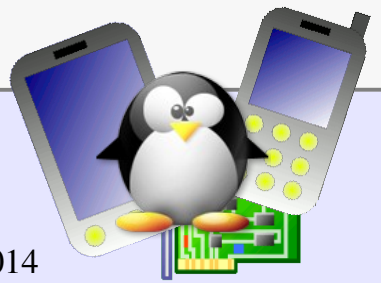
Well known shells

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.



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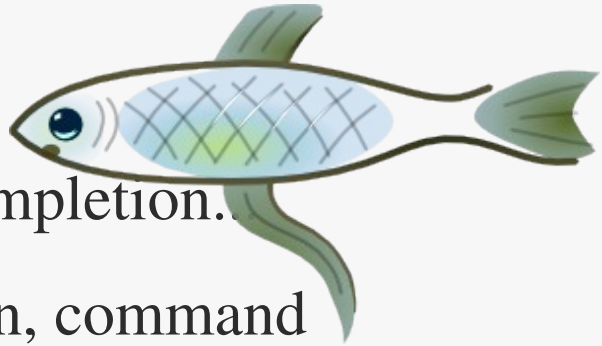
fish: a great new shell

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.

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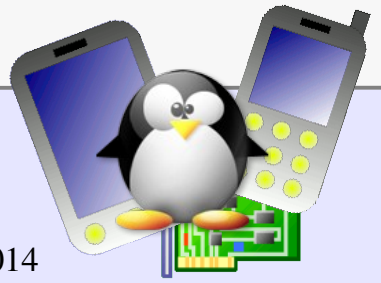
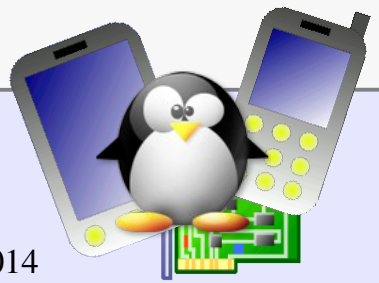


ls command

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



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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`

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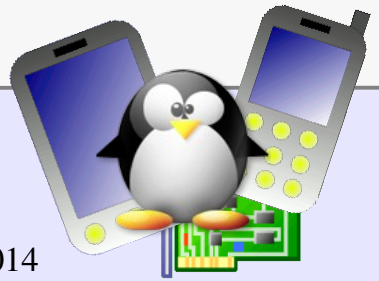

Special directories (1)

`./`

- 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 ..`

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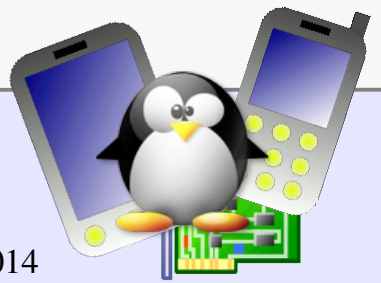


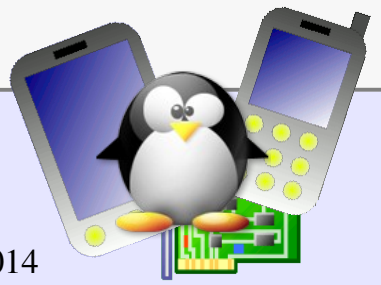
Special directories (2)

`~/`

- 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.



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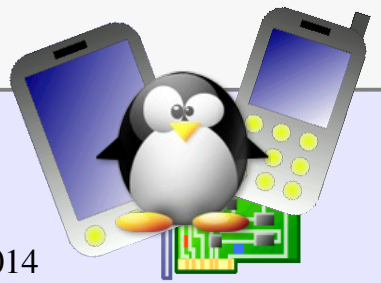
The cd and pwd commands

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



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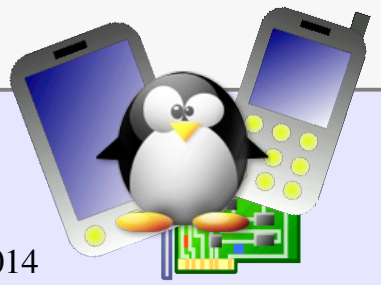
The cp command

- `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.



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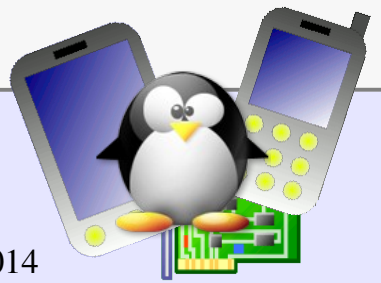
Smart directory copy with rsync

`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.



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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.

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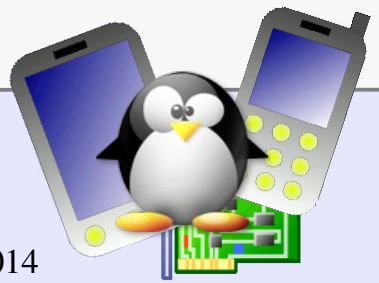

rsync examples (2)

- 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.

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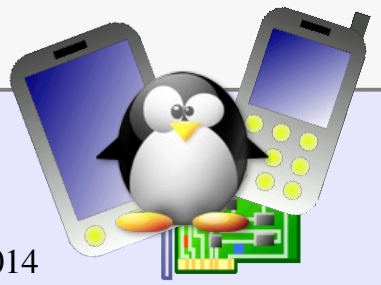
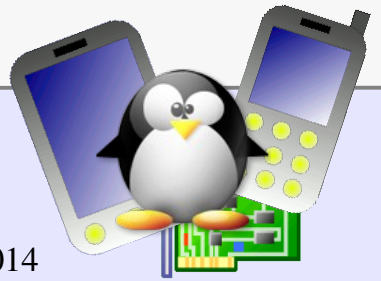


mv and rm commands

- `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.



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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).

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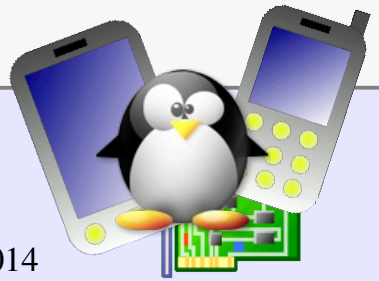
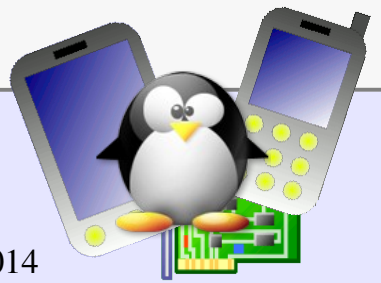


Displaying file contents

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).



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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
```


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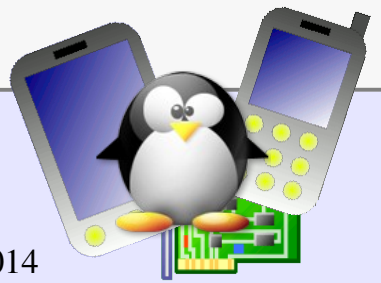
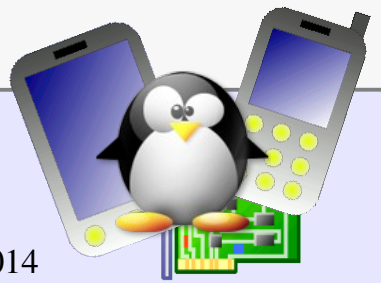


The grep command

- `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`.



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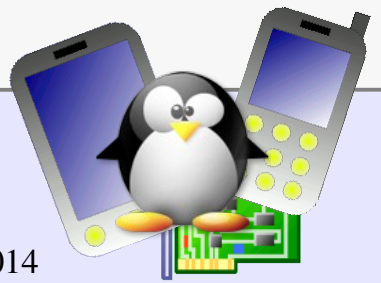
The sort command

- `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!



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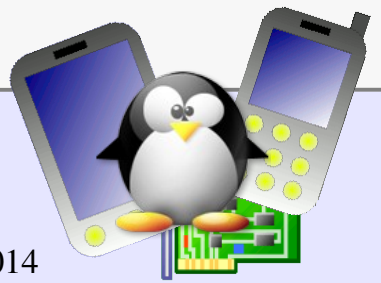
Symbolic links

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.



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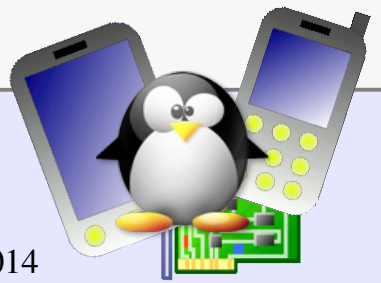
Creating symbolic links

- 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!



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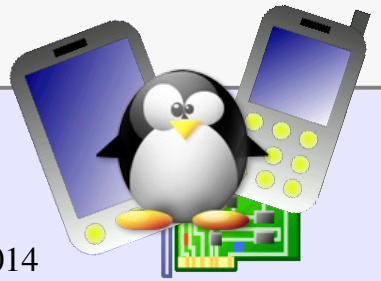
Hard links

- 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.



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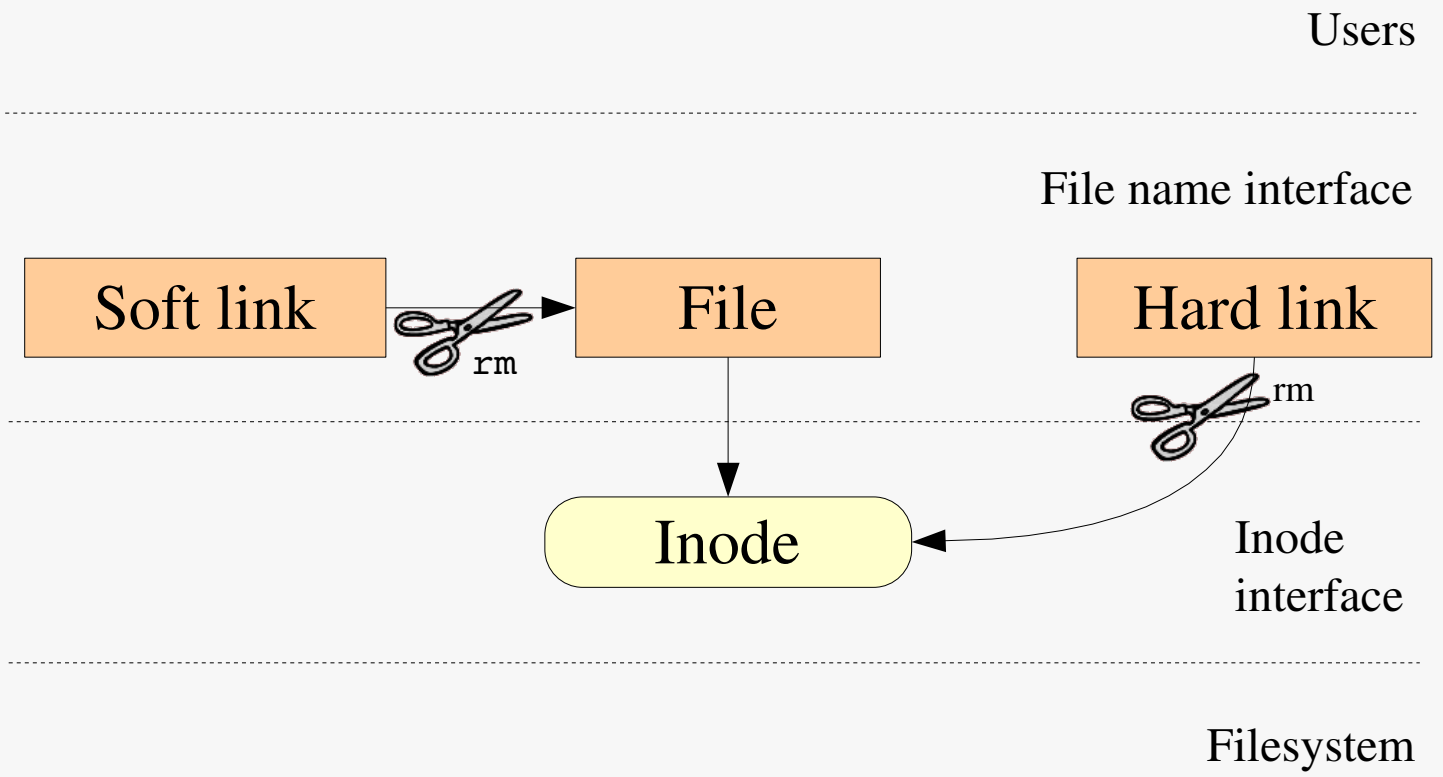
Files names and inodes

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



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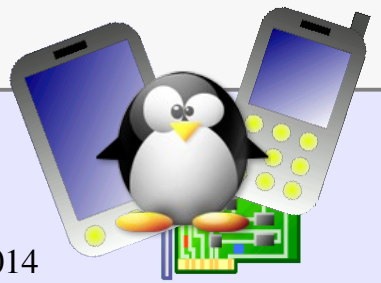


File access rights

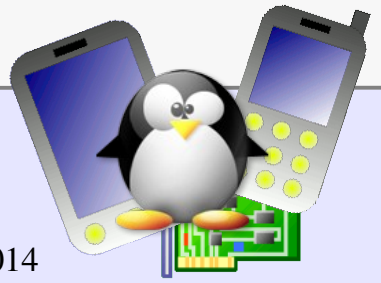
Use `ls -l` to check file access rights

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



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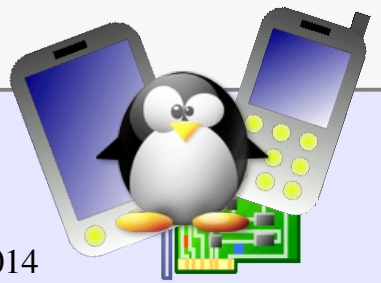
Access right constraints

- `x` without `r` is legal but is useless
  You have to be able to read a file to execute it.
- Both `r` and `x` permissions needed for directories:
  `x` to enter, `r` to list its 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.



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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...

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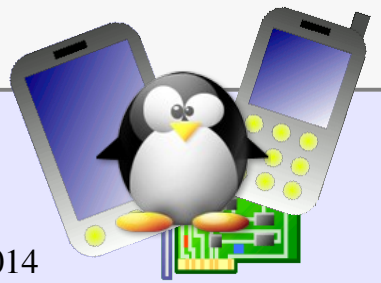
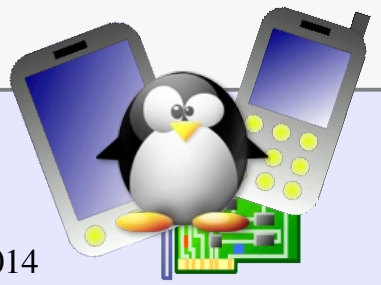


chmod: changing permissions

- `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.



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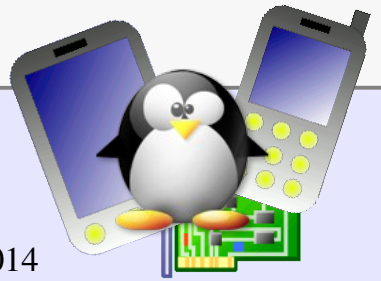
More chmod (1)

