Reference Manual

Mandrakelinux 10.0

http://www.mandrakesoft.com

Reference Manual: Mandrakelinux 10.0
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Legal Notice

Front-cover texts

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"*Building and Installing Free Software*", page 71	by Benjamin Drieu , **APRIL** (`http://www.april.org/`)	GNU General Public License GPL (`http://www.gnu.org/copyleft/gpl.html`)

Tools Used in The Making of This Manual

This manual was written in XML DocBook. The set of files involved were managed using Borges (`http://linux-mandrake.com/en/doc/project/Borges/`). The XML source files were processed by xsltproc, `openjade` and `jadetex` using a customized version of Norman Walsh's stylesheets. Screen shots were taken using `xwd` or GIMP and converted with `convert`. All these programs are free and are available in your Mandrakelinux distribution.

Table of Contents

List of Tables

List of Figures

Preface

1. About Mandrakelinux

Mandrakelinux is a GNU/Linux distribution supported by Mandrakesoft S.A. which was born on the Internet in 1998. Its main goal was and still is to provide an easy-to-use and friendly GNU/Linux system. Mandrakesoft's two pillars are open source and collaborative work.

1.1. Contacting the Mandrakelinux Community

The following are various Internet links pointing you to various Mandrakelinux-related sources. If you wish to know more about the Mandrakesoft company, connect to our web site (`http://www.mandrakesoft.com/`). You can also check out the Mandrakelinux distribution web site (`http://www.mandrakelinux.com/`) and all its derivatives.

Mandrakeexpert (`http://www.mandrakeexpert.com/`) is Mandrakesoft's help platform. It offers a new experience based on trust and the pleasure of rewarding others for their contributions.

We also invite you to subscribe to the various mailing lists (`http://www.mandrakelinux.com/en/flists.php3`), where the Mandrakelinux community demonstrates its vivacity and keenness.

Please also remember to connect to Mandrakesecure (`http://www.mandrakesecure.net/`). It gathers all security-related material about Mandrakelinux distributions. You will find security and bug advisories, as well as security and privacy-related articles. A must for any server administrator or user concerned about security.

1.2. Join the Club

Mandrakesoft offer a wide range of advantages though its Mandrakelinux Users Club (`http://www.mandrakelinux.com/en/club/`):

- download commercial software normally only available in retail packs, such as special hardware drivers, commercial applications, freeware, and demo versions;
- vote and propose new software through a volunteer-run RPM voting system;
- access more than 50,000 RPM packages for all Mandrakelinux distributions;
- obtain discounts for products and services on Mandrakestore (`http://www.mandrakestore.com`);
- access a better mirror list, exclusive to Club members;
- read multilingual forums and articles.

By financing Mandrakesoft through the Mandrakeclub you will directly enhance the Mandrakelinux distribution and help us provide the best possible GNU/Linux desktop to our users.

1.3. Purchasing Mandrakesoft Products

Mandrakelinux users may purchase products on-line through the Mandrakestore (`http://www.mandrakestore.com/`). You will not only find Mandrakelinux software, operating systems and "live" boot CDs (such as Mandrakemove), but also special subscription offers, support, third-party software and licenses, documentation, GNU/Linux-related books, as well as other Mandrakesoft goodies.

1.4. Contribute to Mandrakelinux

The skills of the many talented folks who use Mandrakelinux can be very useful in the making of the Mandrakelinux system:

- **Packaging.** A GNU/Linux system is mainly made of programs picked up on the Internet. They have to be packaged in order to work together.

- **Programming.** There are many, many projects directly supported by Mandrakesoft: find the one which most appeals to you and offer your help to the main developer(s).
- **Internationalization.** You can help us in the translation of web pages, programs and their respective documentation.
- **Documentation.** Last but not least, the manual you are currently reading requires a lot of work to stay up-to-date in regards to the rapid evolution of the system.

Consult the development projects (`http://www.mandrakesoft.com/labs/`) page to learn more about how you can contribute to the evolution of Mandrakelinux.

2. Introduction

This manual is aimed at people wishing to dive into the depths of their GNU/Linux system, and who want to exploit its huge capabilities. It is made up of three parts:

- In *The Linux System*, we introduce you to the command line and its various uses. We also discuss text-editing basics, which are essential under GNU/Linux.

  In the first chapter ("*Basic UNIX System Concepts*", page 5) we introduce the UNIX paradigm while speaking more specifically of the GNU/Linux world. It discusses the standard file-manipulation utilities as well as some useful features provided by the shell. Then comes a complementary chapter ("*Disks and Partitions*", page 13) which discusses how hard disks are managed under GNU/Linux, as well as partitioning. It is very important that you fully understand the concepts discussed in these chapters before going on to "*Introduction to the Command Line*", page 17.

  The next chapter covers text editing ("*Text Editing: Emacs and VI*", page 25). As most UNIX configuration files are text files, you will eventually want or need to edit them in a ***text editor***. You will learn how to use two of the most famous text editors in the UNIX and GNU/Linux worlds: the mighty Emacs and the modern (!) Vi.

  You should then be able to perform basic maintenance on your system. The following two chapters present practical uses of the command line ("*Command-Line Utilities*", page 33), and process control ("*Process Control*", page 43) in general.

- In *Linux in Depth*, we touch upon the Linux kernel and the file-system architecture.

  We explore the organization of the file tree in "*File-Tree Organization*", page 47. UNIX systems tend to grow very large, but every file has its place in a specific directory. After reading this chapter, you will know where to look for files depending on their role in the system.

  Then we cover the topics of ***file systems*** and ***mount points*** ("*File Systems and Mount Points*", page 51). We define both of these terms as well as explain them with practical examples.

  The next chapter deals with file systems ("*The Linux File System*", page 55). After presenting the available file systems, we discuss file types and some additional concepts and utilities such as inodes and pipes. The following chapter ("*The /proc Filesystem*", page 63) introduces a special GNU/Linux file system called `/proc`.

  "*The Start-Up Files: init sysv*", page 69 presents the Mandrakelinux boot-up procedure, and how to use it efficiently.

- In *Advanced Uses*, we finish up with topics which only brave or very skilled users will want to put into practice. We will guide you through the necessary steps to build and install free software from sources in "*Building and Installing Free Software*", page 71. Reading through this chapter should encourage you to try it out, even though it might look intimidating at first. Finally, the information provided in the last chapter ("*Compiling and Installing New Kernels*", page 85) will help you acquire total GNU/Linux autonomy. After reading and applying the theory explained in this chapter, you can start converting Windows users to GNU/Linux (if you haven't started yet!).

3. Note from the Editor

In the open-source philosophy, contributors are always welcome! You could provide help to this documentation project in many different ways. If you have a lot of time, you can write a whole chapter. If you speak a foreign language, you can help us translate our manuals. If you have ideas on how to improve the content, let us know. You can event alert us if you find typos!

For any information about the Mandrakelinux documentation project, please contact the documentation administrator (`mailto:documentation@mandrakesoft.com`) or visit the Mandrakelinux Documentation Project (`http://linux-mandrake.com/en/doc/project/`) web page.

4. Conventions Used in this Book

4.1. Typing Conventions

In order to clearly differentiate special words from the text flow, we use different renderings. The following table shows examples of each special word or group of words with its actual rendering, as well as its signification.

Formatted Example	Meaning
inode	Used to emphasize a technical term.
`ls -lta`	Used for commands and their arguments. Also used for options and file names (see *Commands Synopsis*, page 4).
ls(1)	Reference to a `man` page. To read the page in a shell (or command line), simply type `man 1 ls`.
`$ ls *.pid`	Formatting used for text snapshots of what you may see on your screen including computer interactions, program listings, etc.
`localhost`	Literal data which does not generally fit in any of the previously defined categories. For example, a key word taken from a configuration file.
Apache	Defines application names. The example used ("Apache") is not a command name. However, in some contexts, the application and command name may be the same but formatted differently.
Files	Indicates menu entries or graphical interface labels. The underlined letter informs you of a keyboard shortcut, if applicable.
SCSI-Bus	Denotes a computer part or a computer itself.
Le petit chaperon rouge	Identifies foreign language words.
Warning!	Reserved for special warnings in order to emphasize the importance of words. Read out loud **:-)**

Highlights a note. Generally, it gives additional information about a specific context.

Represents a tip. It can be general advice on how to perform a particular action, or about nice feature which could make your life easier.

Be very careful when you see this icon. It always means that very important information about a specific subject will be dealt with.

4.2. General Conventions

4.2.1. Commands Synopsis

The example below shows the symbols you will see when the writer describes the arguments of a command:

```
command <non literal argument> [--option={arg1,arg2,arg3}]
[optional arg. ...]
```

These conventions are standard and you may find them elsewhere such as in the `man` pages.

The "<" (less than) and ">" (greater than) symbols denote a **mandatory** argument not to be copied verbatim, which should be replaced according to your needs. For example, `<filename>` refers to the actual name of a file. If this name is `foo.txt`, you should type `foo.txt`, not `<foo.txt>` or `<filename>`.

The square brackets ("[ ]") denote optional arguments, which you may or may not include in the command.

The ellipsis ("...") means an arbitrary number of items can be included.

The curly brackets ("{ }") contain the arguments authorized at this specific place. One of them is to be placed here.

4.2.2. Special Notations

From time to time, you will be asked to press, for example, the keys **Ctrl**-**R**, which means you need to press and hold the **Ctrl** key and tap the **R** character as well. The same applies for the **Alt** and **Shift** keys.

Also, regarding menus, going to menu item File→Reload user config (**Ctrl-R**) means: click on the File text displayed on the menu (generally located in the upper-left of the window). Then in the pull-down menu, click on the Reload user config item. Furthermore you are informed that you can use the **Ctrl**-**R** key combination (as described above) to get the same result.

4.2.3. System-Generic Users

Whenever possible, we use two generic users in our examples:

Queen Pingusa	This user is created at installation time.
Peter Pingus	This user is created afterwards by the system administrator.

Chapter 1. Basic UNIX System Concepts

The name "UNIX" may be familiar to some of you. You may even use a UNIX system at work, in which case this chapter may not be very interesting.

For those of you who have never used a UNIX system, reading this chapter is absolutely necessary. Understanding the concepts which will be introduced here will answer a surprisingly large number of questions commonly asked by beginners in the **GNU/Linux** world. Similarly some of these concepts will likely answer most of the problems you may encounter in the future.

1.1. Users and Groups

Since they have a direct influence on all other concepts, this chapter will introduce the concepts of users and groups which are extremely important.

Linux is a true ***multiuser*** system, and in order to use your GNU/Linux machine, you must have an ***account*** on the machine. When you created a user during installation, you actually created a user account. In case you don't remember, you were prompted for the following items:

- the user's "real name" (which could actually be whatever you want)
- a ***login*** name
- and a ***password***.

The two most important parameters here are the login name (commonly abbreviated to login) and password. You must have both of these in order to access the system.

When you create a user, a default group is also created. Later on, we will see that groups are useful when you want to share files with other people. A group may contain as many users as you wish, and it is very common to see such a separation in large systems. For example, at a university, you could have one group per department, another group for teachers, and so on. The opposite is also true: a user may be a member of one or more groups. A math teacher, for example, could be a member of the teachers' group and also of his math students' group.

Now that we've covered the background information, let us look at how to actually log in.

If you chose to have X automatically start on boot up, your start-up screen will look similar to figure 1-1.

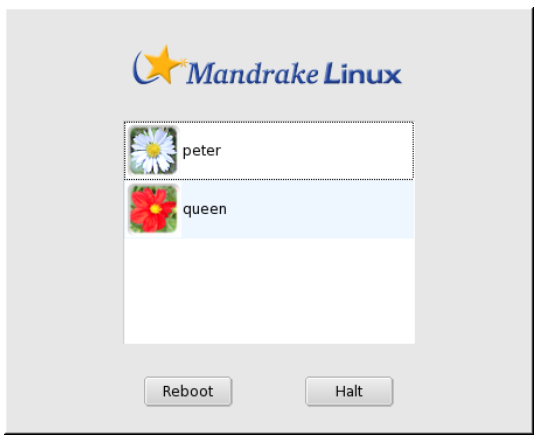


Figure 1-1. Graphical Mode Login Session

In order to log in, you must first select your account from the list. A new dialog will be displayed, prompting you for your password . Note that you will have to type in your password blindly, because the characters will be echoed on screen as stars * instead of the characters you type in the password field. You may also choose your session type (window manager). Once you're ready, press the Login button.

If you are in console or "text" mode, you will be presented with something similar to the following:

```
Mandrakelinux Release 10.0 (CodeName) for i586
Kernel 2.6.3-4mdk on an i686 / tty1
[machine_name] login:
```

To log in, type your login name at the Login: prompt and press Enter. Next, the login program (login) will display a Password: prompt and wait for you to enter your password. Like the graphic mode login, the console login will not echo the characters you are typing on the screen.

Note that you can log in several times with the same account on additional ***consoles*** and under X. Each session you open is independent to the others, and it is even possible to open several X sessions at the same time. By default, Mandrakelinux has six ***virtual consoles*** in addition to the one reserved for the graphical interface. You can switch to any of them by pressing the **Ctrl-Alt-F<n>** key sequence, where <n> is the number of the console that you want to switch to. By default, the graphical interface is on console number 7. Therefore, to switch to the second console, you would simultaneously press the Ctrl, Alt and F2 keys.

During the installation, DrakX also prompted you for the password of a very special user: root. root is the system administrator which will most likely be yourself. For your system's security, it is very important for the root account to be always protected by a good and hard-to-guess password!

If you regularly log in as root, it can be very easy to make a mistake which could render your system unusable: one single mistake can do it. In particular, if you did not set a password for the root account, then **any** user can alter **any** part of your system (and even other operating systems on your machine!). Obviously this is not a good idea.

It's worth mentioning that internally, the system does not identify you by your login name. Instead, it uses a unique number assigned to the name: the *User ID* (UID for short) . Similarly every group is identified by its *Group ID* (GID) and not by its name.

1.2. File Basics

Compared to Windows and most other ***operating systems***, files are handled very differently under GNU/Linux. In this section we will cover the most obvious differences. For more information, please read "*The Linux File System*", page 55.