```
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.



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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.

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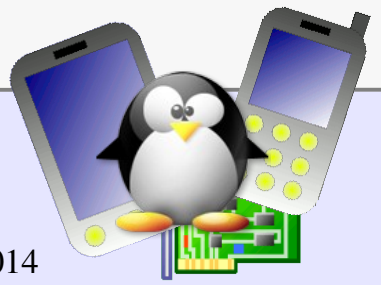
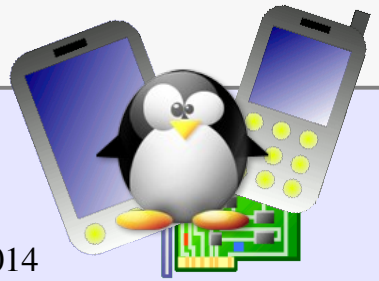


Standard I/O, redirections, pipes



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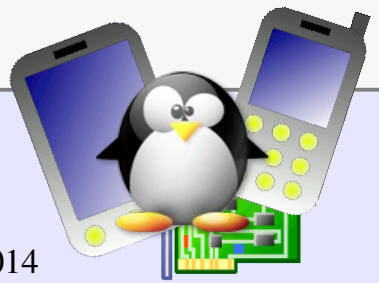
Standard output

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



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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.

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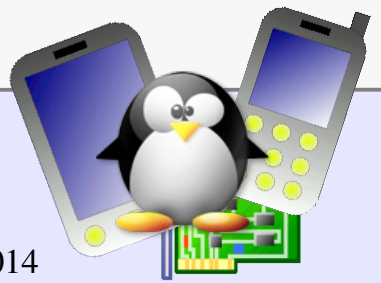


Standard input

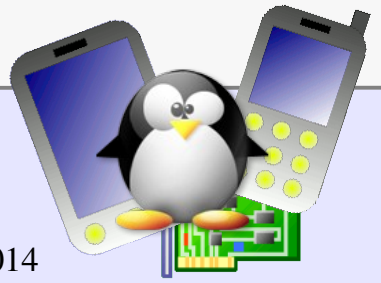
More about command input

- 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.



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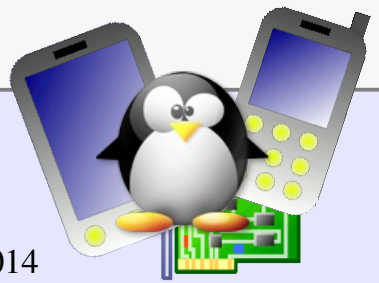
Pipes

- 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!



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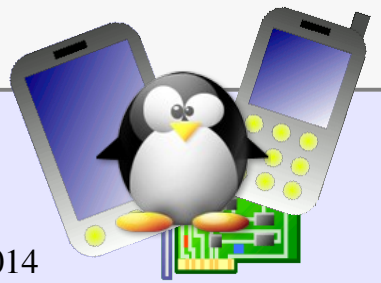
The tee command

```
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`.



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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
```


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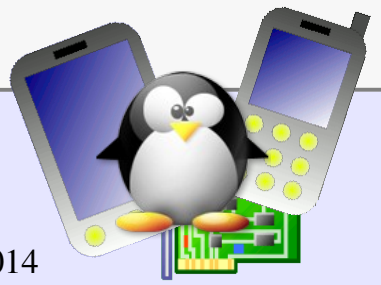
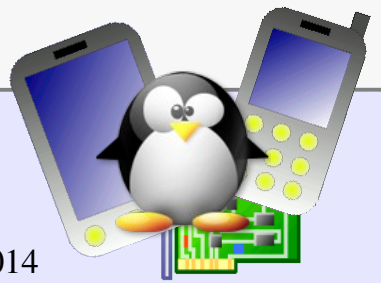


The yes command

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)



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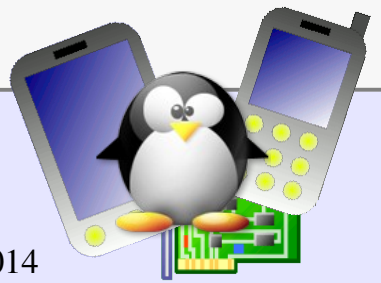
Special devices (1)

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



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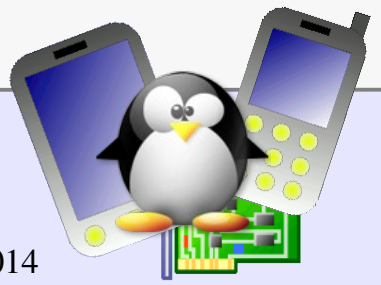
Special devices (2)

- `/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.



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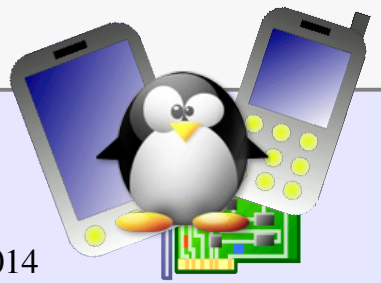
Special devices (3)

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

See `man full` for details.



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Task control

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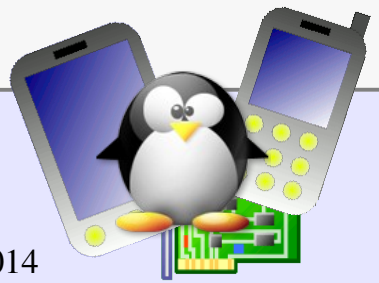
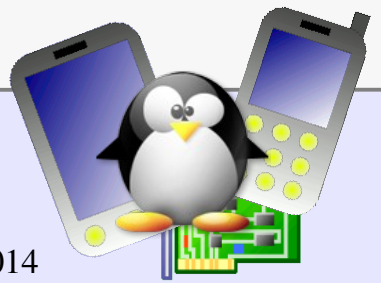


Full control on tasks

- 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.



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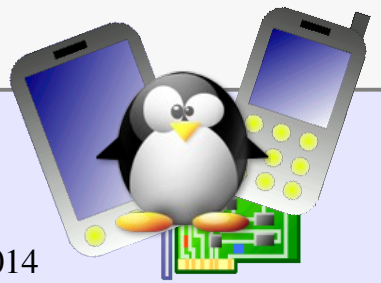
Processes

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

Processes

- 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...



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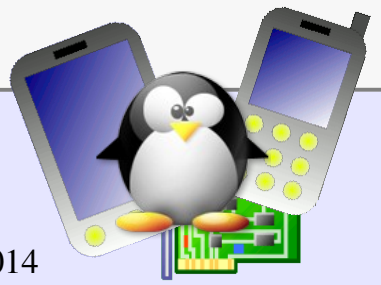
Running jobs in background

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 &
```



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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.

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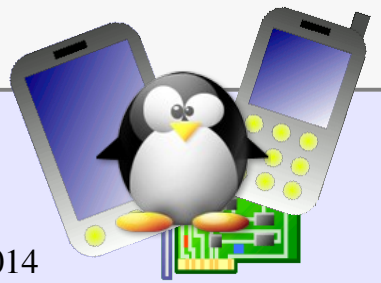

Job control example

```
> 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
```


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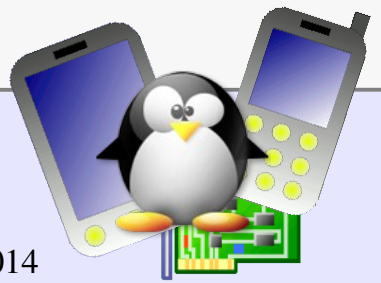

Listing all processes

... 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)...

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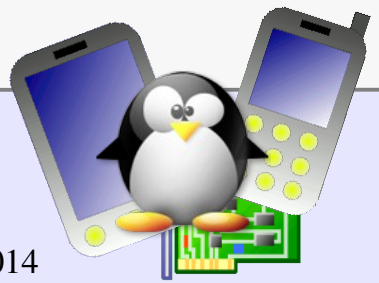


Live process activity

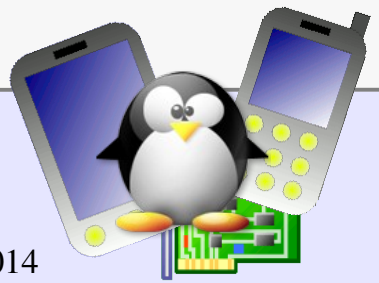
- `top` – Displays most important processes, sorted by cpu percentage

```
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.



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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.

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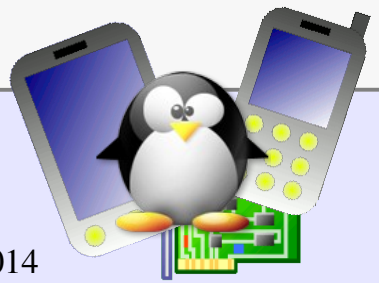
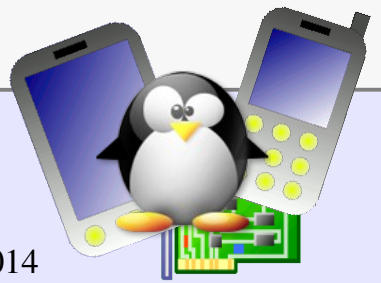


Killing processes (2)

- `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.



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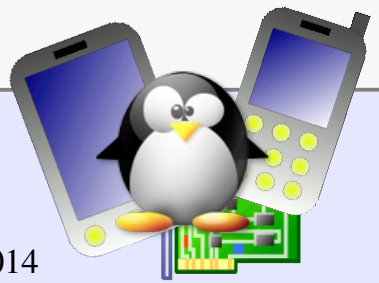
Recovering from stuck graphics

- 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.



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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).

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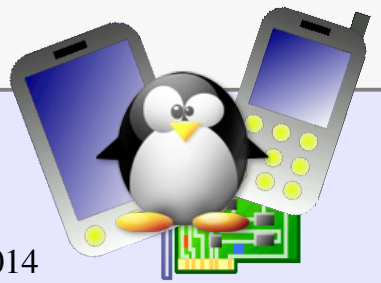


Quoting (1)

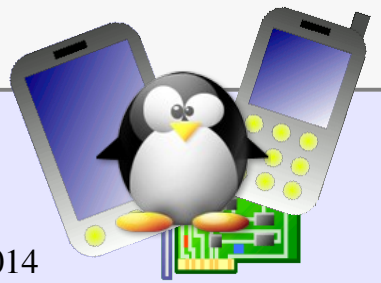
Double (") quotes can be used to prevent the shell from interpreting spaces as argument separators, as well as to prevent file name pattern expansion.

```
> 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
```



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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
```


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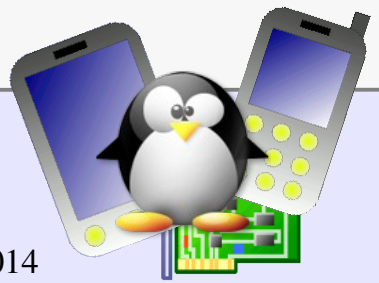
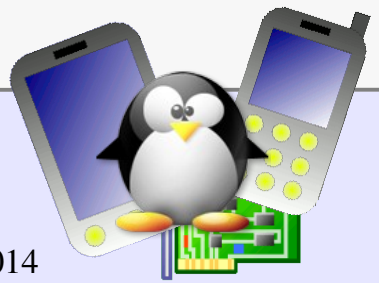


Measuring elapsed time

```
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)



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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.

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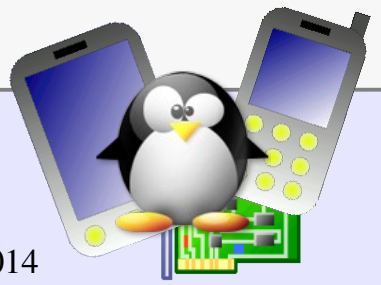


Shell variables examples

Shell variables (bash)

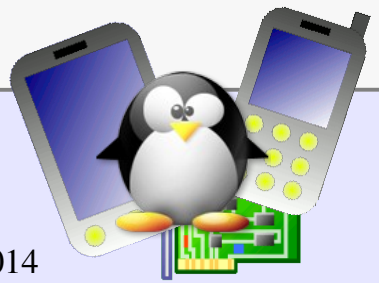
```
projdir=/home/marshall/coolstuff
ls -la $projdir; cd $projdir
```

Environment variables (bash)

```
cd $HOME
```

```
export DEBUG=1
./find_extraterrestrial_life
```

(displays debug information if `DEBUG` is set)



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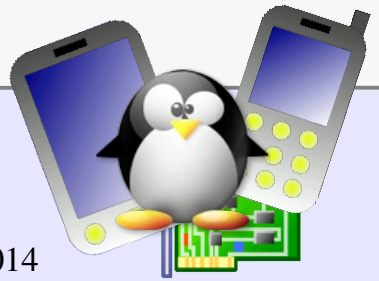
Main standard environment variables

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



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PATH environment variables

- `PATH`
  Specifies the shell search order for commands

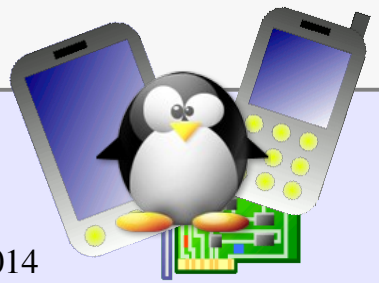
```
/
home/acox/bin:/usr/local/bin:/usr/kerberos/bin:
/usr/bin:/bin:/usr/X11R6/bin:/bin:/usr/bin
```

- `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
```



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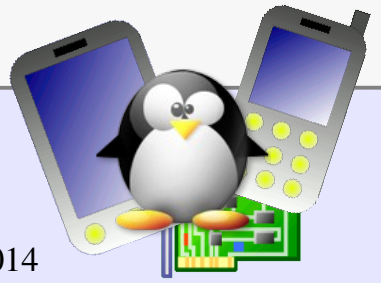
PATH usage warning

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`



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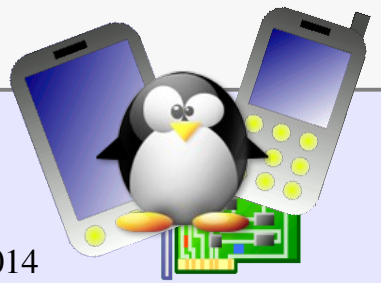
Alias

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).



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The which command

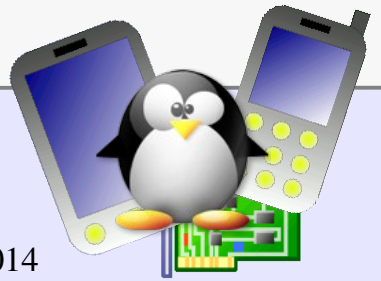
Before you run a command, `which` tells you where it is found

```
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.
```



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~/.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.

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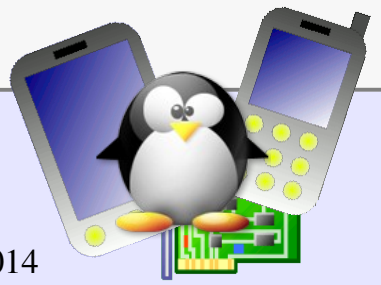
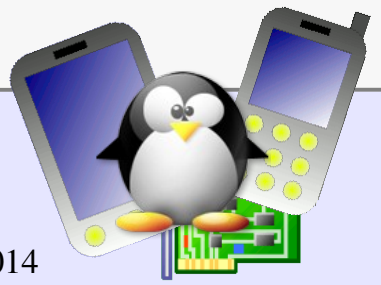


Command editing

- 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.



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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`

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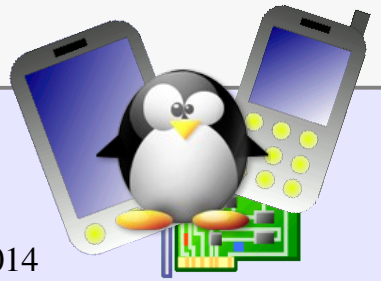
Command history (2)

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



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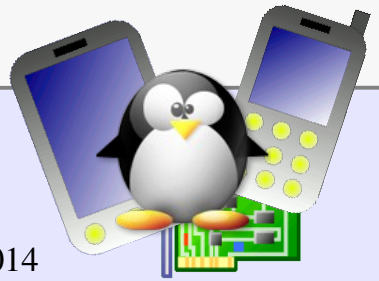
Miscellaneous

Text editors



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Text editors

Graphical text editors

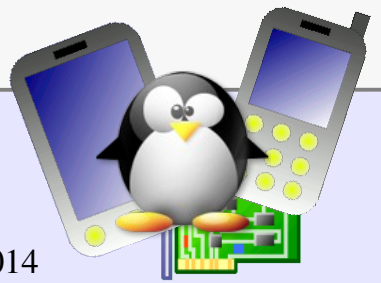
Fine for most needs

- nedit
- Emacs, Xemacs

Text-only text editors

Often needed for sysadmins and great for power users

- vi
- nano



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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

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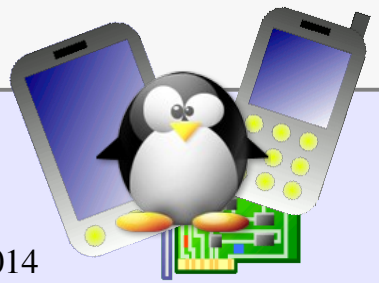
nedit screenshot

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.
```