The major differences result directly from the fact that Linux is a multiuser system: every file is the exclusive property of one user and one group. One thing we didn't mention about users and groups is that every one of them possesses a personal directory (called the ***home directory***). The user is the owner of this directory and of all files created there.

However, this would not be very useful if that were the only notion of file ownership. As the file owner, a user may set **permissions** on files. These permissions distinguish between three user categories: the **owner** of the file, every user who is a member of the **group** associated with the file (also called the ***owner group***) but who is not the owner, and **others**, which includes every other user who is neither the owner nor a member of the owner's group.

There are three different permissions:

1. *Read* permission (r): enables a user to read the contents of a file. For a directory, the user can list its contents (i.e. the files in this directory).
2. *Write* permission (w): allows the modification of a file's contents. For a directory, the write permission allows a user to add or remove files from this directory, even if he is not the owner of these files.
3. *eXecute* permission (x): enables a file to be executed (normally only executable files have this permission set). For a directory, it allows a user to ***traverse*** it, which means going into or through that directory. Note that this is different from the read access: you may be able to traverse a directory but still be unable to read its contents!

Every permission combination is possible. For example, you can allow only yourself to read the file and forbid access to all other users. You can even do the opposite, even if isn't very logical at first glance... As the file owner, you can also change the owner group (if and only if you're a member of the new group), and even deprive yourself of the file (that is, change its owner). Of course, if you deprive yourself of the file, you will also lose all of your rights over it.

Let's take the example of a file and a directory. The display below represents entering the ls -l command from the ***command line***:

```
$ ls -l
total 1
-rw-r-----   1 queen    users           0 Jul  8 14:11 a_file
```

```
drwxr-xr--   2 peter    users        1024 Jul  8 14:11 a_directory/
$
```

The results of the `ls -l` command are (from left to right):

- The first ten characters represent the file's type and the permissions associated with it. The first character is the file's type: if it's a regular file, it will contain a dash (`-`). If it's a directory, the leftmost character will be a `d`. There are other file types, which we'll discuss later on. The next nine characters represent the permissions associated with that file. The nine characters are actually three groups of three permissions. The first group represents the rights associated with the file owner; the next three apply to all users belonging to the same group but who are not the owner; and the last three apply to others. A dash (`-`) means that the permission is not set.
- Next comes the number of links for the file. Later on we'll see that the unique identifier of a file is not its name, but a number (the ***inode number***), and that it's possible for one file on disk to have several names. For a directory, the number of links has a special meaning, which will also be discussed a bit further.
- The next piece of information is the name of the file owner and the name of the owner group.
- Finally, the size of the file (in ***bytes***) and its last modification time are displayed, with the name of the file or directory itself as the last item on the line.

Let's take a closer look at the permissions associated with each of these files. First of all, we must strip off the first character representing the type, and for the file `a_file`, we get the following rights: `rw-r-----`. Here's a breakdown of the permissions.

- the first three characters (`rw-`) are the rights of the owner, which in this case is queen. Therefore, queen has the right to read the file (`r`), to modify its contents (`w`) but not to execute it (`-`).
- the next three characters (`r--`) apply to any user who is not queen but who is a member of the `users` group. They will be able to read the file (`r`), but will not be able to write nor execute it (`--`).
- the last three characters (`---`) apply to any user who is not queen and is not a member of the `users` group. Those users do not have any rights on the file at all.

For the directory `a_directory`, the rights are `rwxr-xr--`, so:

- peter, as the directory owner, can list files contained inside (`r`), add to or remove files from that directory (`w`), and may traverse it (`x`).
- Each user who isn't peter, but is a member of the `users` group, will be able to list files in this directory (`r`), but not remove or add files (`-`), and will be able to traverse it (`x`).
- Every other user will only be able to list the contents of this directory (`r`). Because they do not have `wx` permissions, they will not be able to write files or enter the directory.

There is **one** exception to these rules: `root`. `root` can change attributes (permissions, owner and group owner) of all files, even if he's not the owner, and could therefore grant himself ownership of the file! He can read files on which he has no read permission, traverse directories which he would normally have no access to, and so on. And if he lacks a permission, he only has to add it. `root` has complete control of the system, which involves a certain amount of trust in the person wielding the `root` password.

Lastly, it's worth noting the differences between file names in the UNIX and the Windows worlds. For one, UNIX allows for a much greater flexibility and has fewer limitations.

- A file name may contain any character, including non-printable ones, except for the ASCII character 0, which denotes the end of a string, and `/`, which is the directory separator. Moreover, because UNIX is case sensitive, the files `readme` and `Readme` are different, because `r` and `R` are considered two **different** characters in UNIX-based systems.
- As you may have noticed, a file name does not have to include an extension, unless that's the way you prefer to name your files. File extensions do not identify the content of files under GNU/Linux or almost any other operating system. So-called "file extensions" are quite convenient though. The period (`.`) under UNIX is just one character among others, but it also has one special meaning. Under UNIX, file names beginning with a period are "hidden files", which also includes directories whose names start with a `.`

However it's worth noting that many graphical applications (file managers, office applications, etc.) actually use file extensions to recognize their files. It is therefore a good idea to use file-name extensions for those applications which support them.

1.3. Processes

A ***process*** defines an instance of a program being executed and its ***environment***. We will only mention the most important differences between GNU/Linux and Windows here (please refer to "*Process Control*", page 43 for more information).

The most important difference is directly related to the **user** concept: each process is executed with the rights of the user who launched it. Internally, the system identifies processes with a unique number, called the *process ID*, or PID. From this PID, the system knows who, (that is, which user), has launched the process and a number of other pieces of information, and the system only needs to verify the process' validity. So, if we take our `a_file` example, a process launched by peter will be able to open this file in ***read-only mode***, but not in ***read-write mode*** because the permissions associated with the file forbid it. Once again the exception to this rule is `root`.

Because to this, GNU/Linux is virtually immune to viruses. In order to operate, viruses must infect executable files. As a user, you do not have write access to vulnerable system files, so the risk is greatly reduced. Generally speaking, viruses are very rare in the UNIX world. There are less than a dozen known viruses for Linux, and they are harmless when executed by a normal user. Only one user can damage a system by activating these viruses: `root`.

Interestingly enough, anti-virus software does exist for GNU/Linux, but mostly for DOS/Windows files. Why are there anti-virus programs running on GNU/Linux which focus on DOS/Windows? More and more often, you will see GNU/Linux systems acting as file servers for Windows machines with the help of the Samba software package (see the Sharing Files and Printers chapter of the *Server Administration Guide*).

Linux makes it easy to control processes. One way is through "signals", which allow you to suspend or kill a process by sending the corresponding signal to the process. However, you are limited to sending signals to your own processes. With the exception of `root`, UNIX does not allow you to send signals to a process launched by any other user. In "*Process Control*", page 43, you will learn how to obtain the PID of a process and to send it signals.

1.4. A Short Introduction to the Command Line

The command line is the most direct way to send commands to your machine. If you use the GNU/Linux command line, you'll soon find that it is much more powerful and capable than other command prompts you may have encountered previously. This power is available because you have access, not only to all X applications, but also to thousands of other utilities in console mode (as opposed to graphical mode) which do not have graphical equivalents, with their many options and possible combinations, which would be hard to access in the form of buttons or menus.

Admittedly, most people require a little help to get started. If you are not already working in console mode and are using the graphical interface, the first thing to do is to launch a terminal emulator. Access the main menu of GNOME, KDE or any other window manager you might be using and you'll find a number of emulators in the System+Terminals sub-menu. Choose the one you want, for example Konsole or XTerm. Depending on your user interface, there may also be an icon which clearly identifies it on the panel (figure 1-2).

Figure 1-2. The Terminal Icon on the KDE Panel

When you launch this terminal emulator, you are actually using a shell. This is the name of the program which you interact with. You'll find yourself in front of the ***prompt***:

```
[queen@localhost queen]$
```

This assumes that your user name is queen and that your machine's name is `localhost` (which is the case if your machine is not part of an existing network). Following the prompt there is space for you to type your commands. Note that when you're `root`, the prompt's `$` character becomes a `#` (this is true only in the default configuration, since you may customize all such details in GNU/Linux). In order to become `root`, type `su` after launching a shell.

```
# Enter the root password; (it will not appear on the screen)
[queen@localhost queen]$ su
Password:
# exit (or Ctrl-D) will take you back to your normal user account
[root@localhost queen]# exit
[queen@localhost queen]$
```

Everywhere else in this book, the prompt will be symbolically represented by a `$`, whether you are a normal user or `root`. You will be told when you have to be `root` to execute a command, so please remember the `su` command.

When you ***launch*** a shell for the first time, you normally find yourself in your home directory. To display the name of the directory you are currently in, type `pwd` (which stands for *Print Working Directory*):

```
$ pwd /home/queen
```

Next we'll look at a few basic commands which are very useful.

1.4.1. cd: Change Directory

The `cd` command is just like the DOS one, with extras. It does just what its acronym states, changes the working directory. You can use `.` and `..`, which respectively stand for the current and parent directories. Typing `cd` alone will take you back to your home directory. Typing `cd -` will take you back to the last directory you visited. And lastly, you can specify peter's home directory by typing `cd ~peter` (`~` on its own means your own home directory). Note that as a normal user, you cannot usually get into another user's home directory (unless they explicitly authorized it or if this is the default configuration on the system), unless you are `root`, so let's become `root` and practice:

```
$ pwd
/root
$ cd /usr/share/doc/HOWTO
$ pwd
/usr/share/doc/HOWTO
$ cd ../FAQ-Linux
$ pwd
/usr/share/doc/FAQ-Linux
$ cd ../../../lib
$ pwd
/usr/lib
$ cd ~peter
$ pwd
/home/peter
$ cd
$ pwd
/root
```

Now, go back to being a normal user again by typing `exit`.

1.4.2. Some Environment Variables and the echo Command

All processes have their ***environment variables*** and the shell allows you to view them directly with the `echo` command. Some interesting variables are:

1. `HOME`: this environment variable contains a string which represents your home directory.
2. `PATH`: this variable contains the list of all directories in which the shell should look for executables when you type a command. Note that unlike DOS, by default, a shell will **not** look for commands in the current directory!
3. `USERNAME`: this variable contains your login name.
4. `UID`: this one contains your user ID.
5. `PS1`: this variable determines what your prompt will display, and is often a combination of special sequences. You may read the bash(1) ***manual page*** for more information.

To have the shell print a variable's value, you must put a `$` in front of its name. Here, the `echo` command will give an example:

```
$ echo Hello
Hello
$ echo $HOME
/home/queen
$ echo $USERNAME
queen
$ echo Hello $USERNAME
Hello queen
$ cd /usr
$ pwd
/usr
$ cd $HOME
$ pwd
/home/queen
```

As you can see, the shell substitutes the variable's value before it executes the command. Otherwise, our `cd $HOME` example would not have worked. In fact, the shell first replaced `$HOME` by its value, `/home/queen`, so the line became `cd /home/queen`, which is what we wanted. The same thing happened with the `echo $USERNAME` example.

1.4.3. cat: Print the Contents of One or More Files to the Screen

Nothing much to say, this command does just that: it prints the contents of one or more files to the standard output, normally the screen:

```
$ cat /etc/fstab
/dev/hda5 / ext2 defaults 1 1
/dev/hda6 /home ext2 defaults 1 2
/dev/hda7 swap swap defaults 0 0
/dev/hda8 /usr ext2 defaults 1 2
/dev/fd0 /mnt/floppy auto sync,user,noauto,nosuid,nodev 0 0
none /proc proc defaults 0 0
none /dev/pts devpts mode=0620 0 0
/dev/cdrom /mnt/cdrom auto user,noauto,nosuid,exec,nodev,ro 0 0
$ cd /etc
$ cat modules.conf shells
alias parport_lowlevel parport_pc
pre-install plip modprobe parport_pc ; echo 7 > /proc/parport/0/irq
#pre-install pcmcia_core /etc/rc.d/init.d/pcmcia start
#alias char-major-14 sound
alias sound esssolo1
keep
/bin/zsh
/bin/bash
/bin/sh
/bin/tcsh
/bin/csh
```

```
/bin/ash
/bin/bsh
/usr/bin/zsh
```

1.4.4. less: a Pager

The name is a play on words related to the first pager ever used under UNIX, called `more`. A ***pager*** is a program which allows a user to view long files page by page (more accurately, screen by screen). The reason that we discuss `less` rather than `more` is that `less` is more intuitive. You should use `less` to view large files which will not fit on a single screen. For example:

```
less /etc/termcap
```

To browse through this file, use the up and down arrow keys. Press **Q** to quit. `less` can do far more than just that: press **H** for help to display the various options available.

1.4.5. ls: Listing Files

The `ls` (*LiSt*) command is equivalent to the `dir` command in DOS, but it can do much much more. In fact, this is largely because files can do more too. The command syntax for `ls` is:

```
ls [options] [file|directory] [file|directory...]
```

If no file or directory is specified on the command line, `ls` will list files in the current directory. Its options are numerous, so we'll only describe a few of them:

- `-a`: lists all files, including ***hidden files***. Remember that in UNIX, hidden files are those whose names begin with a `.`; the `-A` option lists "almost" all files, which means every file the `-a` option would print except for "." and ".."
- `-R`: lists recursively, i.e. all files and subdirectories of directories entered on the command line.
- `-s`: prints the file size in kilobytes next to each file.
- `-l`: prints additional information about the files such as the permissions associated to it, the owner and owner group, the file's size and the last-access time.
- `-i`: prints the inode number (the file's unique number in the file system, see "*The Linux File System*", page 55) next to each file.
- `-d`: treats directories on the command line as if they were normal files rather than listing their contents.

Here are some examples:

- `ls -R`: recursively lists the contents of the current directory.
- `ls -is images/ ..`: lists the inode number and the size in kilobytes for each file in the `images/` directory as well as in the parent of the current directory.
- `ls -l images/*.png`: lists all files in the `images/` directory whose names end with `.png`, including the file `.png`, if it exists.

1.4.6. Useful Keyboard Shortcuts

There are a number of shortcuts available, with the primary advantage being that they save you a lot of typing time. This section assumes you're using the default shell provided with Mandrakelinux, bash, but these keystrokes might work with other shells too.

First: the arrow keys. bash maintains a history of previous commands which you can view with the up and down arrow keys. You can scroll up to a maximum number of lines defined in the `HISTSIZE` environment variable. In addition, the history is persistent from one session to another, so you will not lose all the commands you typed in previous sessions.

The left and right arrow keys move the cursor left and right on the current line, allowing you to edit your commands. But there's more to editing than just moving one character at a time: **Ctrl-A** and **Ctrl-E**, for example, will take you to the beginning and the end of the current line. The **Backspace** and **Del** keys work as expected. **Backspace** and **Ctrl-H** are equivalent. **Del** and **Ctrl-D** can also be used interchangeably. **Ctrl-K** will delete from the position of the cursor to the end of line, and **Ctrl-W** will delete the word before the cursor (so will **Alt-Backspace**).

Typing **Ctrl-D** on a blank line will let you close the current session, which is much shorter than having to type `exit`. **Ctrl-C** will interrupt the currently running command, except if you were in the process of editing your command line, in which case it will cancel the editing and get you back to the prompt. **Ctrl-L** clears the screen. **Ctrl-Z** temporarily stops a task, it suspends it. This shortcut is very useful when you forget to type the "&" character after typing a command. For instance:

```
$ xpdf MyDocument.pdf
```

Hence you cannot use your shell anymore since the foreground task is allocated to the xpdf process. To put that task in the background and restore your shell, simply type `bg`.

Finally, there are **Ctrl-S** and **Ctrl-Q**, which are used to suspend and restore output to the screen. They are not used often, but you might type **Ctrl-S** by mistake (after all, **S** and **D** are close to each other on the keyboard). So, if you get into the situation where you're typing but you can't see any characters appearing on the Terminal, try **Ctrl-Q**. Note that all the characters you typed between the unwanted **Ctrl-S** and **Ctrl-Q** will be printed to the screen all at once.

Chapter 2. Disks and Partitions

This chapter contains information for those who simply wish to know more about the technical details underlying their system. It will give a complete description of the PC partitioning scheme. Therefore it will be most useful if you plan to manually configure your hard drive partitions. Since the installer can partition your hard disk automatically, it's not critical to understand everything if you perform a standard installation. However if you plan on modifying the partition scheme, the information in this chapter will be important.

2.1. Structure of a Hard Disk

A disk is physically divided into sectors. A sequence of sectors can form a partition. Roughly speaking, you can create as many partitions as you wish, up to 67 (3 primary partitions and a secondary partition containing up to 64 logical partitions inside): each of them is regarded as a single hard drive.

2.1.1. Sectors

To simplify, a hard disk is merely a sequence of sectors, which are the smallest data unit on a hard disk. The typical size of a sector is 512 bytes. The sectors on a hard disk of "n" sectors are numbered from "0" to "n-1".

2.1.2. Partitions

The use of multiple partitions enables you to create many virtual hard drives on your real physical drive. This has many advantages:

- Different operating systems use different disk structures (called ***file systems***): this is the case with Windows and GNU/Linux. Having multiple partitions on a hard drive allows you to install various operating systems on the same physical drive.
- For performance reasons, a single operating system may prefer different drives with various file systems on them because they may be used for completely different things. One example is GNU/Linux which requires a second partition called Swap. The latter is used by the virtual memory manager as virtual memory.
- Even if all of your partitions use the same file system, it may prove useful to separate the different parts of your OS into different partitions. A simple configuration example would be to split your files into two partitions: one for your personal data, and another one for your programs. This allows you to update your OS, completely erasing the partition containing the programs while keeping the data partition safe.
- Physical errors on a hard disk are generally located on adjacent sectors, not scattered across the disk. Distributing your files across different partitions could limit data loss if your hard disk is physically damaged.

Normally, the partition type specifies the file system which the partition is supposed to contain. Each operating system might recognize some partition types, but not others. Please see "*File Systems and Mount Points*", page 51, and "*The Linux File System*", page 55, for more information.

2.1.3. Defining the Structure of Your Disk

2.1.3.1. The Simplest Way

This scenario would imply only two partitions: one for the Swap space, the other one for the files[1].

1. the default file system under Mandrakelinux is called `ext3`

A rule of thumb is to set the swap partition size to twice the size of your RAM memory (i.e.: if you have 128 MB of RAM memory the swap size should be of 256 MB). However for large memory configurations (>512 MB), this rule isn't critical, and smaller sizes are acceptable.

2.1.3.2. Another Common Scheme

Separate data from programs. To be even more efficient, one usually defines a third partition called `root` and labelled as `/`. It will contain the programs required to start your system and to perform basic maintenance.

Therefore we could define four partitions:

Swap

A Swap partition whose size is roughly twice the amount of physical RAM.

Root: `/`

The most important partition. Not only does it contain critical data and programs for the system, it also acts as a mount point for other partitions (see "*File Systems and Mount Points*", page 51).

The needs of the root partition in terms of size are very limited, 400MB is generally enough. However, if you plan to install commercial applications, which are most often located in the `/opt/` directory, you will need to increase the size of the root partition. Alternatively, you may create a separate partition for `/opt/`.

Static data: `/usr/`

Most packages install the majority of their executables and data files under the `/usr/` directory. The advantage of creating a separate partition is that it allows you to easily share it with other machines over a network.

The recommended size depends on the packages you wish to install, and can vary from 100MB for a very lightweight installation, to several GB for a full installation. A compromise of two or three GB (depending on your disk size) is usually sufficient.

Home directories: `/home/`

This directory contains the personal directories for all of the users hosted on your machine. The partition size depends on the number of users hosted and their needs.

Another solution is to **not** create a separate partition for the `/usr/` files: `/usr/` will simply be a directory inside the root (`/`) partition.

2.1.3.3. Exotic Configurations

When setting up your machine for specific uses — such as a web server or a firewall — the needs are radically different than for a standard desktop machine. For example, a FTP server will probably need a large separate partition for `/var/ftp/`, while the `/usr/` directory could be relatively small. In these situations, you're encouraged to carefully think about your needs before even beginning the installation process.

If you need to resize your partitions or use a different partition scheme, note that it is possible to resize most partitions without the need to reinstall your system and without losing your data. Please consult *Managing Your Partitions* of the *Starter Guide* .

With some practice, you'll even be able to move a crowded partition to a brand new hard drive.

2.2. Conventions for Naming Disks and Partitions

GNU/Linux uses a logical method to name partitions. First, when numbering the partitions, it ignores the file-system type of each partition you may have. Second, it names the partitions according to the disk on which they are located. This is how the disks are named:

- The primary master and primary slave IDE devices (whether they be hard disks, CD-ROM drives or anything else) are called `/dev/hda` and `/dev/hdb` respectively.
- On the secondary interface, the master is called `/dev/hdc` and the slave is `/dev/hdd`.
- If your computer contains other IDE interfaces (for example, the IDE interface present on some Soundblaster cards), the disks will be called `/dev/hde`, `/dev/hdf`, etc. You may also have additional IDE interfaces if you have RAID controllers.
- SCSI disks are called `/dev/sda`, `/dev/sdb`, etc., in the order of their appearance on the SCSI chain (depending on the increasing IDs). The SCSI CD-ROM drives are called `/dev/scd0`, `/dev/scd1`, always in the order of their appearance on the SCSI chain.

The partitions are named after the disk on which they're found, in the following way (in our example, we've used partitions on a primary master IDE disk):

- The primary (or extended) partitions are named `/dev/hda1` through `/dev/hda4`, when present.
- Logical partitions, if any, are named `/dev/hda5`, `/dev/hda6`, etc. in the order of their appearance in the table of logical partitions.

So GNU/Linux will name the partitions as follows:

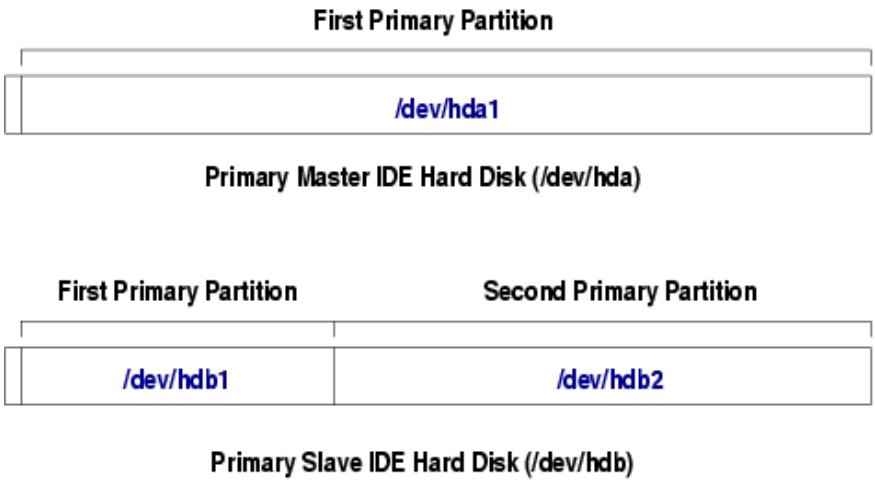


Figure 2-1. First Example of Partition Naming under GNU/Linux

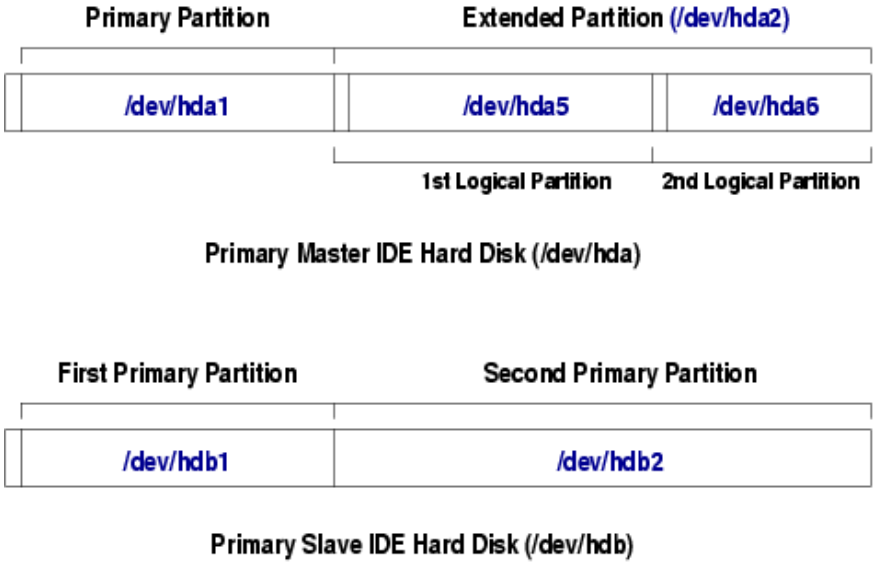


Figure 2-2. Second Example of Partition Naming under GNU/Linux

With this knowledge in hand, you should be able to name your various partitions and hard disks when you need to manipulate them. You'll also see that GNU/Linux names the partitions even if it doesn't know how to manage them initially (it ignores the fact that they're not native GNU/Linux partitions).

For `2.4` and `2.6` kernels, Mandrakelinux uses the Linux DevFS (Device File System) (`http://www.atnf.csiro.au/~rgooch/linux/docs/devfs.html`). It ensures full compatibility with the scheme described above, but this compatibility may disappear in the future. Each device is dynamically added to the system as soon as it becomes available or needed.

For example, the first IDE hard drive now becomes `/dev/ide/host0/bus0/target0/lun0/disc` instead of `/dev/hda`.

Chapter 3. Introduction to the Command Line

In the chapter "*Basic UNIX System Concepts*", page 5, you were shown how to launch a shell. In this chapter, we will show you how to work with it.

The shell's main asset is the number of existing utilities: there are thousands of them, and each one is devoted to a particular task. We will only look at a (very) small number of them here. One of UNIX's greatest assets is the ability to combine these utilities, as we shall see later.

3.1. File-Handling Utilities

In this context, file handling means copying, moving and deleting files. Later, we will look at ways of changing file attributes (owner, permissions).

3.1.1. mkdir, touch: Creating Empty Directories and Files

`mkdir` (*MaKe DIRectory*) is used to create directories. Its syntax is simple:

```
mkdir [options] <directory> [directory ...]
```

Only one option is worth noting: the `-p` option. It does two things:

1. it will create parent directories if they did not exist before. Without this option, `mkdir` would just fail, complaining that the said parent directories do not exist;
2. it will return silently if the directory you wanted to create already exists. Similarly, if you did not specify the `-p` option, `mkdir` will send back an error message, complaining that the directory already exists.

Here are some examples:

- `mkdir foo`: creates a directory `foo` in the current directory;
- `mkdir -p images/misc docs`: creates the `misc` directory in the `images` directory. First, it creates the latter if it does not exist (`-p`); it also creates a directory named `docs` in the current directory.

Initially, the `touch` command was not intended for creating files but for updating file access and modification times[1]. However, `touch` will create the files listed as empty files if they do not exist. The syntax is:

```
touch [options] file [file...]
```

So running the command:

```
touch file1 images/file2
```

will create an empty file called `file1` in the current directory and an empty file `file2` in directory `images`, if the files did not previously exist.

3.1.2. rm: Deleting Files or Directories

The `rm` command (*ReMove*) replaces the DOS commands `del` and `deltree`, and adds more options. Its syntax is as follows:

```
rm [options] <file|directory> [file|directory...]
```

Options include:

- `-r`, or `-R`: delete recursively. This option is **mandatory** for deleting a directory, empty or not. However, you can also use `rmdir` to delete empty directories.

1. In UNIX, there are three distinct timestamps for each file: the last file access date (`atime`), i.e. the last date when the file was opened for read or write; the last date when the inode attributes were modified (`mtime`); and finally, the last date when the **contents** of the file were modified (`ctime`).

- `-i`: request confirmation before each deletion. Note that by default in Mandrakelinux, `rm` is an ***alias*** to `rm -i`, for safety reasons (similar aliases exist for `cp` and `mv`). Your mileage may vary as to the usefulness of these aliases. If you want to remove them, you can create an empty `~/.alias` file which will prevent setting system wide aliases. Alternatively you can edit your `~/.bashrc` file to disable some of the system wide aliases by adding this line: `unalias rm cp mv`
- `-f`, the opposite of `-i`, forces deletion of the files or directories, even if the user has no write access on the files[2].