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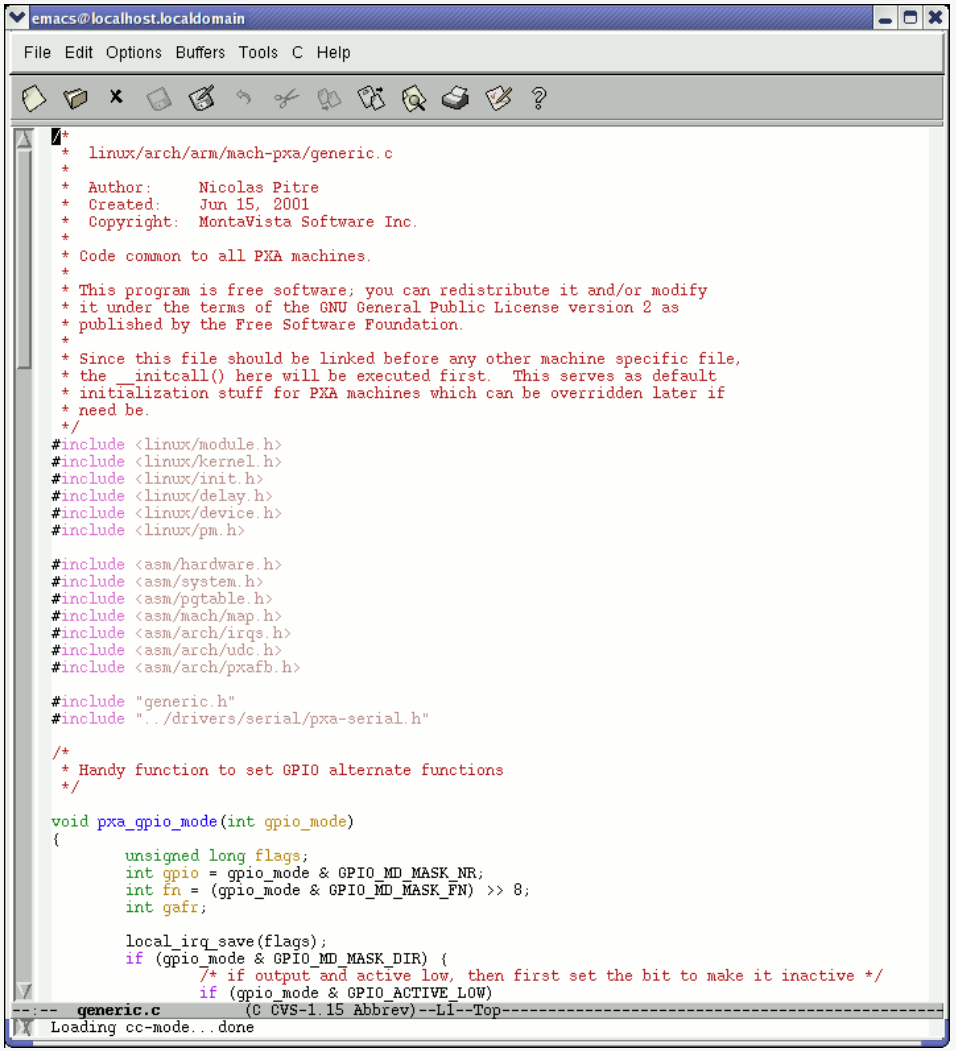
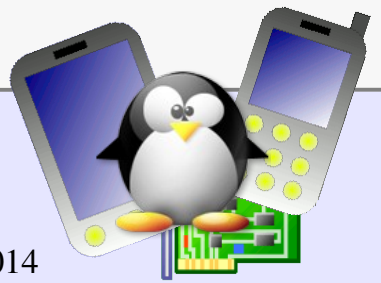
Emacs / Xemacs



- 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.



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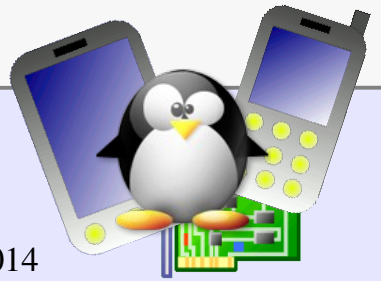
vi

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.



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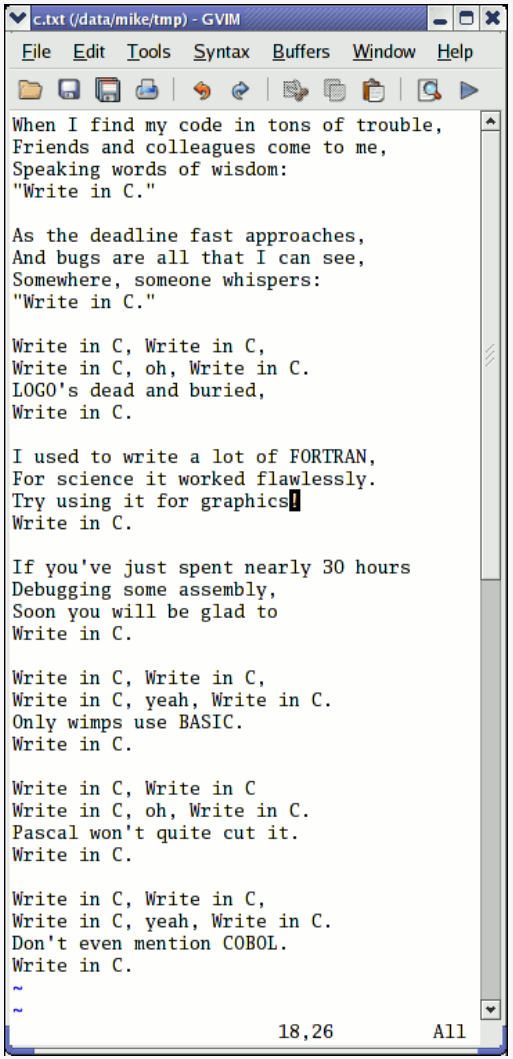
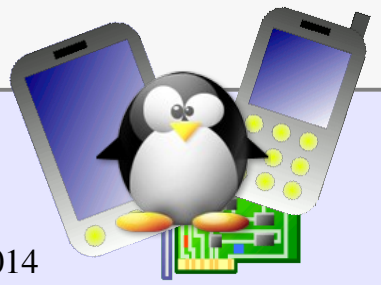
vim - vi improved



- `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)



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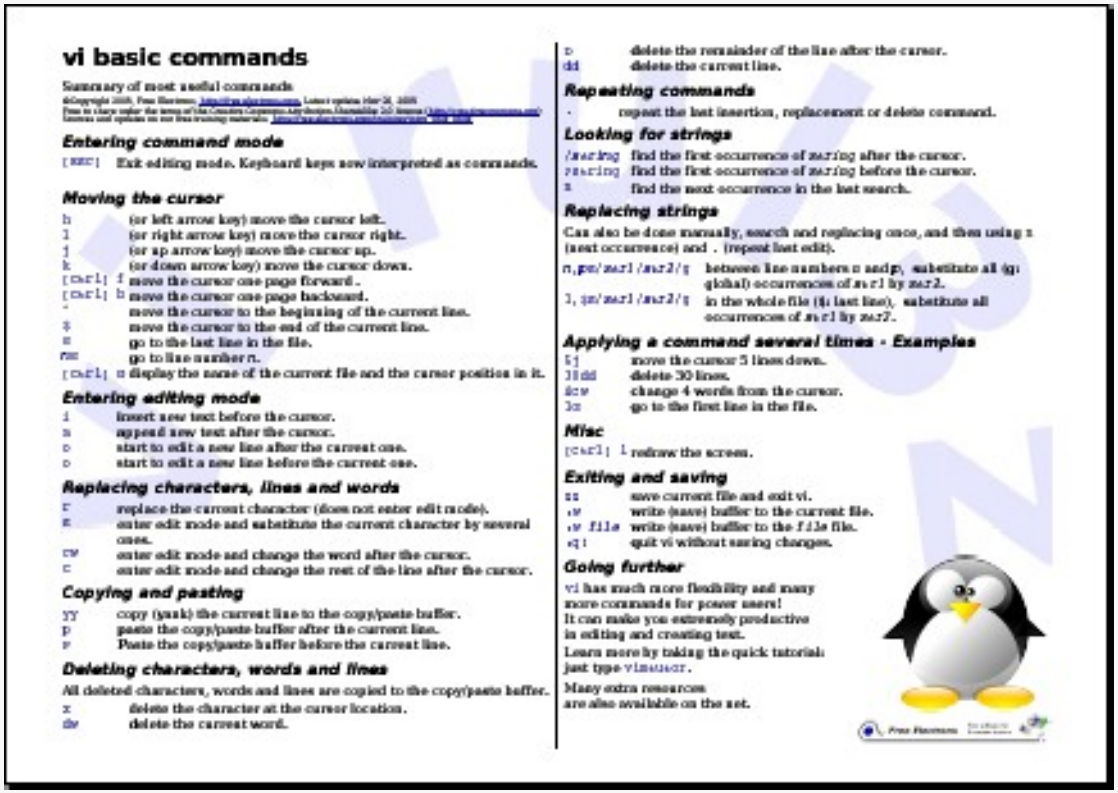
vi basic commands



vi basic commands

Summary of most useful commands

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.
j (or up arrow key) move the cursor up.
k (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,pg/str1/str2/g between line numbers n and p, substitute all (g: global) occurrences of str1 by str2.
1,$g/str1/str2/g in the whole file (1: 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.
dcw 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/training/intro_unix_linux

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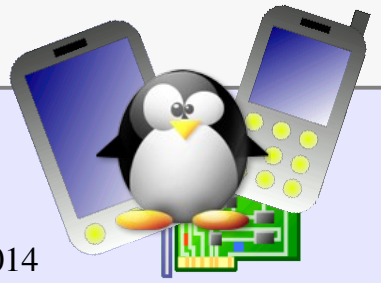
GNU nano

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.



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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
```

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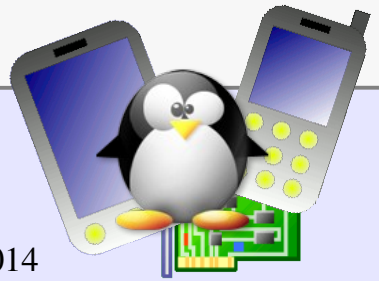
Miscellaneous

Compressing and archiving



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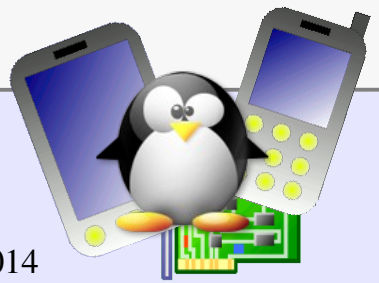
Measuring disc usage

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.



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Measuring disk space

- `df -h <dir>`

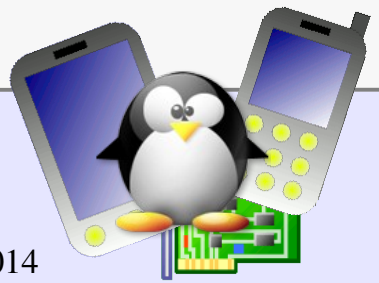
  Returns disk usage and free space for the filesystem containing the given directory.
  Similarly, the `-h` option only exists in GNU `df`.

- 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.



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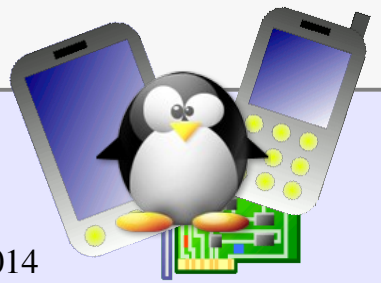
Compressing

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.
- Using 7-zip
  Much better compression ratio than bzip2 (up to 10 to 20%).
  See the 7-zip page for details.



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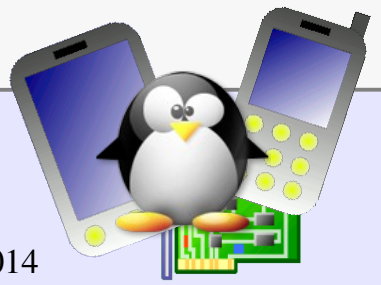
Archiving (1)

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
  ```



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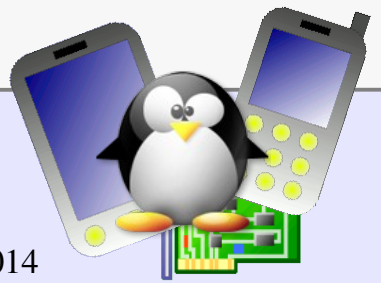
Archiving (2)

- 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.