Some examples:

- `rm -i images/*.jpg file1`: deletes all files with names ending in `.jpg` in the `images` directory and deletes `file1` in the current directory, requesting confirmation for each file. Answer **y** to confirm deletion, **n** to cancel.
- `rm -Rf images/misc/ file*`: deletes, without requesting confirmation, the whole directory `misc/` in the `images/` directory, together with all files in the current directory whose names begin with `file`.

Using `rm` deletes files **irrevocably**. There is no way to restore them[3]! Don't hesitate to use the `-i` option to ensure that you do not delete something by mistake.

3.1.3. mv: Moving or Renaming Files

The syntax of the `mv` (*MoVe*) command is as follows:

```
mv [options] <file|directory> [file|directory ...] <destination>
```

Some options:

- `-f`: forces operation — no warning if an existing file is overwritten.
- `-i`: the opposite. Asks the user for confirmation before overwriting an existing file.
- `-v`: ***verbose*** mode, report all changes and activity.

Some examples:

- `mv -i /tmp/pics/*.png .`: move all files in the `/tmp/pics/` directory whose names end with `.png` to the current directory (`.`), but request confirmation before overwriting any files already there.
- `mv foo bar`: rename file `foo` to `bar`. If a `bar` directory already existed, the effect of this command would be to move file `foo` or the whole directory (the directory itself plus all files and directories in it, recursively) into the `bar` directory.
- `mv -vf file* images/ trash/`: move, without requesting confirmation, all files in the current directory whose names begin with `file`, together with the entire `images/` directory to the `trash/` directory, and show each operation carried out.

3.1.4. cp: Copying Files and Directories

`cp` (*CoPy*) replaces the DOS commands `copy` and `xcopy` and adds more options. Its syntax is as follows:

```
cp [options] <file|directory> [file|directory ...] <destination>
```

`cp` has a lot of options. Here are the most common:

- `-R`: recursive copy; **mandatory** for copying a directory, even an empty directory.
- `-i`: request confirmation before overwriting any files which might be overwritten.

2. It is enough for the user to have write access to the **directory** to be able to delete files in it, even if he is not the owner of the files.

- `-f`: the opposite of `-i`, replaces any existing files without requesting confirmation.
- `-v`: verbose mode, displays all actions performed by `cp`.

Some examples:

- `cp -i /timages/* images/`: copies all files in the `/timages/` directory to the `images/` directory located in the current directory. It requests confirmation if a file is going to be overwritten.
- `cp -vR docs/ /shared/mp3s/* mystuff/`: copies the whole `docs` directory, plus all files in the `/shared/mp3s` directory to the `mystuff` directory.
- `cp foo bar`: makes a copy of the `foo` file with the name `bar` in the current directory.

3.2. Handling File Attributes

The series of commands shown here are used to change the owner or owner group of a file or its permissions. We looked at the different permissions in chapter `Basic UNIX System Concepts`.

3.2.1. chown, chgrp: Change the Owner and Group of One or More Files

The syntax of the `chown` (*CHange OWNer*) command is as follows:

```
chown [options] <user[:group]> <file|directory> [file|directory...]
```

The options include:

- `-R`: recursive. To change the owner of all files and subdirectories in a given directory.
- `-v`: verbose mode. Displays all actions performed by `chown`; reports which files have changed ownership as a result of the command and which files have not been changed.
- `-c`: like `-v`, but only reports which files have been changed.

Some examples:

- `chown nobody /shared/book.tex`: changes the owner of the `/shared/book.tex` file to `nobody`.
- `chown -Rc queen:music *.mid concerts/`: changes the ownership of all files in the current directory whose name ends with `.mid` and all files and subdirectories in the `concerts/` directory to user `queen` and group `music`, reporting only files affected by the command.

The `chgrp` (*CHange GRouP*) command lets you change the group ownership of a file (or files); its syntax is very similar to that of `chown`:

```
chgrp [options] <group> <file|directory> [file|directory...]
```

The options for this command are the same as for `chown`, and it is used in a very similar way. Thus, the command:

```
chgrp disk /dev/hd*
```

changes the ownership of all files in directory `/dev/` with names beginning with `hd` to group `disk`.

3.2.2. chmod: Changing Permissions on Files and Directories

The `chmod` (*CHange MODe*) command has a very distinct syntax. The general syntax is:

```
chmod [options] <change mode> <file|directory> [file|directory...]
```

but what distinguishes it is the different forms that the mode change can take. It can be specified in two ways:

1. in octal. The owner user permissions then correspond to figures with the form `<x>00`, where `<x>` corresponds to the permission assigned: 4 for read permission, 2 for write permission and 1 for execute permission. Similarly, the owner group permissions take the form `<x>0` and permissions for "others" the form `<x>`. Then, all you need to do is add together the assigned permissions to get the right mode. Thus, the permissions `rwxr-xr--` correspond to 400+200+100 (owner permissions, `rwx`) +40+10 (group permissions, `r-x`) +4 (others' permissions, `r--`) = 754; in this way, the permissions are expressed in absolute terms. This means that previous permissions are unconditionally replaced;
2. with expressions. Here permissions are expressed by a sequence of expressions separated by commas. Hence an expression takes the following form: `[category]<+|-|=><permissions>`.

   The category may be one or more of:

   - `u` (*User*, permissions for owner);
   - `g` (*Group*, permissions for owner group);
   - `o` (*Others*, permissions for "others").

   If no category is specified, changes will apply to all categories. A `+` sets a permission, a `-` removes the permission and a `=` sets the permission. Finally, the permission is one or more of the following:

   - `r` (*Read*);
   - `w` (*Write*) or;
   - `x` (*eXecute*).

The main options are quite similar to those of `chown` and `chgrp`:

- `-R`: changes permissions recursively.
- `-v`: verbose mode. Displays the actions carried out for each file.
- `-c`: like `-v` but only shows files affected by the command.

Examples:

- `chmod -R o-w /shared/docs`: recursively removes write permission for `others` on all files and subdirectories in the `/shared/docs/` directory.
- `chmod -R og-w,o-x private/`: recursively removes write permission for `group` and `others` for the whole `private/` directory, and removes the execution permission for `others`.
- `chmod -c 644 misc/file*`: changes permissions of all files in the `misc/` directory whose names begin with `file` to `rw-r--r--` (i.e. read permission for everyone and write permission only for the owner), and reports only files affected by this command.

3.3. Shell Globbing Patterns

You probably already use ***globbing*** characters without knowing it. When you specify a file in Windows or when you look for a file, you use * to match a random string. For example, `*.txt` matches all files with names ending with `.txt`. We also used it heavily in the last section. But there is more to globbing than just *.

When you type a command like `ls *.txt` and press Enter, the task of finding which files match the `*.txt` pattern is not done by the `ls` command, but by the shell itself. This requires a little explanation about how a command line is interpreted by the shell. When you type:

```
$ ls *.txt
      readme.txt  recipes.txt
```

the command line is first split into words (`ls` and `*.txt` in this example). When the shell sees a * in a word, it will interpret the whole word as a globbing pattern and will replace it with the names of all matching files. Therefore, the command, just before the shell executes it, has become `ls readme.txt recipe.txt`, which gives the expected result. Other characters make the shell react this way too:

- `?`: matches one and only one character, regardless of what that character is;
- `[...]`: matches any character found in the brackets. Characters can be referred to either as a range of characters (i.e. `1-9`) or ***discrete values***, or even both. Example: `[a-zBE5-7]` will match all characters between `a` and `z`, a `B`, an `E`, a `5`, a `6` or a `7`;
- `[!...]`: matches any character **not** found in the brackets. `[!a-z]`, for example, will match any character which is not a lowercase letter[4];
- `{c1,c2}`: matches `c1` or `c2`, where `c1` and `c2` are also globbing patterns, which means you can write `{[0-9]*,[acr]}` for example.

Here are some patterns and their meanings:

- `/etc/*conf`: all files in the `/etc` directory with names ending in `conf`. It can match `/etc/inetd.conf`, `/etc/conf.linuxconf`, **and also** `/etc/conf` if such a file exists. Remember that * can also match an empty string.
- `image/{cars,space[0-9]}/*.jpg`: all file names ending with `.jpg` in directories `image/cars`, `image/space0`, (...), `image/space9`, if those directories exist.
- `/usr/share/doc/*/README`: all files named `README` in all of `/usr/share/doc`'s immediate subdirectories. This will make `/usr/share/doc/mandrake/README` match, for example, but not `/usr/share/doc/myprog/doc/README`.
- `*[!a-z]`: all files with names which do **not** end with a lowercase letter in the current directory.

3.4. Redirections and Pipes

3.4.1. A Little More About Processes

To understand the principle of redirections and pipes, we need to explain a notion about processes which has not yet been introduced. Most UNIX processes (this also includes graphical applications but excludes most daemons) use a minimum of three file descriptors: standard input, standard output and standard error. Their respective numbers are 0, 1 and 2. In general, these three descriptors are associated with the terminal from which the process was started, with the input being the keyboard. The aim of redirections and pipes is to redirect these descriptors. The examples in this section will help you better understand this concept.

4. Beware! While this is true for most languages, this may not be true for your own language setting (`locale`). This depends on the **collating order**. On some language configurations, `[a-z]` will match a, A, b, B, (...), z. And we do not even mention the fact that some languages have accentuated characters...

3.4.2. Redirections

Imagine, for example, that you wanted a list of files ending with `.png`[5] in the `images` directory. This list is very long, so you may want to store it in a file in order to look through it at your leisure. You can enter the following command:

```
$ ls images/*.png 1>file_list
```

This means that the standard output of this command (`1`) is redirected (`>`) to the file named `file_list`. The `>` operator is the output redirection operator. If the redirection file does not exist, it is created, but if it exists, its previous contents are overwritten. However, the default descriptor redirected by this operator is the standard output and does not need to be specified on the command line. So you can write more simply:

```
$ ls images/*.png >file_list
```

and the result will be exactly the same. Then you could look at the file using a text file viewer such as `less`.

Now, imagine you want to know how many of these files exist. Instead of counting them by hand, you can use the utility called `wc` (*Word Count*) with the `-l` option, which writes on the standard output the number of lines in the file. One solution is as follows:

```
wc -l 0<file_list
```

and this gives the desired result. The `<` operator is the input redirection operator, and the default redirected descriptor is the standard input one, i.e. `0`, and you simply need to write the line:

```
wc -l <file_list
```

Now suppose you want to remove all the file "extensions" and put the result in another file. One tool for doing this is `sed` (*Stream EDitor*). You simply redirect the standard input of `sed` to the `file_list` file and redirect its output to the result file, i.e. `the_list`:

```
sed -e 's/\.png$//g' <file_list >the_list
```

and your list is created, ready for you to view at your leisure with any viewer.

It can also be useful to redirect standard errors. For example, you want to know which directories in `/shared` you cannot access: one solution is to list this directory recursively and to redirect the errors to a file, while not displaying the standard output:

```
ls -R /shared >/dev/null 2>errors
```

which means that the standard output will be redirected (`>`) to `/dev/null`, a special file in which everything you write is discarded (i.e. the standard output is not displayed) and the standard error channel (`2`) is redirected (`>`) to the `errors` file.

3.4.3. Pipes

Pipes are in some ways a combination of input and output redirections. The principle is that of a physical pipe, hence the name: one process sends data into one end of the pipe and another process reads the data at the other end. The pipe operator is `|`. Let us go back to the file list example above. Suppose you want to find out directly how many corresponding files there are without having to store the list in a temporary file, you would then use the following command:

```
ls images/*.png | wc -l
```

which means that the standard output of the `ls` command (i.e. the list of files) is redirected to the standard input of the `wc` command. This then gives you the desired result.

You can also directly put together a list of files "without extensions" using the following command:

```
ls images/*.png | sed -e 's/\.png$//g' >the_list
```

5. You might think it is crazy to say "files ending with `.png`" rather than "PNG images". However, once again, files under UNIX only have an extension by convention: extensions in no way define a file type. A file ending with `.png` could perfectly well be a JPEG image, an application file, a text file or any other type of file. The same is true under Windows as well!

or, if you want to consult the list directly without storing it in a file:

```
ls images/*.png | sed -e 's/\.png$//g' | less
```

Pipes and redirections are not restricted solely to text which can be read by human beings. For example, the following command sent from a Terminal:

```
xwd -root | convert - ~/my_desktop.png
```

will send a screen shot of your desktop to the `my_desktop.png` [6] file in your personal directory.

3.5. Command-Line Completion

Completion is a very handy function, and all modern shells (including bash) have it. Its role is to give the user as little work to do as possible. The best way to illustrate completion is to give an example.

3.5.1. Example

Suppose your personal directory contains the `file_with_very_long_name_impossible_to_type` file, and you want to look at it. Suppose you also have, in the same directory, another file called `file_text`. You are in your personal directory, so type the following sequence:

```
$ less fi<TAB>
```

(i.e., type `less fi` and then press the `TAB` key). The shell will then expand the command line for you:

```
$ less file_
```

and also give the list of possible choices (in its default configuration, which can be customized). Then type the following key sequence:

```
less file_w<TAB>
```

and the shell will extend the command line to give you the result you want:

```
less file_with_very_long_name_impossible_to_type
```

All you need to do then is press the `Enter` key to confirm and read the file.

3.5.2. Other Completion Methods

The TAB key is not the only way to activate completion, although it is the most common one. As a general rule, the word to be completed will be a command name for the first word of the command line (`nsl<TAB>` will give `nslookup`), and a file name for all the others, unless the word is preceded by a "magic" character like `~`, `@` or `$`, in which case the shell will try to complete a user name, a machine name or an environment variable name respectively[7]. There is also a magic character for completing a file name (`/`) and a command to recall a command from the history (`!`).

The other two ways to activate completion are the sequences `Esc-<x>` and `Ctrl+x <x>`, where `<x>` is one of the magic characters already mentioned. `Esc-<x>` will attempt to come up with a unique completion. If it fails, it will complete the word with the largest possible substring in the choice list. A ***beep*** means either that the choice is not unique, or simply that there is no corresponding choice. The sequence `Ctrl+x <x>` displays the list of possible choices without attempting any completion. Pressing the `TAB` key is the same as successively pressing `Esc-<x>` and `Ctrl+x <x>`, where the magic character depends on the context.

Thus, one way to see all the environment variables defined is to type the sequence `Ctrl+x $` on a blank line. Another example: if you want to see the man page for the `nslookup` command, you simply type `man nsl` then `Esc-!`, and the shell will automatically complete the command to `man nslookup`.

6. Yes, it will indeed be a PNG image (however, the ImageMagick package needs to be installed...).
7. Remember: UNIX differentiates between uppercase and lowercase. The `HOME` environment variable and the `home` variable are not the same.

3.6. Starting and Handling Background Processes: Job Control

You have probably noticed that when you enter a command from a Terminal, you normally have to wait for the command to finish before the shell returns control to you. This means that you have sent the command in the ***foreground***. However, there are occasions when this is not desirable.

Suppose, for example, that you decide to copy a large directory recursively to another. You have also decided to ignore errors, so you redirect the error channel to `/dev/null`:

```
cp -R images/ /shared/ 2>/dev/null
```

Such a command can take several minutes until it is fully executed. You then have two solutions: the first one is violent, and means stopping (killing) the command and then doing it again when you have the time. To do this, press `Ctrl+c`: this will terminate the process and take you back to the prompt. But wait, don't do it yet! Read on.

Suppose you want the command to run while you do something else. The solution is then to put the process into the ***background***. To do this, press `Ctrl+z` to suspend the process:

```
$ cp -R images/ /shared/ 2>/dev/null
# Type C-z here
[1]+  Stopped                 cp -R images/ /shared/ 2>/dev/null
$
```

and there you are again at the prompt. The process is then on standby, waiting for you to restart it (as shown by the `Stopped` keyword). That, of course, is what you want to do, but in the background. Type `bg` (for *Back-Ground*) to get the desired result:

```
$ bg
      [1]+ cp -R images/ /shared/ 2>/dev/null &
      $
```

The process will then start running again as a background task, as indicated by the `&` (ampersand) sign at the end of the line. You will then be back at the prompt and able to continue working. A process which runs as a background task, or in the background, is called a background ***job***.

Of course, you can start processes directly as background tasks by adding an **&** character at the end of the command. For example, you can start the command to copy the directory in the background by writing:

```
cp -R images/ /shared/ 2>/dev/null &
```

If you want, you can also restore this process to the foreground and wait for it to finish by typing `fg` (*ForeGround*). To put it into the background again, type the sequence `Ctrl+z`, `bg`.

You can start several jobs this way: each command will then be given a job number. The shell command `jobs` lists all the jobs associated with the current shell. The job preceded by a + sign indicates the last process begun as a background task. To restore a particular job to the foreground, you can then type `fg <n>` where `<n>` is the job number, i.e. `fg 5`.

Note that you can also suspend or start ***full-screen*** applications this way, such as `less` or a text editor like Vi, and restore them to the foreground when you want.

3.7. A Final Word

As you can see, the shell is very comprehensive and using it effectively is a matter of practice. In this relatively long chapter, we have only mentioned a few of the available commands: Mandrakelinux has thousands of utilities, and even the most experienced users do not make use of them all.

There are utilities for all tastes and purposes: you have utilities for handling images (like `convert` mentioned above, but also GIMP ***batch*** mode and all ***pixmap*** handling utilities), sound (Ogg Vorbis encoders, audio CD players), CD writing, e-mail clients, FTP clients and even web browsers (like `lynx` or `links`), not to mention all the administration tools.

Even if graphical applications with equivalent functions do exist, they are usually graphical interfaces built around these very same utilities. In addition, command-line utilities have the advantage of being able to operate in non-interactive mode: you can start writing a CD and then log off the system with the confidence that the writing will take place (see the nohup(1) man page or the screen(1) man page).

Chapter 4. Text Editing: Emacs and VI

As stated in the introduction, text editing[1] is a fundamental feature when using a UNIX system. The two editors we are going to take a quick look at are a little difficult to use initially, but once you understand the basics, each one can prove to be a powerful tool.

4.1. Emacs

Emacs is probably the most powerful text editor in existence. It can do absolutely everything and is infinitely extensible through its built-in lisp-based programming language. With Emacs, you can move around the web, read your mail, take part in Usenet newsgroups, make coffee, and so on. This is not to say that you will learn how to do all of that in this chapter, but you will get a good start with opening Emacs, editing one or more files, saving them and quitting Emacs.

4.1.1. Short Presentation

Invoking Emacs is done as follows:

```
emacs [file] [file...]
```

Emacs will open every file entered as an argument into a separate buffer, with a maximum of two buffers visible at a time. If you start Emacs without specifying any files on the command line you will be placed into a buffer called `*scratch*`. If you are in X, menus will be available, but in this chapter we will concentrate on working strictly with the keyboard.

4.1.2. Getting Started

It's now time to get some hands-on experience. For our example, let us start by opening two files, `file1` and `file2`. If these files do not exist, they will be created as soon as you write something in them:

```
$ emacs file1 file2
```

By typing that command, the following window will be displayed:

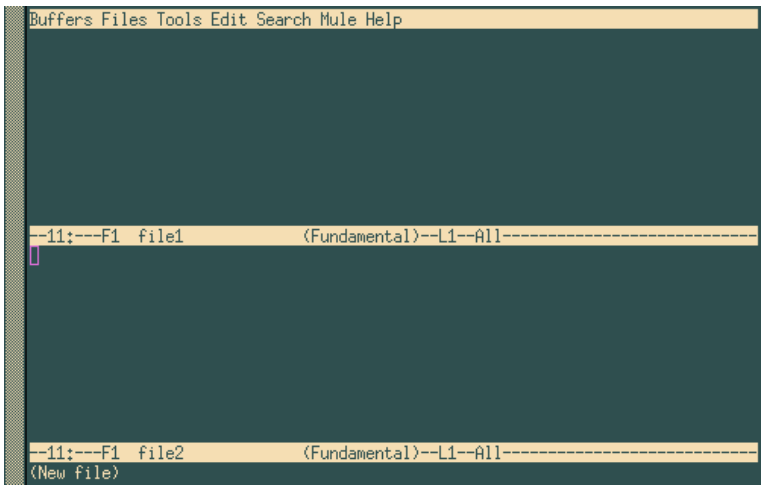


Figure 4-1. Editing Two Files at Once

As you can see, one buffer has been created. A third one is also present at the bottom of the screen (where you see `(New file)`). That is the mini-buffer. You cannot access this buffer directly. You must be invited by Emacs during interactive entries. To change the current buffer, type `Ctrl+x o`. You type text just as in a "normal" editor, deleting characters with the `DEL` or `Backspace` key.

1. "To edit text" means to modify the contents of a file containing only letters, digits, and punctuation symbols. Such files may be e-mail messages, source code, documents, or even configuration files.

To move around, you can use the arrow keys, or you could use the following key combinations: `Ctrl+a` to go to the beginning of the line, `Ctrl+e` to go to the end of the line, `Alt+<` to go to the beginning of the buffer and `Alt+>` to go to the end of the buffer. There are many other combinations, even ones for each of the arrow keys [2].

Once you are ready to save your changes to disk, type `Ctrl+x Ctrl+s`, or if you want to save the contents of the buffer to another file, type `Ctrl+x Ctrl+w`. Emacs will ask you for the name of the file that the contents of the buffer should be written to. You can use ***completion*** to do this.

4.1.3. Handling buffers

If you want, you can switch to displaying a single buffer on the screen. There are two ways of doing this:

- If you are in the buffer that you want to hide: type `Ctrl+x 0`
- If you are in the buffer which you want to keep on the screen: type `Ctrl+x 1`.

There are two ways of restoring a buffer back to the screen:

- type `Ctrl+x b` and enter the name of the buffer you want, or
- type `Ctrl+x Ctrl+b`. This will open a new buffer called `*Buffer List*`. You can move around this buffer using the sequence `Ctrl+x o`, then select the buffer you want and press the `Enter` key, or else type the name of the buffer in the mini-buffer. The buffer `*Buffer List*` returns to the background once you have made your choice.

If you have finished with a file and you want to get rid of the associated buffer, type `Ctrl+x k`. Emacs will then ask you which buffer it should close. By default, this will be the buffer you are currently in. If you want to get rid of a buffer other than the one suggested, enter its name directly or press `TAB`: Emacs will open yet another buffer called `*Completions*` giving the list of possible choices. Confirm the choice with the `Enter` key.

You can also restore two visible buffers to the screen at any time. To do this type `Ctrl+x 2`. By default, the new buffer created will be a copy of the current buffer (which enables you, for example, to edit a large file in several places "at the same time"). To move between buffers, use the commands that were previously mentioned.

You can open other files at any time, using `Ctrl+x Ctrl+f`. Emacs will prompt you for the file name and you can again use completion if you find it more convenient.

4.1.4. Copy, Cut, Paste, Search

Suppose you find yourself in the following situation: figure 4-2.

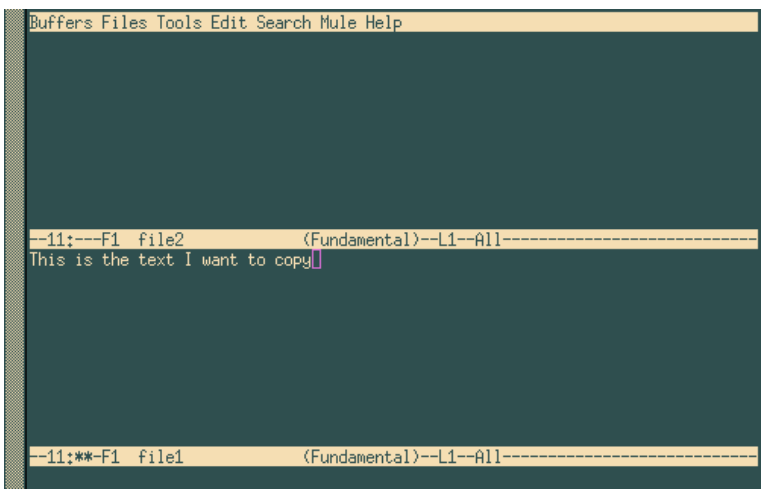


Figure 4-2. Emacs, before copying the text block

2. Emacs has been designed to work on a great variety of machines, some of which do not have arrow keys on their keyboards. This is even more true of Vi.

First off, you will need to select the text you want to copy. In this example we want to copy the entire sentence. The first step is to place a mark at beginning of the area. Assuming the cursor is in the position where it is in figure 4-2, the command sequence would be `Ctrl+ SPACE` (`Control` + space bar). Emacs will display the message `Mark set` in the mini-buffer. Next, move to the beginning of the line with `Ctrl+a`. The area selected for copying or cutting is the entire area located between the mark and the cursor's current position, so in this case it will be the entire line of text. There are two command sequences available: `Alt+w` (to copy) or `Ctrl+w` (to cut). If you copy, Emacs will briefly return to the mark position so that you can view the selected area.

Finally, go to the buffer where you want the text to end up and type `Ctrl+y`. This will give you the following result:

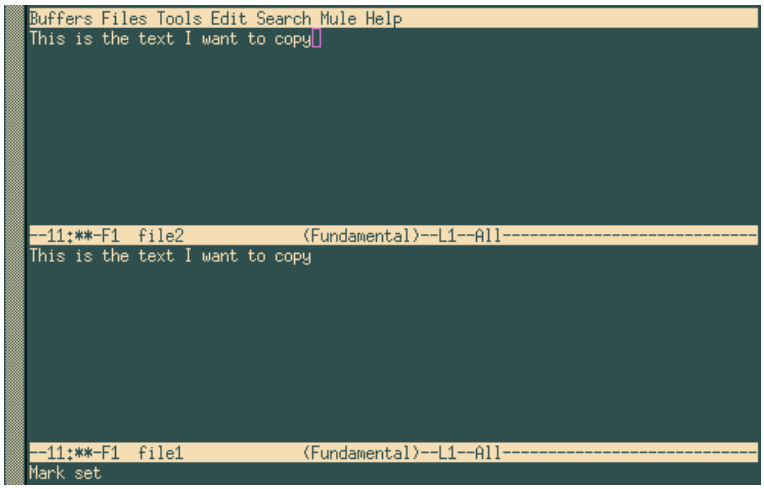


Figure 4-3. Copying Text with emacs

In fact, what you've done is copy text to Emacs's ***kill ring***. This kill ring contains all of the areas copied or cut since Emacs was started. **Any** area just copied or cut is placed at the top of the kill ring. The `Ctrl+y` sequence only "pastes" the area at the top. If you want to access any of the other areas, press `Ctrl+y` then `Alt+y` until you get to the desired text.

To search for text, go to the desired buffer and type `Ctrl+s`. Emacs will ask you what string it should search for. To continue a search with the same string in the current buffer, just type `Ctrl+s` again. When Emacs reaches the end of the buffer and finds no more occurrences, you can type `Ctrl+s` again to restart the search from the beginning of the buffer. Pressing the `Enter` key ends the search.

To search and replace, type `Alt+%`. Emacs asks you what string to search for, what to replace it with, and asks for confirmation for each occurrence it finds.

To Undo, type `Ctrl+x u` which will undo the previous operation. You can undo as many operations as you want.

4.1.5. Quit emacs

The shortcut to quit Emacs is `Ctrl+x Ctrl+c`. If you have not saved your changes, Emacs will ask you whether you want to save your buffers or not.

4.2. Vi: the ancestor

Vi was the first full-screen editor in existence. It is one of the main programs UNIX detractors point to, but also one of the better arguments of its defenders: while it is complicated to learn, it is also an extremely powerful tool once you get into the habit of using it. With a few keystrokes, a Vi user can move mountains, and other than Emacs, few text editors can make the same claims.

The version supplied with Mandrakelinux is in fact vim, for *VI iMproved*, but we will refer to it as Vi throughout this chapter.