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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`
- Examples (which one will you remember?)
  - `gtar jcvf bills_bugs.tar.bz2 bills_bugs`
  - `tar cvf - bills_bugs | bzip2 > bills_bugs.tar.bz2`

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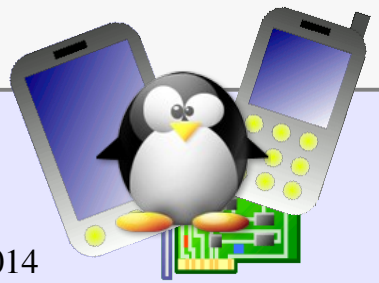
7-zip (1)

http://www.7-zip.org/
Now the best solution for your archives!

- License: GNU LGPL
- 7-zip compresses much better than bzip2 (up to 10 or 20%) and of course zip (30 to 50 %).
  Benchmark compressing Knoppix 5.0.1: -22% (vs. bzip2)!
- Caution: 7-zip cannot replace tar for archiving on Unix.
  It doesn't keep file owner and group information,
  but of course keeps file permissions.
  Use it to compress tar archives!



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7-zip (2)

- 7-zip supports strong AES-256 encryption.
  No need to encrypt in a separate pass.
- At last a solution available for Unix and Windows!
  The tool supports most other compression formats:
  zip, cab, arj, gzip, bzip2, tar, cpio, rpm and deb.

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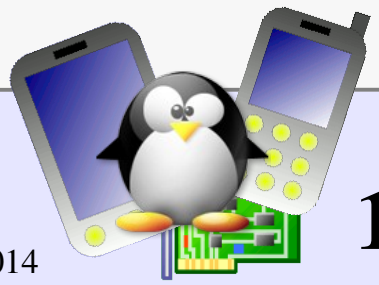


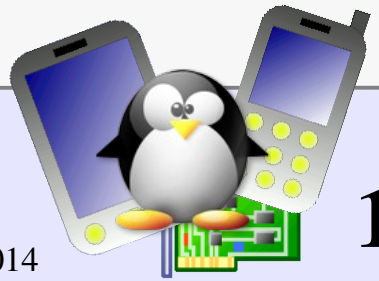
Using 7-zip

Archive files are usually created with a `.7z` extension

- Creating an archive: (`a`: add)
  ```
  7z a <archive> <files or directories>
  ```
- List files in archive: (`l`: list)
  ```
  7z l <archive>
  ```
- Extracting from a 7-zip archive: (`e`: extract)
  ```
  7z x <archive>
  ```
- Backup a directory (keeping owner and group information):
  ```
  tar cf - <dir> | 7z a -si dir.tar.7z
  ```
- Restore this backup:
  ```
  7z x -so dir.tar.7z | tar xf -
  ```

standard input

standard output



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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.

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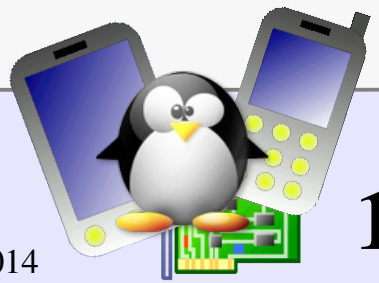
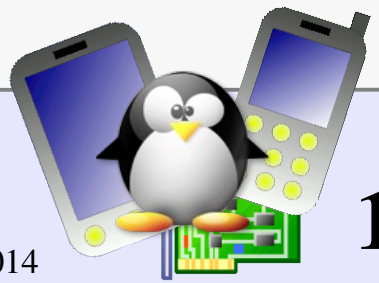


Miscellaneous
Printing



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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.

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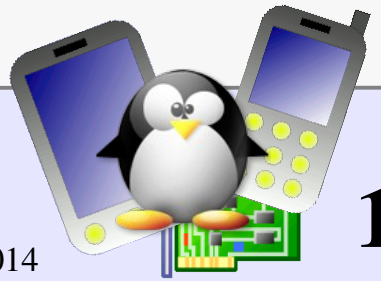

Printing commands

- 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...

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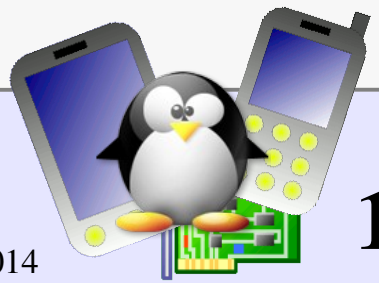


Print job control

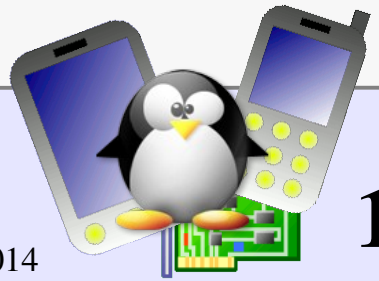
- `lpq [-P<queue>]`

  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.



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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
```


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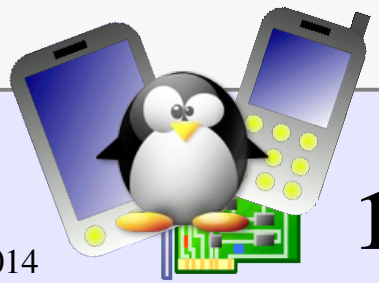
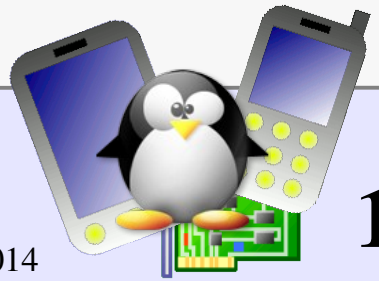


Miscellaneous

Comparing files and directories



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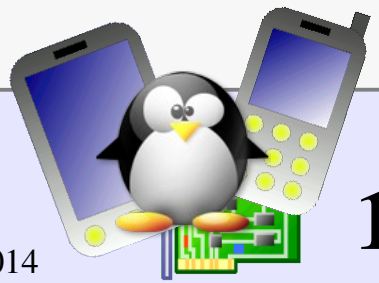
Comparing files and directories

- `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.
- To investigate differences in detail, better use graphical tools!



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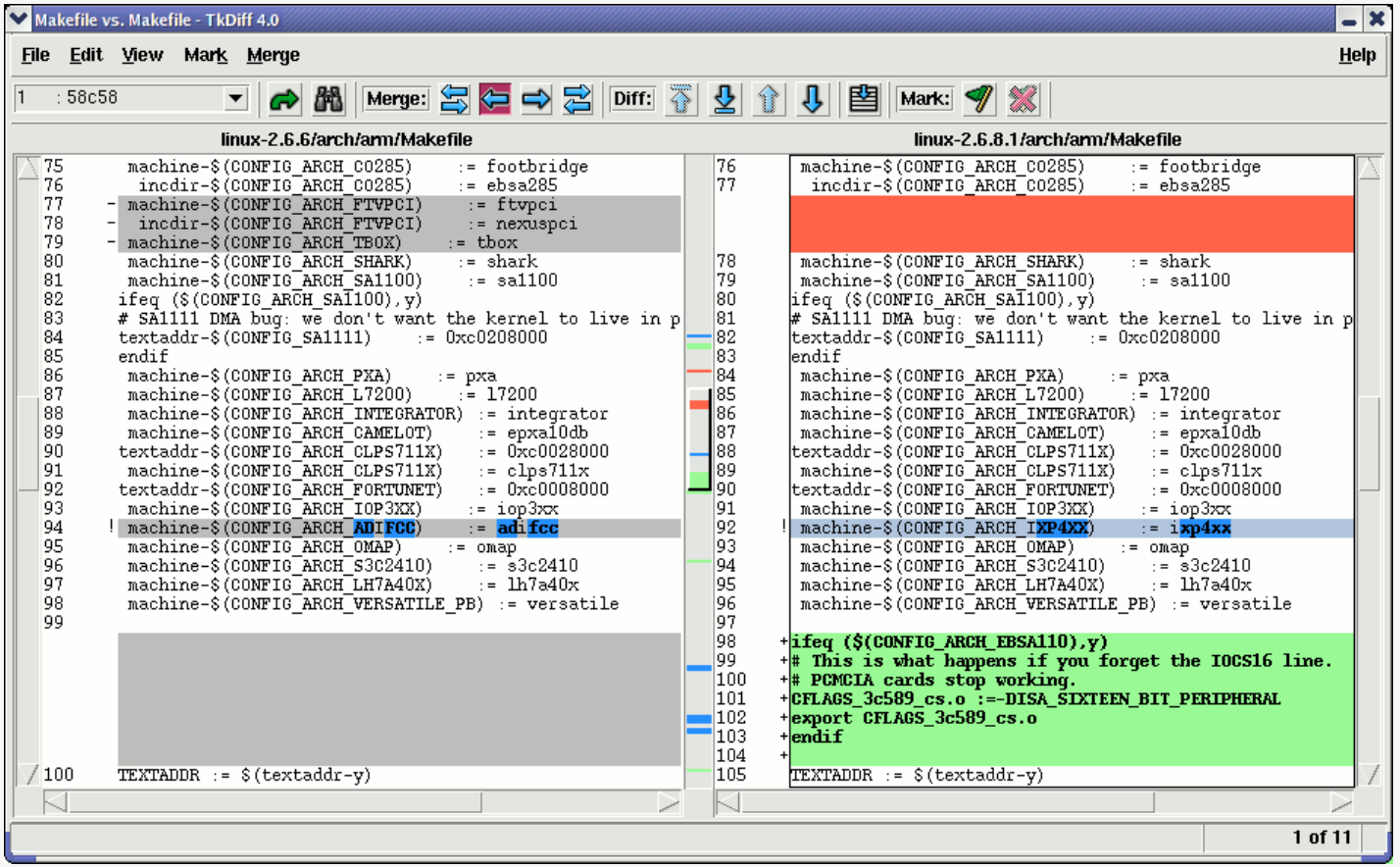
tkdiff

http://tkdiff.sourceforge.net/

Useful tool to compare files and merge differences



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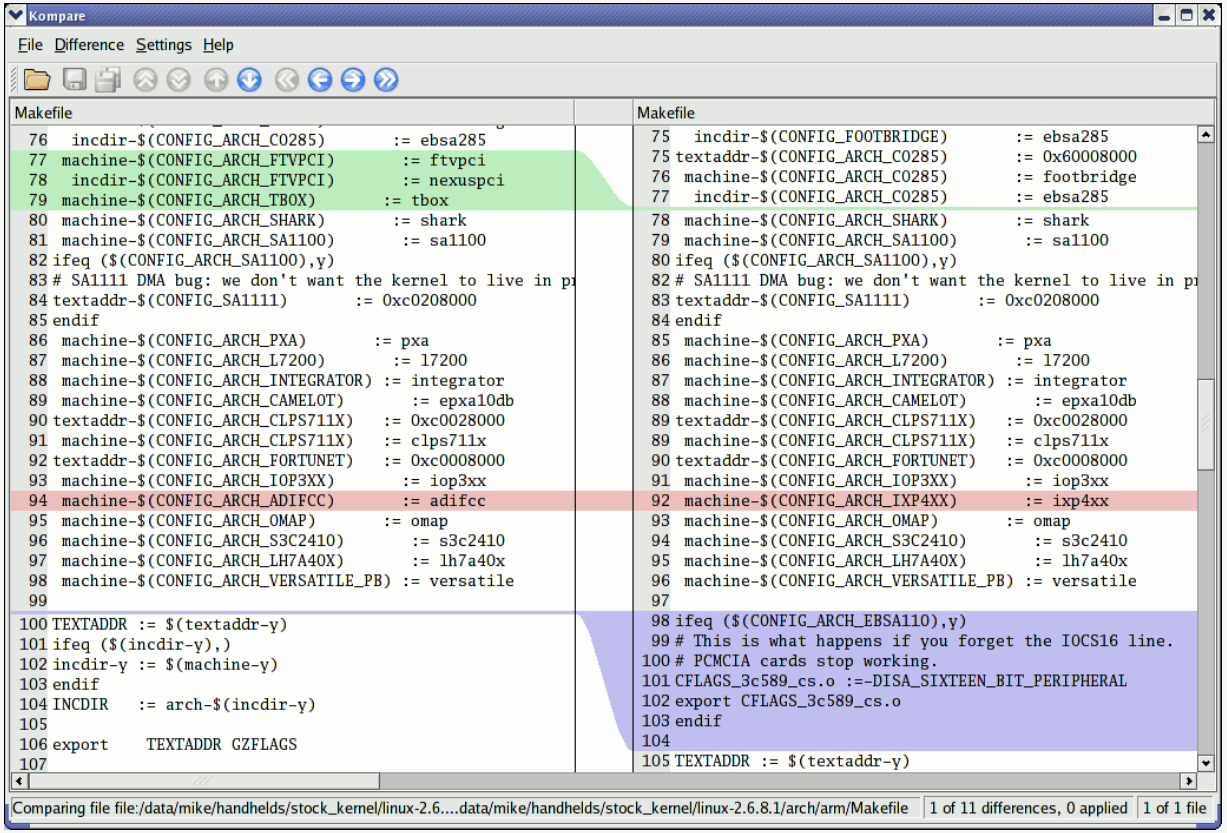
kompare

Another nice tool to compare files and merge differences

Part of the `kdesdk` package (Fedora Core)



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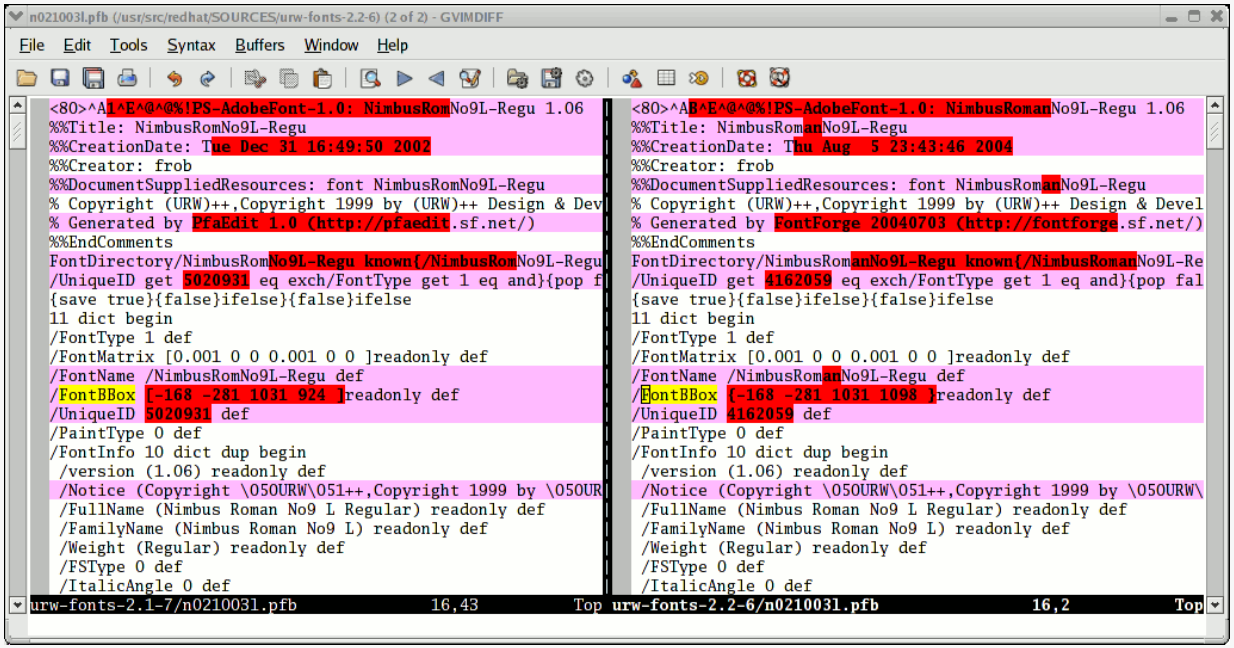
gvimdiff

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!



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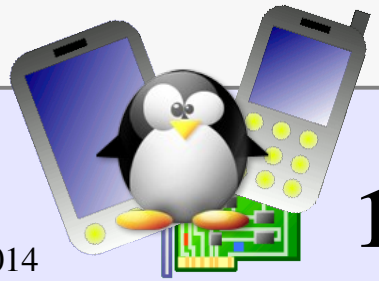
Miscellaneous

Looking for files



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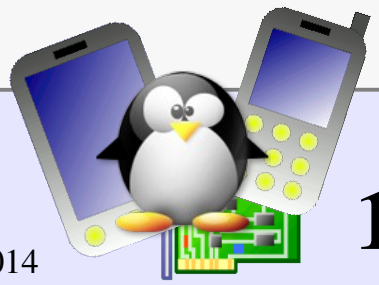
The find command

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.



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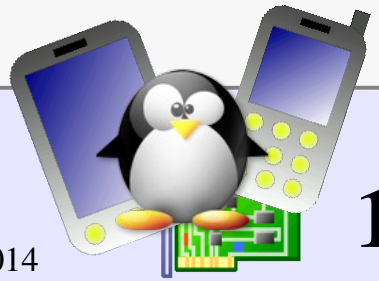
The locate command

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.



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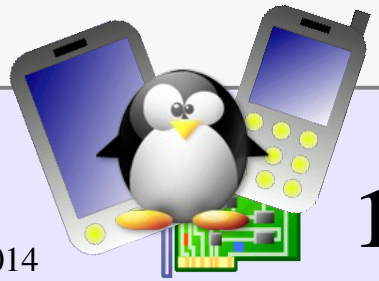
Miscellaneous

Various commands



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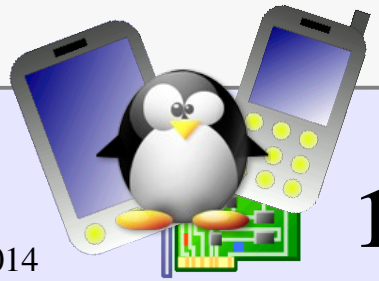
Getting information about users

- `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).



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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.

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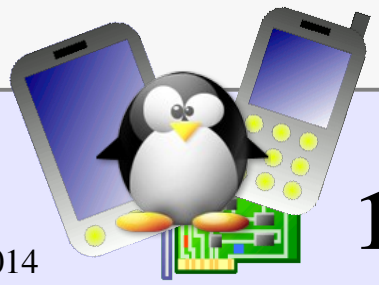
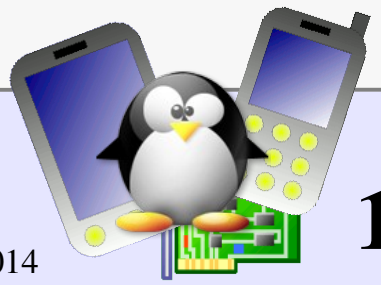


The wget command

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)



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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.

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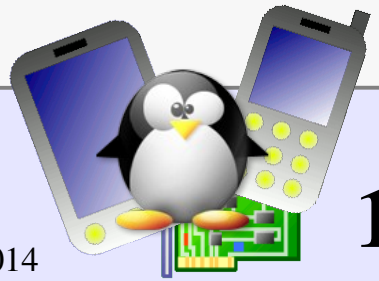

Misc commands (1)

- `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.

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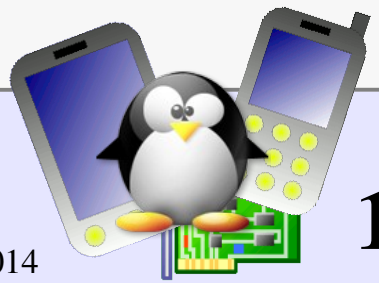


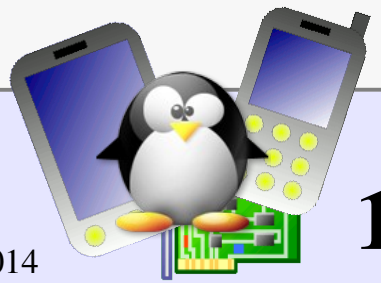
Misc commands (2)

- `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.



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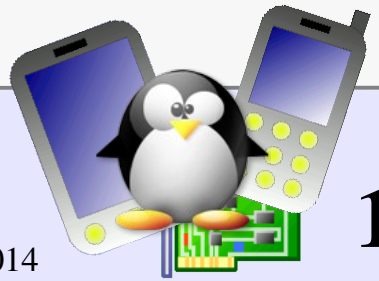
System administration basics



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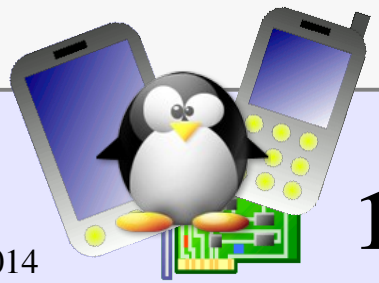
File ownership

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.



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Shutting down

- `shutdown -h +5` (`-h`: halt)
  Shuts the system down in 5 minutes.
  Users get a warning in their consoles.
- `shutdown -r now` (`-r`: reboot)
- `init 0`
  Another way to shutdown
  (`init` is used internally by `shutdown`).
- `init 6`
  Another way to reboot.
- `[Ctrl][Alt][Del]`
  Also works on GNU/Linux (at least on PCs!).

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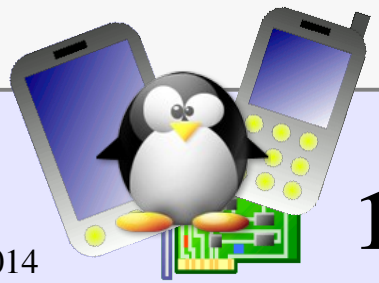

Network setup (1)

- `ifconfig -a`
  Prints details about all the network interfaces available on your system.
- `ifconfig eth0`
  Lists details about the `eth0` interface
- `ifconfig eth0 192.168.0.100`
  Assigns the `192.168.0.100` IP address to `eth0` (1 IP address per interface).
- `ifconfig eth0 down`
  Shuts down the `eth0` interface (frees its IP address).

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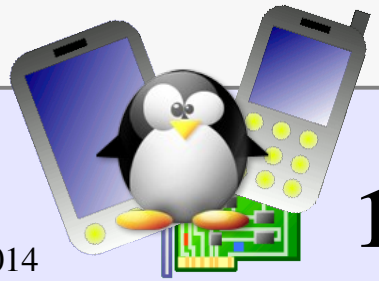
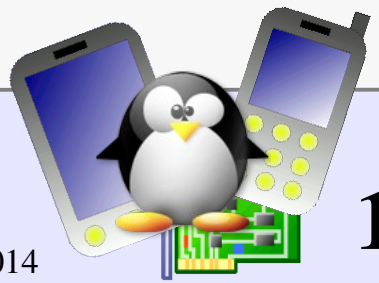


Network setup (2)

- `route add default gw 192.168.0.1`
  Sets the default route for packets outside the local network. The gateway (here `192.168.0.1`) is responsible for sending them to the next gateway, etc., until the final destination.
- `route`
  Lists the existing routes
- `route del default`
  `route del <IP>`
  Deletes the given route
  Useful to redefine a new route.



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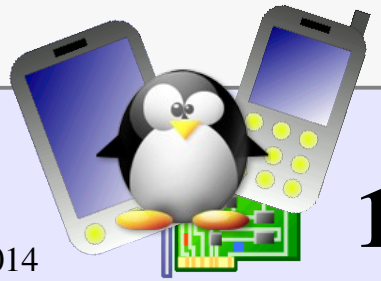
Network testing

- `ping freshmeat.net`
  `ping 192.168.1.1`
  Tries to send packets to the given machine and get acknowledgment packets in return.