4.2.1. Insert Mode, Command Mode, ex Mode...

To begin using Vi we use the same sort of command line as we did with Emacs. So let us go back to our two files and type:

```
$ vi file1 file2
```

At this point, you will find yourself looking at a window resembling the following one:

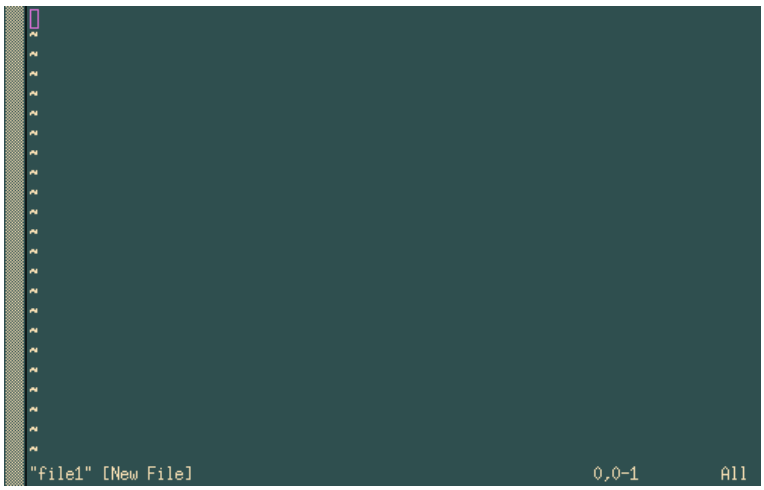


Figure 4-4. Starting position in VIM

You are now in ***command mode*** in front of the first opened file. In this mode you cannot insert text into a file. To do so you must switch to ***insert mode***.

Here are some shortcuts to inserting text:

- **a** and **i**: to insert text after and before the cursor (**A** and **I** insert text at the end and at the beginning of the current line);
- **o** and **O** : to insert text below and above the current line.

In insert mode, you will see the string `--INSERT--` appear at the bottom of the screen (so you know which mode you are in). This is the only mode which will allow you to insert text. To return to command mode, press the `Esc` key.

In insert mode, you can use the `Backspace` and `DEL` keys to delete text as you go along. The arrow keys will allow you to move around within the text in Command mode and Insert mode. In command mode, there are also other key combinations which we will look at later.

`ex` mode is accessed by pressing the **:** key in command mode. A **:** will appear at the bottom left of the screen with the cursor positioned after it. Vi will consider everything you type up to the `Enter` key as an `ex` command. If you delete the command and the **:** you typed in, you will be returned to command mode and the cursor will go back to its original position in the text.

To save changes to a file type `:w` in command mode. If you want to save the contents of the buffer to another file, type `:w <file_name>`.

4.2.2. Handling Buffers

To move, in the same buffer, between the files whose names were passed on the command line, type `:next` to move to the next file and `:prev` to move to the previous file. You can also use `:e <file_name>`, which allows you to either change to the desired file if it is already open, or to open another file. You may also use completion.

As with Emacs, you can have several buffers displayed on the screen. To do this, use the `:split` command.

To change buffers, type `Ctrl+w j` to go to the buffer below or `Ctrl+w k` to go to the buffer above. You can also use the up and down arrow keys instead of **j** or **k**. The `:close` command hides a buffer and the `:q` command closes it.

You should be aware that if you try to hide or close a buffer without saving the changes, the command will not be carried out and Vi will display this message:

```
No write since last change (use ! to override)
```

In this case, do as you are told and type `:q!` or `:close!`.

4.2.3. Editing Text and Move Commands

Apart from the `Backspace` and `DEL` keys in edit mode, Vi has many other commands for deleting, copying, pasting, and replacing text in command mode. All the commands shown hereafter are in fact separated into two parts: the action to be performed and its effect. The action may be:

- **c**: to replace (*Change*). The editor deletes the requested text and goes back into insert mode after this command.
- **d**: to delete (*Delete*);
- **y**: to copy ("Yank"). We will look at this in the next section.
- **.**: repeats last action.

The effect defines which group of characters the command acts upon.

- **h**, **j**, **k**, **l**: one character left, down, up, right[3]
- **e**, **b**, **w**: to the end, beginning of the current word and the beginning of the next word.
- **^**, **0**, **$**: to the first non-blank character of the current line, the beginning of the current line, and the end of current line.
- `f<x>`: go to next occurrence of character `<x>`. For example, `fe` moves the cursor to the next occurrence of the character **e**.
- `/<string>`, `?<string>`: to the next and previous occurrence of string or regexp `<string>`. For example, `/foobar` moves the cursor to the next occurrence of the word `foobar`.
- {, }: to the beginning, to the end of current paragraph;
- **G**, **H**: to end of file, to beginning of screen.

Each of these "effect" characters or move commands can be preceded by a repetition number. For **G**, ("Go") this references the line number in the file. Based on this information, you can make all sorts of combinations.

Here are some examples:

- `6b`: moves 6 words backwards;
- `c8fk`: delete all text until the eighth occurrence of the character **k** then go into insert mode;
- `91G`: goes to line 91 of the file;
- `d3$`: deletes up to the end of the current line plus the next two lines.

While many of these commands are not very intuitive, the best method to remember the commands is to practice them. But you can see that the expression "move mountains with a few keys" is not much of an exaggeration.

3. A shortcut for `dl` (delete one character forward) is **x**; a shortcut for `dh` is **X**; `dd` deletes the current line.

4.2.4. Cut, Copy, Paste

Vi contains a command which we have already seen for copying text: the **y** command. To cut text, simply use the **d** command. There are 27 memories or buffers for storing text: an anonymous memory and 26 memories named after the 26 lowercase letters of the alphabet.

To use the anonymous memory you enter the command "as is". So the command `y12w` will copy the 12 words after the cursor into anonymous memory[4]. Use `d12w` if you want to cut this area.

To use one of the 26 named memories, enter the sequence `"<x>` before the command, where `<x>` gives the name of the memory. Therefore, to copy the same 12 words into the memory **k**, you would write `"ky12w`, or `"kd12w` to cut them.

To paste the contents of the anonymous memory, use the commands **p** or **P** (for *Paste*), to insert text after or before the cursor. To paste the contents of a named memory, use `"<x>p` or `"<x>P` in the same way (for example `"dp` will paste the contents of memory `d` after the cursor).

Let us look at an example:.

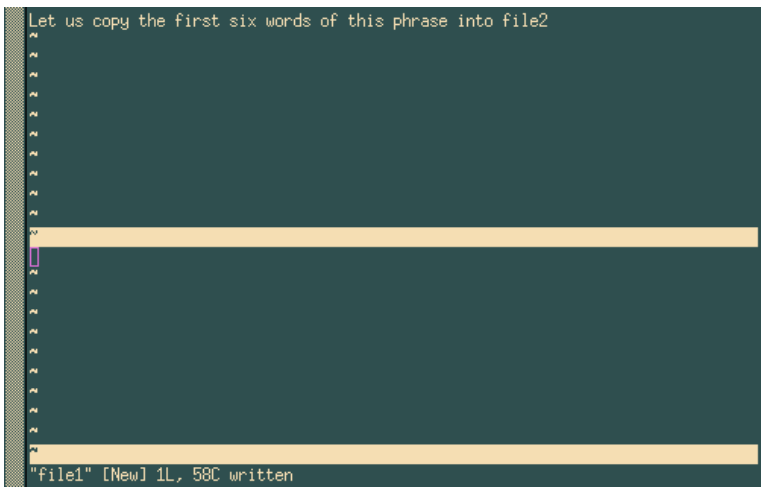


Figure 4-5. VIM, before copying the text block

To carry out this action, we will:

- recopy the first 6 words of the sentence into memory **r** (for example): `"ry6w`[5];
- go into the buffer `file2`, which is located below: `Ctrl+w j`;
- paste the contents of memory **r** before the cursor: `"rp`.

We get the expected result, as shown in figure 4-6.

4. But only if the cursor is positioned at the beginning of the first word!
5. `y6w` literally means: "Yank 6 words".

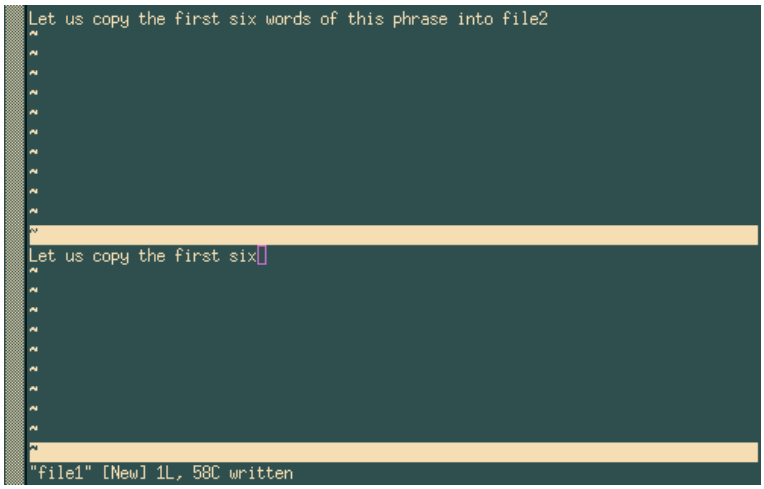


Figure 4-6. VIM, after having copied the text block

Searching for text is very simple: in command mode, you simply type **/** followed by the string to search for, and then press the `Enter` key. For example, `/party` will search for the string `party` from the current cursor position. Pressing **n** takes you to the next occurrence, and if you reach the end of the file, the search will start again from the beginning. To search backwards, use **?** instead of **/**.

4.2.5. Quit Vi

The command to quit is `:q` (in fact, this command actually closes the active buffer, as we have already seen, but if it is the only buffer open, you will quit Vi). There is a shortcut: most of the time you edit only one file. So to quit, you will use:

- `:wq` to save changes and quit (a quicker solution is `ZZ`), or
- `:q!` to quit without saving.

You should note that if you have several buffers, `:wq` will only write the active buffer and then close it.

4.3. A last word...

Of course, we have said much more here than was necessary (after all, the first aim was to edit a text file), but hopefully we have been able to show you some of the possibilities of each of these editors. There is a great deal more to be said about them, as witnessed by the number of books dedicated to each of these editors.

Take the time to absorb all this information, opt for one of them, or learn only as much as you think necessary. But at least you know that when you want to go further, you can.

Chapter 5. Command-Line Utilities

The purpose of this chapter is to introduce a number of command-line tools that may prove useful for everyday use. Of course, you may skip this chapter if you only intend to use a graphical environment, but a quick glance may change your opinion.

Each command will be illustrated by an example, but this chapter is meant as an exercise in order for you to fully grasp their function and use.

5.1. File Operations and Filtering

Most command-line work is done on files. In this section we discuss how to watch and filter file content, take required information from files using a single command, and to sort files.

5.1.1. cat, tail, head, tee: File Printing Commands

These commands have almost the same syntax:

```
command_name [option(s)] [file(s)]
```

and may be used in a pipe. All of them are used to print part of a file according to certain criteria.

The `cat` utility concatenates files and prints to the standard output. This is one of the most widely used commands. You can use:

```
# cat /var/log/mail/info
```

to print, for example, the content of a mailer daemon log file to standard output[1]. The `cat` command has a very useful option (`-n`) which allows you to print numbers of all output lines.

Some files, like daemon log files (if they are running) are usually huge in size[2] and printing them completely on the screen is not very useful. Often you need to see only some lines of the file. You can use the `tail` command to see the last lines. So the following command will print the last 10 lines of the file `/var/log/mail/info`:

```
# tail /var/log/mail/info
```

Value `10` is the default if no single parameter was specified. If you want to display only the last 2 lines you can use the `-n` option:

```
# tail -n2 /var/log/mail/info
```

The `head` command is similar to `tail`, but it prints the first lines of a file. Used without options it prints the first 10 lines of the specified file:

```
# head /var/log/mail/info
```

As with `tail` you can print the first 2 lines of this file using the `-n` option:

```
# head -n2 /var/log/mail/info
```

You can also use these commands together. For example, if you wish to display only lines 9 and 10, you can use a command where the `head` command will select the first 10 lines from a file and pass them through a pipe to the `tail` command.

```
# head /var/log/mail/info | tail -n2
```

The last part will then select the last 2 lines and will print them to the screen. In the same way you can select line number 20 from the end of a file:

```
# tail -n20 /var/log/mail/info |head -n1
```

1. Some examples in this section are based on real work with log files of some servers (services, daemons). Make sure the syslogd is running (allows daemon's logging), corresponding daemon (in our case Postfix) and you work as `root`. Anyway you can always apply our examples to other files.
2. For example, the `/var/log/mail/info` file contains information about all sent mails, messages about fetching mail by users with the POP protocol, etc.

In this example we tell `tail` to select the file's last 20 lines and pass them through a pipe to `head`. Then the `head` command prints to the screen the first line from the obtained data.

Let's suppose we want to print the result of the last example to the screen and save it to the file `results.txt` at the same time. The `tee` utility can help us. Its syntax is:

```
tee [option(s)] [file]
```

Now we can change the previous command this way:

```
# tail -n20 /var/log/mail/info |head -n1|tee results.txt
```

Let's take yet another example. We want to select the last 20 lines, save them to `results.txt`, but print on screen only the first of the 20 selected lines. Then we should type:

```
# tail -n20 /var/log/mail/info |tee results.txt |head -n1
```

The `tee` command has a useful option (`-a`) which allows you to append received data to an existing file.

Let's go back to the `tail` command. Files such as logs usually vary dynamically because the daemon constantly add actions and events to the log file. So, if you want to interactively watch the changes to the log file you can take advantage of one more of `tail`'s useful options: `-f`:

```
# tail -f /var/log/mail/info
```

In this case all changes in the `/var/log/mail/info` file will be printed on screen immediately. Using the `tail` command with option `-f` is very helpful when you want to know how your system works. For example, looking through the `/var/log/messages` log file, you can keep up with system messages and various daemons. Also you can use `tail` with the `-f` option to see changes in any other files.

In the next section we will see how we can use grep as a filter to separate Postfix messages from messages coming from other services.

5.1.2. grep: Locate Strings in Files

Neither the name nor the acronym ("General Regular Expression Parser") is very intuitive, but what it does and its use are simple: grep looks for a pattern given as an argument in one or more files. Its syntax is:

```
grep [options] <pattern> [one or more file(s)]
```

If several files are mentioned, their names will precede each matching line displayed in the result. Use the `-h` option to prevent the display of these names; use the `-l` option to get nothing but the matching filenames. The pattern is a regular expression, even though most of the time it consists of a simple word. The most frequently used options are the following:

- `-i`: make a case insensitive search (i.e. ignore differences between lower and uppercase);
- `-v`: invert search. display lines which do **not** match the pattern;
- `-n`: display the line number for each line found;
- `-w`: tells grep that the pattern should match a whole word.