```
PING 192.168.1.1 (192.168.1.1) 56(84) bytes of data.
64 bytes from 192.168.1.1: icmp_seq=0 ttl=150 time=2.51 ms
64 bytes from 192.168.1.1: icmp_seq=1 ttl=150 time=3.16 ms
64 bytes from 192.168.1.1: icmp_seq=2 ttl=150 time=2.71 ms
64 bytes from 192.168.1.1: icmp_seq=3 ttl=150 time=2.67 ms
```

- When you can ping your gateway, your network interface works fine.
- When you can ping an external IP address, your network settings are correct!



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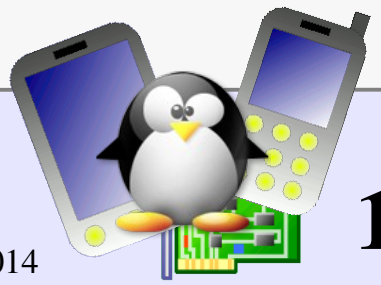
Network setup summary

Only for simple cases with 1 interface, no dhcp server...

- Connect to the network (cable, wireless card or device...)
- Identify your network interface:
  `ifconfig -a`
- Assign an IP address to your interface (assuming `eth0`)
  `ifconfig eth0 192.168.0.100` (example)
- Add a route to your gateway (assuming `192.168.0.1`) for packets outside the network:
  `route add default gw 192.168.0.1`



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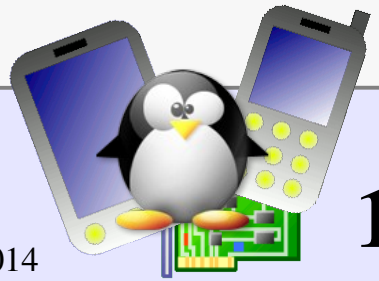
Name resolution

- Your programs need to know what IP address corresponds to a given host name (such as `kernel.org`)
- Domain Name Servers (DNS) take care of this.
- You just have to specify the IP address of 1 or more DNS servers in your `/etc/resolv.conf` file:

```
nameserver 217.19.192.132
nameserver 212.27.32.177
```

- The changes takes effect immediately!



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Creating filesystems

Examples

- `mkfs.ext2 /dev/sda1`
  Formats your USB key (`/dev/sda1`: 1st partition raw data) in ext2 format.
- `mkfs.ext2 -F disk.img`
  Formats a disk image file in ext2 format
- `mkfs.vfat -v -F 32 /dev/sda1` (`-v`: verbose)
  Formats your USB key back to FAT32 format.
- `mkfs.vfat -v -F 32 disk.img`
  Formats a disk image file in FAT32 format.

Blank disk images can be created as in the below example:

```
dd if=/dev/zero of=disk.img bs=1024 count=65536
```


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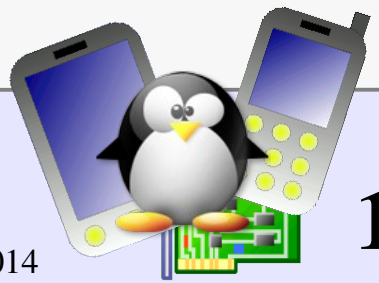
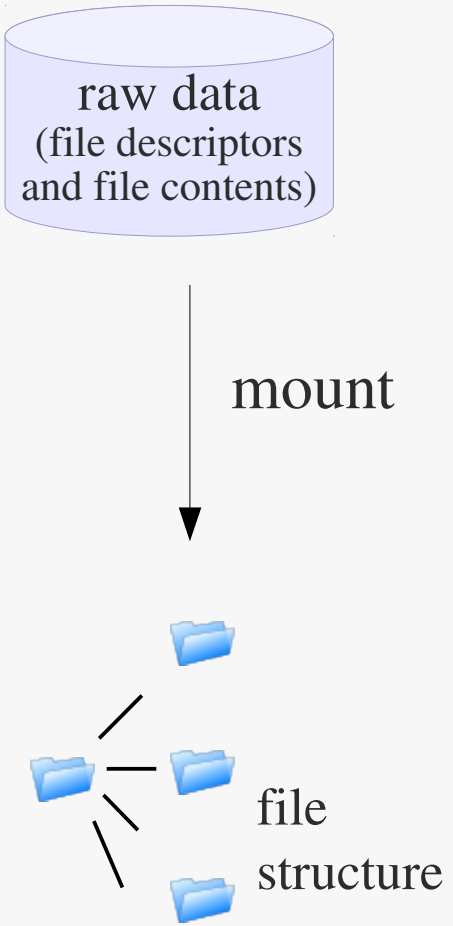


Mounting devices (1)

- To make filesystems on any device
  (internal or external storage)
  visible on your system, you have to *mount* them.
- The first time, create a mount point in your system:
  `mkdir /mnt/usbdisk` (example)
- Now, mount it:
  `mount -t vfat /dev/sda1 /mnt/usbdisk`
  `/dev/sda1`: physical device
  `-t`: specifies the filesystem (format) type
  (`ext2`, `ext3`, `vfat`, `reiserfs`, `iso9660`...)



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Mounting devices (2)

- Lots of `mount` options are available, in particular to choose permissions or the file owner and group... See the `mount` manual page for details.
- Mount options for each device can be stored in the `/etc/fstab` file. Thanks to this file, you just need to state the mount point:

```
# /etc/fstab: static file system information.
# <file system> <mount point>   <type>  <options>                 <dump> <pass>
proc            /proc           proc    defaults                      0      0
/dev/hda3       /               ext3    defaults,errors=remount-ro    0      1
/dev/hda4       /home           ext3    defaults                      0      2
/dev/hda2       /root2          ext3    defaults                      0      2
/dev/hda1       none            swap    sw                            0      0
/dev/hdc        /media/cdrom0   udf,iso9660 user,noauto                0      0
```

- `mount` examples with `/etc/fstab`:

```
mount /proc
mount /media/cdrom0
```


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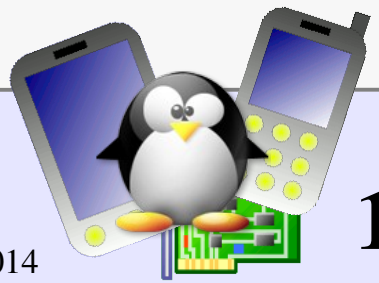
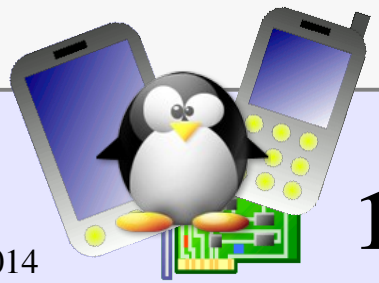


Mounting devices (3)

You can also mount a filesystem image stored in a regular file (*loop devices*)

- Useful to develop filesystems for another machine
- Useful to access the contents of an ISO cdrom image without having to burn it.
- Useful to create a Linux partition on a hard disk with only Windows partitions

```
cp /dev/sda1 usbkey.img
mount -o loop -t vfat usbkey.img /mnt/usbdisk
```



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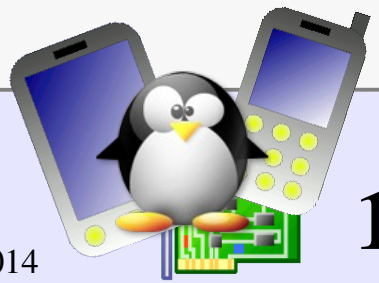
Listing mounted filesystems

- Just use the `mount` command with no argument:

```
/dev/hda6 on / type ext3 (rw,noatime)
none on /proc type proc (rw,noatime)
none on /sys type sysfs (rw)
none on /dev/pts type devpts (rw,gid=5,mode=620)
usbfs on /proc/bus/usb type usbfs (rw)
/dev/hda4 on /data type ext3 (rw,noatime)
none on /dev/shm type tmpfs (rw)
/dev/hda1 on /win type vfat (rw,uid=501,gid=501)
none on /proc/sys/fs/binfmt_misc type binfmt_misc (rw)
```

- Or display the `/etc/mtab` file
  (same result, updated by `mount` and `umount` each time they are run)



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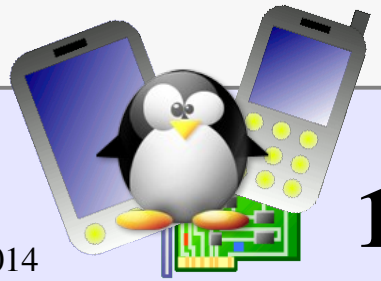
Unmounting devices

- `umount /mnt/usbdisk`
  Commits all pending writes and unmounts the given device, which can then be removed in a safe way.
- To be able to unmount a device, you have to close all the open files in it:
  - Close applications opening data in the mounted partition
  - Make sure that none of your shells have a working directory in this mount point.
  - You can run the `lsof` command (list open files) to view which processes still have open files in the mounted partition.



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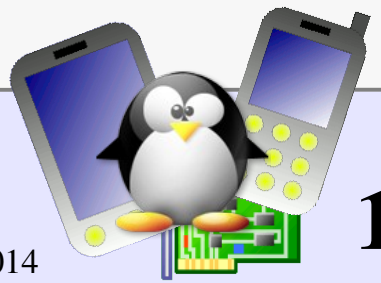
Beware of the dark side of root

- `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.



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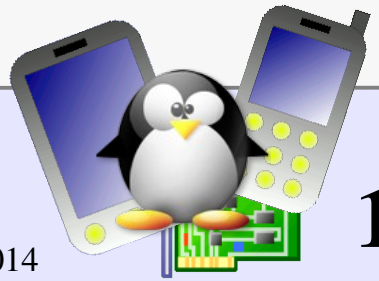
Using the root account

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`
- Distributions like Debian or Ubuntu by default don't allow the `root` user to use graphical applications (more complex and thus more vulnerable).
- If you really want to start a graphical application with `root`, type:
  As `root`: `export DISPLAY=:0` (i.e. use the first display)
  As your regular user: `xhost +` (i.e. allow other users)



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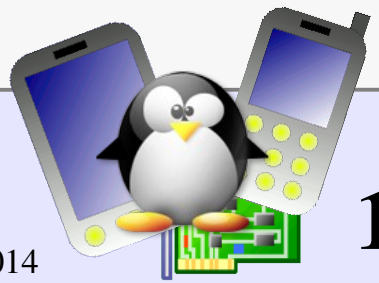
GNU / Linux: distribution packages



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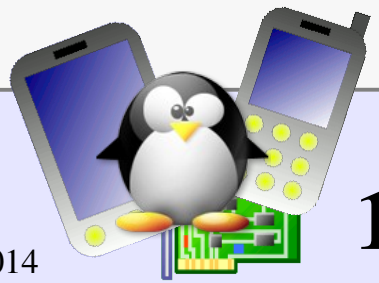
How to find packages

- Debian packages: http://www.debian.org/distrib/packages
  Search by package or file name
- rpmfind: http://rpmfind.net/
  Lots of RPM packages for Red Hat, Mandriva, Suse...



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Identifying packages

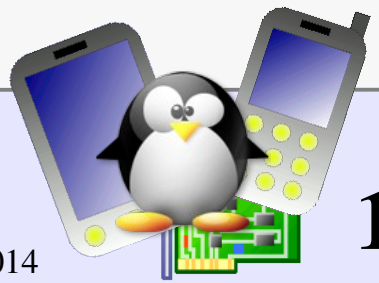
What package does a file belong to?

- Useful to get more information, get the code, find newer versions, report issues...
- Distribution with RPM packages:
  (Red Hat, Fedora, Mandriva, Suse...)

```
> rpm -qf /bin/ls
coreutils-5.2.1-7
```

- Debian, Ubuntu:

```
> dpkg -S /bin/ls
fileutils: /bin/ls
```



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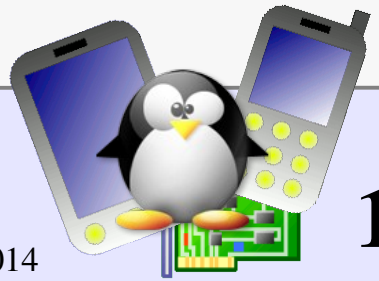
Information about packages

- Access package description, version number, sources, etc.
- RPM based distributions:

```
rpm -qi <package-name>
```

- Debian:

```
dpkg -s <package-name>
```



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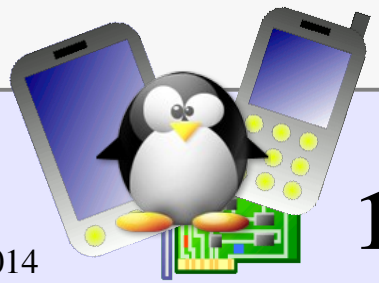
Going further



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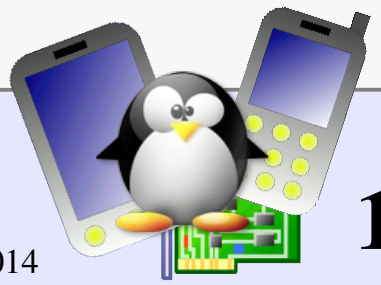
Command help

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.



The Unix and GNU / Linux command line
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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.

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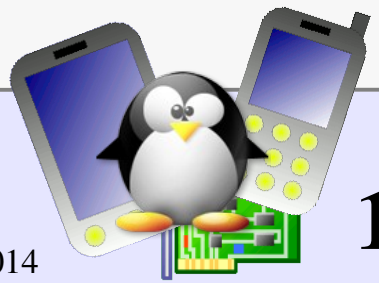
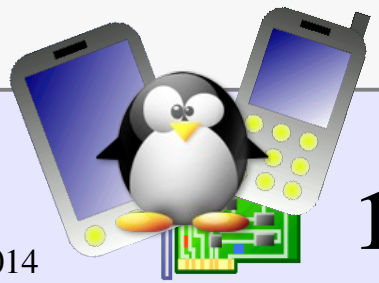


Info pages

- 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



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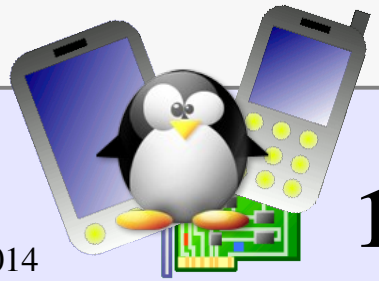
Searching the Internet for resources (1)

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.



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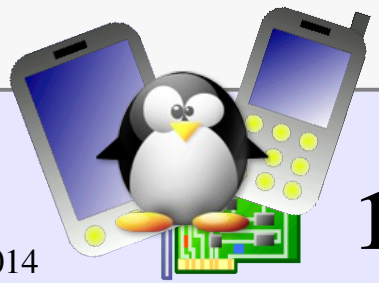
Searching the Internet for resources (2)

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.



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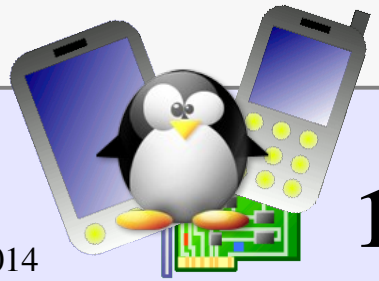
Training labs

Training labs are also available from the same location:
http://free-electrons.com/training/intro_unix_linux

They are a useful complement to consolidate what you learned from this training. They don't tell *how* to do the exercises. However, they only rely on notions and tools introduced by the lectures.

If you happen to be stuck with an exercise, this proves that you missed something in the lectures and have to go back to the slides to find what you're looking for.



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Related documents

All the technical presentations and training materials created and used by Free Electrons, available under a free documentation license (more than 1500 pages!).

http://free-electrons.com/training

- Introduction to Unix and GNU/Linux
- Embedded Linux kernel and driver development
- Free Software tools for embedded Linux systems
- Audio in embedded Linux systems
- Multimedia in embedded Linux systems

http://free-electrons.com/articles

- Advantages of Free Software in embedded systems
- Embedded Linux optimizations
- Embedded Linux from Scratch... in 40 min!
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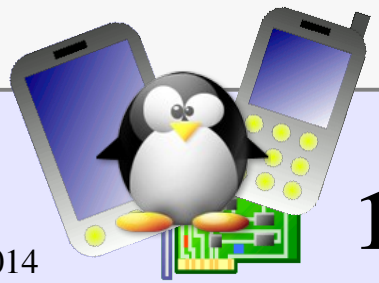
- Real-time in embedded Linux systems
- Introduction to uClinux
- Linux on TI OMAP processors
- Free Software development tools
- Java in embedded Linux systems
- Introduction to GNU/Linux and Free Software
- Linux and ecology
- What's new in Linux 2.6?
- How to port Linux on a new PDA



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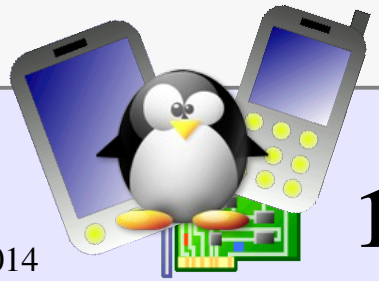
- By sending corrections, suggestions, contributions and translations
- By asking your organization to order training sessions performed by the author of these documents (see http://free-electrons.com/training)
- By speaking about it to your friends, colleagues and local Free Software community.
- By adding links to our on-line materials on your website, to increase their visibility in search engine results.



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Thanks

- To the OpenOffice.org project, for their presentation and word processor tools which satisfied all my needs.
- To the Handhelds.org community, for giving me so much help and so many opportunities to help.
- To the members of the whole Free Software and Open Source community, for sharing the best of themselves: their work, their knowledge, their friendship.
- To people who sent comments and corrections:
  Tyler Le, Laurent Thomas, Jeff Ghislain, Leif Thande, Frédéric Desmoulins, Przemysław Ciesielski

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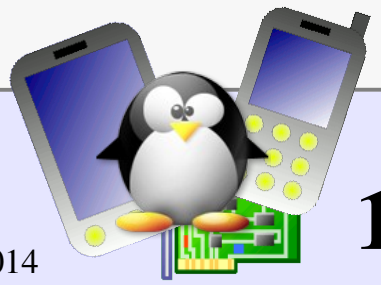

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System optimization
Linux kernel drivers
Application and interface development

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System architecture
Identification of suitable technologies
Managing licensing requirements
System design and performance review

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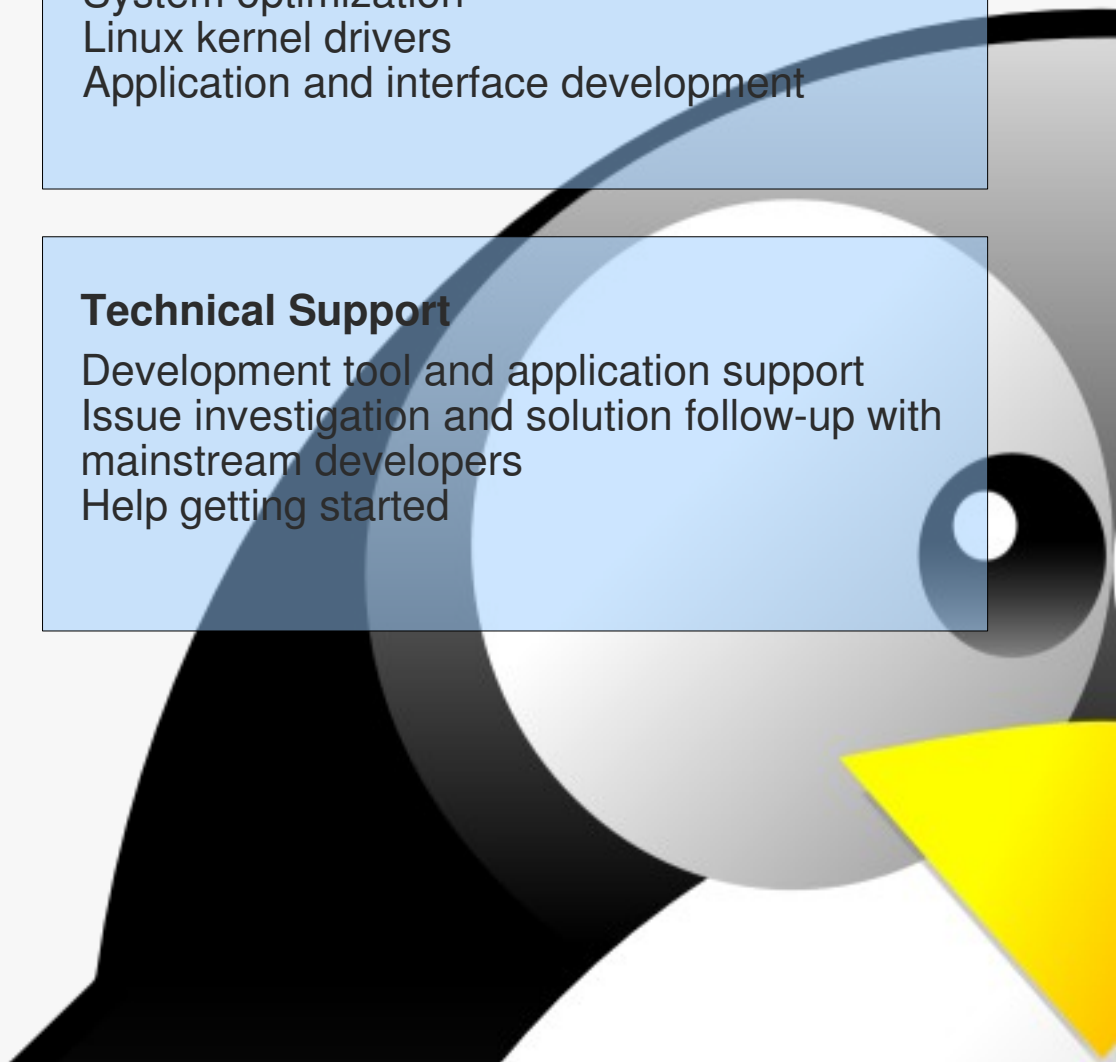
Help getting started



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