So let's go back to analyze the mailer daemon's log file. We want to find all lines in the file `/var/log/mail/info` which contain the "postfix" pattern. Then we type this command:

```
# grep postfix /var/log/mail/info
```

The grep command can be used in a pipe. Thus we can get the same result as in the previous example by doing this:

```
# cat /var/log/mail/info | grep postfix
```

If we want to find all lines not containing the "postfix" pattern, we would use the `-v` option:

```
# grep -v postfix /var/log/mail/info
```

Let's suppose we want to find all messages about successfully sent mails. In this case we have to filter all lines which were added into the log file by the mailer daemon (contains the "postfix" pattern) and they must contain a message about successful sending ("status=sent"):

```
# grep postfix /var/log/mail/info |grep status=sent
```

In this case grep is used twice. It is allowed, but not very elegant. We can get the same result by using the `fgrep` utility. First, we need to create a file containing patterns written out in a column. Such a file can be created this way (we use `patterns.txt` as the file name):

```
# echo -e 'status=sent\npostfix' >./patterns.txt
```

Then we call the next command where we use the `patterns.txt` file with a list of patterns and the `fgrep` utility instead of the "double calling" of grep:

```
# fgrep -f ./patterns.txt /var/log/mail/info
```

The file `./patterns.txt` may contain as many patterns as you wish. Each of them has to be typed as a single line. For example, to select messages about successfully sent mails to `peter@mandrakesoft.com`, it would be enough to add this email into our `./patterns.txt` file by running this command:

```
# echo 'peter@mandrakesoft.com' >>./patterns.txt
```

It is clear that you can combine grep with `tail` and `head`. If we want to find messages about the last but one email sent to `peter@mandrakesoft.com` we type:

```
# fgrep -f ./patterns.txt /var/log/mail/info | tail -n2 | head -n1
```

Here we apply the filter described above and place the result in a pipe for the `tail` and `head` commands. They select the last but one value from received data.

5.1.3. wc: Count Elements in Files

The `wc` command (*Word Count*) is used to count the number of strings and words in files. It is also helpful to count bytes, characters and the length of the longest line. Its syntax:

```
wc [option(s)] [file(s)]
```

The following options are useful:

- `-l`: print the number of new lines;
- `-w`: print the number of words;
- `-m`: print the total number of characters;
- `-c`: print the number of bytes;
- `-L`: print the length of the longest line in the obtained text.

The `wc` command prints the number of newlines, words and characters by default. Here some usage examples:

If we want to find the number of users in our system, we can type:

```
$wc -l /etc/passwd
```

If we want to know the number of CPU's in our system, we write:

```
$grep "model name" /proc/cpuinfo |wc -l
```

In the previous section we obtained a list of messages about successfully sent mails to e-mail addresses listed in our `./patterns.txt` file. If we want to know the number of such messages, we can redirect our filter's results in a pipe for the `wc` command:

```
# fgrep -f ./patterns.txt /var/log/mail/info | wc -l
```

5.1.4. sort: Sorting File Content

Here is the syntax of this powerful sorting utility[3]:

```
sort [option(s)] [file(s)]
```

Let's consider sorting on part of the `/etc/passwd` file. As you can see this file is not sorted:

```
$ cat /etc/passwd
```

If we want to sort it by `login` field. Then we type:

```
$ sort /etc/passwd
```

The `sort` command sorts data in ascending order starting by the first field (in our case, the `login` field) by default. If we want to sort data in descending order, we use the option `-r`:

```
$ sort -r /etc/passwd
```

Every user has his own `UID` written in the `/etc/passwd` file. Let's sort a file in ascending order using the `UID` field:

```
$ sort /etc/passwd -t":" -k3 -n
```

Here we use the following `sort` options:

- `-t":"`: tells `sort` that the field separator is the `":"` symbol;
- `-k3`: means that sorting must be done on the third column;
- `-n`: says that the sort is to occur on numerical data, not alphabetical.

The same can be done in reverse:

```
$ sort /etc/passwd -t":" -k3 -n -r
```

Note that `sort` has two other important options:

- `-u`: perform a strict ordering: duplicate sort fields are discarded;
- `-f`: ignore case (treat lowercase as uppercase characters).

Finally, if we want to find the user with the highest `UID` we can use this command:

```
$ sort /etc/passwd -t":" -k3 -n |tail -n1
```

where we sort the `/etc/passwd` file in ascending order according to the `UID` column, and redirect the result through a pipe to the `tail` command which will print out the first value of the sorted list.

5.2. find: Find Files According to Certain Criteria

`find` is a long-standing UNIX utility. Its role is to recursively scan one or more directories and find files which match a certain set of criteria in those directories. Even though it is very useful, the syntax is truly obscure, and using it requires a little work. The general syntax is:

```
find [options] [directories] [criterion] [action]
```

If you do not specify any directory, `find` will search the current directory. If you do not specify criteria, this is equivalent to "true", thus all files will be found. The options, criteria and actions are so numerous that we will only mention a few of each here. Let's start with options:

- `-xdev`: do not search on directories located on other file systems

3. We only discuss `sort` briefly here because whole books can be written about its features.

- `-mindepth <n>`: descend at least `<n>` levels below the specified directory before searching for files
- `-maxdepth <n>`: search for files which are located at most `n` levels below the specified directory
- `-follow`: follow symbolic links if they link to directories. By default, `find` does not follow links.
- `-daystart`: when using tests related to time (see below), take the beginning of current day as a timestamp instead of the default (24 hours before current time).

A criteria may be one or more of several ***atomic*** tests. Some useful tests are:

- `-type <type>`: search for a given type of file. `<type>` can be one of: `f` (regular file), `d` (directory), `l` (symbolic link), `s` (socket), `b` (block mode file), `c` (character mode file) or `p` (named pipe).
- `-name <pattern>`: find files whose names match the given `<pattern>`. With this option, `<pattern>` is treated as a ***shell globbing*** pattern (see chapter *Shell Globbing Patterns*, page 20);
- `-iname <pattern>`: like `-name`, but ignore case
- `-atime <n>`, `-amin <n>`: find files that have last been accessed `<n>` days ago (`-atime`) or `<n>` minutes ago (`-amin`). You can also specify `+<n>` or `-<n>`, in which case the search will be done for files accessed at most or at least `<n>` days/minutes ago;
- `-anewer <file>`: find files which have been accessed more recently than file `<file>`
- `-ctime <n>`, `-cmin <n>`, `-cnewer <file>`: same as for `-atime`, `-amin` and `-anewer`, but applies to the last time that the contents of the file were modified
- `-regex <pattern>`: same as `-name`, but `pattern` is treated as a ***regular expression***
- `-iregex <pattern>`: same as `-regex`, but ignore case.

There are many other tests, refer to `find`(1) for more details. To combine tests, you can use one of:

- `<c1>` -a `<c2>`: true if both `<c1>` and `<c2>` are true; `-a` is implicit, therefore you can type `<c1>` `<c2>` `<c3>` ... if you want all tests `<c1>`, `<c2>`, ... to match
- `<c1>` -o `<c2>`: true if either `<c1>` or `<c2>` are true, or both. Note that `-o` has a lower ***precedence*** than `-a`, therefore if you want to match files which match criteria `<c1>` or `<c2>` and match criterion `<c3>`, you will have to use parentheses and write `( <c1>` -o `<c2> )` -a `<c3>`. You must ***escape*** (deactivate) parentheses, as otherwise they will be interpreted by the shell!
- `-not <c1>`: inverts test `<c1>`, therefore `-not <c1>` is true if `<c1>` is false.

Finally, you can specify an action for each file found. The most frequently used are:

- `-print`: just prints the name of each file on the standard output. This is the default action.
- `-ls`: prints on the standard output the equivalent of `ls -ilds` for each file found.
- `-exec <command>`: execute command `<command>` on each file found. The command line `<command>` must end with a `;`, which you must escape so that the shell does not interpret it; the file position is marked with `{}`. See the usage examples.
- `-ok <command>`: same as `-exec` but asks for confirmation for each command.

The best way to consolidate all of the options and parameters is with some examples. Let's say you want to find all directories in the `/usr/share` directory. You would type:

```
find /usr/share -type d
```

Suppose you have an HTTP server, all your HTML files are in `/var/www/html`, which is also your current directory. You want to find all files whose contents have not been modified for a month. Because you have pages from several writers, some files have the `html` extension and some have the `htm` extension. You want to link these files in directory `/var/www/obsolete`. You would type[4]:

```
find \( -name "*.htm" -o -name "*.html" \) -a -ctime -30 \
-exec ln {} /var/www/obsolete \;
```

4. Note that this example requires that `/var/www` and `/var/www/obsolete` be on the same file system!

This is a fairly complex example, and requires a little explanation. The criterion is this:

```
\( -name "*.htm" -o -name "*.html" \) -a -ctime -30
```

which does what we want: it finds all files whose names end either in `.htm` or `.html` " `\( -name "*.htm" -o -name "*.html" \)` ", **and** (`-a`) which have not been modified in the last 30 days, which is roughly a month (`-ctime -30`). Note the parentheses: they are necessary here, because `-a` has a higher precedence. If there weren't any, all files ending with `.htm` would have been found, plus all files ending with `.html` and which haven't been modified for a month, which is not what we want. Also note that parentheses are escaped from the shell: if we had put `( .. )` instead of `\( .. \)`, the shell would have interpreted them and tried to execute `-name "*.htm" -o -name "*.html"` in a sub-shell... Another solution would have been to put parentheses between double quotes or single quotes, but a backslash here is preferable as we only have to isolate one character.

And finally, there is the command to be executed for each file:

```
-exec ln {} /var/www/obsolete \;
```

Here too, you have to escape the `;` from the shell, because otherwise the shell interprets it as a command separator. If you happen to forget, `find` will complain that `-exec` is missing an argument.

A last example: you have a huge directory (`/shared/images`) containing all kinds of images. Regularly, you use the touch command to update the times of a file named `stamp` in this directory, so that you have a time reference. You want to find all ***JPEG*** images which are newer than the `stamp` file, but because you got the images from various sources, these files have extensions `jpg`, `jpeg`, `JPG` or `JPEG`. You also want to avoid searching in the `old` directory. You want this file list to be mailed to you, and your user name is `peter`:

```
find /shared/images -cnewer     \
     /shared/images/stamp       \
     -a -iregex ".*\.jpe?g"     \
     -a -not -regex ".*/old/.*" \
       | mail peter -s "New images"
```

Of course, this command is not very useful if you have to type it each time, and you would like it to be executed regularly. A simple way to have the command run periodically is:

5.3. Commands Startup Scheduling

5.3.1. crontab: reporting or editing your crontab file

`crontab` is a command which allows you to execute commands at regular time intervals, with the added bonus that you don't have to be logged in. `crontab` will have the output of your command mailed to you. You can specify the intervals in minutes, hours, days, and even months. Depending on the options, `crontab` will act differently:

- `-l`: Print your current `crontab` file.
- `-e`: Edit your `crontab` file.
- `-r`: Remove your current `crontab` file.
- `-u <user>`: Apply one of the above options for user `<user>`. Only `root` can do this.

Let's start by editing a `crontab`. If you type `crontab -e`, you will be in front of your favorite text editor if you have set the `EDITOR` or `VISUAL` environment variable, otherwise Vi will be used. A line in a `crontab` file is made of six fields. The first five fields are time intervals for minutes, hours, days in the month, months and days in the week. The sixth field is the command to be executed. Lines beginning with a `#` are considered to be comments and will be ignored by `crond` (the program which is responsible for executing `crontab` files). Here is an example of `crontab`:

in order to print this out in a readable font, we had to break up long lines. Therefore, some chunks must be typed on a single line. When the \ character ends a line, this means this line is to be continued. This convention works in `Makefile` files and in the shell as well as in other contexts.

```
# If you don't want to be sent mail, just comment
#   out the following line
#MAILTO=""
#
# Report every 2 days about new images at 2 pm,
#   from the example above - after that, "retouch"
#   the "stamp" file. The "%" is treated as a
#   newline, this allows you to put several
#   commands in a same line.
0 14 */2 * *  find /shared/images              \
  -cnewer /shared/images/stamp                 \
  -a -iregex ".*\.jpe?g"                       \
  -a -not -regex                               \
    ".*/old/.*"%touch /shared/images/stamp
#
# Every Christmas, play a melody :)
0 0 25 12 * mpg123 $HOME/sounds/merryxmas.mp3
#
# Every Tuesday at 5pm, print the shopping list...
0 17 * * 2 lpr $HOME/shopping-list.txt
```

There are several ways to specify intervals other than the ones shown in this example. For example, you can specify a set of ***discrete values*** separated by commas (`1,14,23`) or a range (`1-15`), or even combine both of them (`1-10,12-20`), optionally with a step (`1-12,20-27/2`). Now it's up to you to find useful commands to put in it!

5.3.2. at: schedule a command, but only once

You may also want to launch a command at a given day, but not regularly. For example, you want to be reminded of an appointment, today at 6pm. You run X, and you would like to be notified at 5:30pm, for example, that you must go. `at` is what you want here:

```
$ at 5:30pm
  # You're now in front of the "at" prompt
at> xmessage "Time to go now! Appointment at 6pm"
  # Type CTRL-d to exit
at> <EOT>
$
```

You can specify the time in different ways:

- `now +<interval>`: Means, well, now, plus an interval (optionally. No interval specified means just now). The syntax for the interval is `<n>` (minutes | hours | days | weeks | months). For example, you can specify `now + 1 hour` (an hour from now), `now + 3 days` (three days from now) and so on.
- `<time> <day>`: Fully specify the date. The `<time>` parameter is mandatory. `at` is very liberal in what it accepts: you can for example type `0100`, `04:20`, `2am`, `0530pm`, `1800`, or one of three special values: `noon`, `teatime` (4pm) or `midnight`. The `<day>` parameter is optional. You can specify this in different ways as well: `12/20/2001` for example, which stands for December 20th, 2001, or, the European way, `20.12.2001`. You may omit the year, but then only the European notation is accepted: `20.12`. You can also specify the month in full letters: `Dec 20` or `20 Dec` are both valid.

`at` also accepts different options:

- `-l`: Prints the list of currently queued jobs; the first field is the job number. This is equivalent to the `atq` command.

- `-d <n>`: Remove job number `<n>` from the queue. You can obtain job numbers from `atq`. This is equivalent to `atrm <n>`.

As usual, see the at(1) `manpage` for more options.

5.4. Archiving and Data Compression

5.4.1. tar: Tape ARchiver

Although we have already seen a use for `tar` in the "*Building and Installing Free Software*", page 71 chapter, we have not explained how it works, which we will do in this section. Just like `find`, `tar` is a long standing UNIX utility, so its syntax is a bit special. The syntax is:

```
tar [options] [files...]
```

Here is a list of some options. Note that all of them have an equivalent long option, but you will have to refer to the manual page for this as we will not list them here.

the initial dash (-) of short options is now deprecated with `tar`, except after a long option.

- `c`: this option is used in order to create new archives
- `x`: this option is used in order to extract files from an existing archive
- `t`: lists files from an existing archive
- `v`: lists the files which are added to an archive or extracted from an archive, or, in conjunction with the `t` option (see above), it outputs a long listing of files instead of a short one
- `f <file>`: create archive with name `<file>`, extract from archive `<file>` or list files from archive `<file>`. If this parameter is omitted, the default file will be `/dev/rmt0`, which is generally the special file associated with a ***streamer***. If the file parameter is - (a dash), the input or output (depending on whether you create an archive or extract from one) will be associated to the standard input or standard output
- `z`: tells `tar` that the archive to create should be compressed with `gzip`, or that the archive to extract from is compressed with `gzip`
- `j`: same as `z`, but the program used for compression is `bzip2`
- `p`: when extracting files from an archive, preserve all file attributes, including ownership, last access time and so on. Very useful for file system dumps.
- `r`: append the list of files given on the command line to an existing archive. Note that the archive to which you want to append files should **not** be compressed!
- `A`: append archives given on the command line to the one submitted with the `f` option. Similar to `r`, the archives should not be compressed in order for this to work.

There are many, many, many other options, so you may want to refer to the tar(1) manual page for the entire list. See, for example, the `d` option. Let's proceed with an example. Say you want to create an archive of all images in `/shared/images`, compressed with `bzip2`, named `images.tar.bz2` and located in your home directory. You would then type:

```
 #
 # Note: you must be in the directory from which
 #   you want to archive files!
 #
$ cd /shared
$ tar cjf ~/images.tar.bz2 images/
```

As you can see, we used three options here: `c` told `tar` we wanted to create an archive, `j` to compress it with `bzip2`, and `f ~/images.tar.bz2` that the archive was to be created in our home directory, and its name will be `images.tar.bz2`. We may want to check if the archive is valid now. We can do this by listing its files:

```
 #
 # Get back to our home directory
 #
$ cd
$ tar tjvf images.tar.bz2
```

Here, we told `tar` to list (`t`) files from archive `images.tar.bz2` (`f images.tar.bz2`), warned that this archive was compressed with `bzip2` (`j`), and that we wanted a long listing (`v`). Now, say you have erased the images directory. Fortunately, your archive is intact, and you now want to extract it back to its original place, in `/shared`. But as you don't want to break your `find` command for new images, you need to preserve all file attributes:

```
 #
 # cd to the directory where you want to extract
 #
$ cd /shared
$ tar jxpf ~/images.tar.bz2
```

And here you are!

Now, let's say you want to extract the directory `images/cars` from the archive, and nothing else. Then you can type this:

```
$ tar jxf ~/images.tar.bz2 images/cars
```

If you try to back up special files, `tar` will take them as what they are, special files, and will not dump their contents. So yes, you can safely put `/dev/mem` in an archive. It also deals correctly with links, so do not worry about this either. For symbolic links, also look at the `h` option in the `manpage`.

5.4.2. bzip2 and gzip: Data Compression Programs

You can see that we have already talked of these two programs when dealing with `tar`. Unlike WinZip in Windows, archiving and compressing are done using two separate utilities — `tar` for archiving, and the two programs which we will now introduce for compressing data: `bzip2` and `gzip`. You might also use a different compression tool, programs like `zip`, `arj` or `rar` also exist for GNU/Linux (but they are rarely used).

At first, `bzip2` was written as a replacement for `gzip`. Its compression ratios are generally better, but on the other hand, it requires more RAM while working. The reason that `gzip` is still used is that it is still more widespread than `bzip2`.

Both commands have a similar syntax:

```
gzip [options] [file(s)]
```

If no filename is given, both `gzip` and `bzip2` will wait for data from the standard input and send the result to the standard output. Therefore, you can use both programs in pipes. Both programs also have a set of common options:

- `-1`, ..., `-9`: set the compression ratio. The higher the number, the better the compression, but better also means slower.
- `-d`: uncompress file(s). This is equivalent to using `gunzip` or `bunzip2`.

- `-c`: dump the result of compression/decompression of files given as parameters to the standard output.

By default, both `gzip` and `bzip2` erase the file(s) that they have compressed (or uncompressed) if you don't use the `-c` option. You can avoid doing this in `bzip2` by using the `-k` option. `gzip` has no equivalent option.

Now some examples. Let's say you want to compress all files ending with `.txt` in the current directory using `bzip2`. You would type:

```
$ bzip2 -9 *.txt
```

Let's say you want to share your image archives with someone, but he does not have `bzip2`, only `gzip`. You don't need to uncompress the archive and re-compress it, you can just uncompress to the standard output, use a pipe, compress from standard input and redirect the output to the new archive. Like this:

```
bzip2 -dc images.tar.bz2 | gzip -9 >images.tar.gz
```

You could have typed `bzcat` instead of `bzip2 -dc`. There is an equivalent for `gzip` but its name is `zcat`, not **gzcat**. You also have `bzless` for `bzip2` file and `zless` for `gzip` if you want to view compressed files directly instead of having to uncompress them first. As an exercise, try and find the command you would have to type in order to view compressed files without uncompressing them, and without using `bzless` or `zless`.

5.5. Many, many more...

There are so many commands that a comprehensive book about them would be the size of an encyclopedia. This chapter hasn't even covered a tenth of the subject, yet you can do much with what you learned here. If you wish, you may read some `manual` pages: sort(1), sed(1) and zip(1) (yes, that's what you think: you can extract or make `.zip` archives with GNU/Linux), convert(1), and so on. The best way to get accustomed to these tools is to practice and experiment with them, and you will probably find a lot of uses for them, even quite unexpected ones. Have fun!

Chapter 6. Process Control

6.1. More About Processes

It is possible to monitor processes and to "ask" them to terminate, pause, continue, etc. To understand the examples we're going to examine, it is helpful to know a bit more about processes.

6.1.1. The Process Tree

As with files, all processes that run on a GNU/Linux system are organized in the form of a tree. The root of this tree is `init`, a system-level process which is started at boot time. Each process is assigned a number by the system to uniquely identify it (its PID, *Process ID*), and also inherits the PID of its parent process (PPID, *Parent Process ID*). The PID and PPID of `init` is 1: `init` is its own father.

6.1.2. Signals

Every process in UNIX can react to signals sent to it. There are 64 different signals which are identified either by their number (starting from 1) or by their symbolic names (`SIGx`, where `x` is the signal's name). The 32 "higher" signals (33 to 64) are real-time signals and are beyond the scope of this chapter. For each of these signals, the process can define its own behavior, except for two signals: signal number 9 (`KILL`) and number 19 (`STOP`).

Signal `9` terminates a process irrevocably without giving it the time to terminate properly. This is the signal you send to a process which is stuck or exhibits other problems. A full list of signals is available using the `kill -l` command.

6.2. Information on Processes: ps and pstree

These two commands display a list of processes currently running on the system, according to criteria you set.

6.2.1. ps

Sending this command without an argument will show only processes initiated by you and attached to the terminal you are using:

```
$ ps
       PID TTY          TIME CMD
     18614 pts/3    00:00:00 bash
     20173 pts/3    00:00:00 ps
```

As with many UNIX utilities, `ps` has a handful of options, the most common of which are:

- `a`: displays processes started by other users;
- `x`: displays processes with no control terminal or with a control terminal different to the one you are using;
- `u`: displays for each process the name of the user who started it and the time at which it was started.

There are many other options. Refer to the ps(1) manual page for more information.

The output of this command is divided into different fields: the one that will interest you the most is the `PID` field which contains the process identifier. The `CMD` field contains the name of the executed command. A very common way of invoking `ps` is as follows:

```
$ ps ax | less
```

This gives you a list of all processes currently running so that you can identify one or more processes which are causing problems, and subsequently terminate them.

6.2.2. pstree

The `pstree` command displays processes in the form of a tree structure. One advantage is that you can immediately see which is the parent process of what: when you want to kill a whole series of processes and if they are all parents and children, you can simply kill the parent. You will want to use the `-p` option to display the PID of each process, and the `-u` option to show the name of the user who started the process. Because the tree structure is generally quite long, you will want to invoke `pstree` in the following way:

```
$ pstree -up | less
```

This gives you an overview of the whole process tree structure.

6.3. Sending Signals to Processes: kill, killall and top

6.3.1. kill, killall

These two commands are used to send signals to processes. The `kill` command requires a process number as an argument, while `killall` requires a process name.

Both of these commands can optionally receive the signal number of the signal to be sent as an argument. By default, they both send the signal 15 (`TERM`) to the relevant process(es). For example, if you want to kill the process with PID 785, you enter the command:

```
$ kill 785
```

If you want to send it signal 19 (`STOP`), you enter:

```
$ kill -19 785
```

Suppose instead that you want to kill a process where you know the command name. Instead of finding the process number using `ps`, you can kill the process by its name:

```
$ killall -9 mozilla
```

Whatever happens, you will only kill your own processes (unless you are `root`) so you do not need to worry about your "neighbor's" processes if you're running on a multi-user system since they will not be affected.

6.3.2. Mixing ps and kill: top

`top` is a program that simultaneously fulfills the functions of `ps` and `kill` and is also used to monitor processes in real-time giving information about CPU and memory usage, running time, etc. as shown in figure 6-1.

```
top - 22:54:53 up 15:10,  0 users,  load average: 0.02, 0.06, 0.01
Tasks:  80 total,   1 running,  79 sleeping,   0 stopped,   0 zombie
Cpu(s):  1.7% us,  0.7% sy,  0.0% ni, 97.7% id,  0.0% wa,  0.0% hi,  0.0% si
Mem:    515640k total,   484920k used,    30720k free,    39856k buffers
Swap:   506008k total,        4k used,   506004k free,   244752k cached

  PID USER      PR  NI  VIRT  RES  SHR S %CPU %MEM    TIME+  COMMAND
16666 reine     15   0 25232  14m  23m S  0.7  2.8   0:51.21 kscd
 1732 root      15   0 57860  21m  38m S  0.3  4.3  21:14.37 X
13510 reine     16   0  2172 1036 1964 R  0.3  0.2   0:00.03 top
13512 reine     15   0  9364 2580 8912 S  0.3  0.5   0:00.01 import
    1 root      16   0  1580  516 1424 S  0.0  0.1   0:03.45 init
    2 root      34  19     0    0    0 S  0.0  0.0   0:00.01 ksoftirqd/0
    3 root       5 -10     0    0    0 S  0.0  0.0   0:00.55 events/0
    4 root       5 -10     0    0    0 S  0.0  0.0   0:00.02 kblockd/0
    5 root      15   0     0    0    0 S  0.0  0.0   0:00.03 kapmd
    6 root      25   0     0    0    0 S  0.0  0.0   0:00.00 pdflush
    7 root      15   0     0    0    0 S  0.0  0.0   0:00.20 pdflush
    8 root      15   0     0    0    0 S  0.0  0.0   0:00.04 kswapd0
    9 root      10 -10     0    0    0 S  0.0  0.0   0:00.00 aio/0
   11 root      20   0     0    0    0 S  0.0  0.0   0:00.00 kseriod
   15 root      15   0     0    0    0 S  0.0  0.0   0:00.83 kjournald
  121 root      16   0  2036 1204 1588 S  0.0  0.2   0:00.31 devfsd
  247 root      15   0     0    0    0 S  0.0  0.0   0:00.00 khubd
```

Figure 6-1. Monitoring Processes with top

The `top` utility is entirely keyboard controlled. You can access help by pressing **h**. Its most useful commands are the following:

- **k**: this command is used to send a signal to a process. `top` will then ask you for the process' PID followed by the number of the signal to be sent (`TERM` — or `15` — by default);
- **M**: this command is used to sort processes by the amount of memory they take up (field `%MEM`);
- **P**: this command is used to sort processes by the CPU time they take up (field `%CPU`; this is the default sorting method);
- **u**: this one is used to display a given user's processes, `top` will ask you which one. You need to enter the user's **name**, not his UID. If you do not enter any name, all processes will be displayed;
- **i**: by default, all processes, even sleeping ones, are displayed. This command ensures that only processes currently running are displayed (processes whose `STAT` field shows `R`, *Running*) and not the others. Using this command again takes you back to showing all processes.

6.4. Setting Priority to Processes: nice, renice

Every process in the system is running with defined priorities (also called "nice value"). This value may vary from -20 to +20. The maximum priority value for processes is -20. If it is not defined, every process will run with a default priority of 0 (the "base" scheduling priority). Processes with maximum priority (any negative value up to -20) use more system resources than others. Processes with minimal priority (+20) will work when the system is not used by other tasks. Users other than the super-user may only lower the priority of processes they own within a range of 0 to 20. The super-user (`root`) may set the priority of any process to any value.

6.4.1. renice

If one or more processes use too many system resources, you can change their priorities instead of killing them. For such tasks the `renice` command can be used. Its syntax is as follows:

```
renice priority [[-p] pid ...] [[-g] pgrp ...] [[-u] user ...]
```

where `priority` is the value of the priority, `pid` (use option `-p` for multiple processes) is the process ID, `pgrp` (introduced by `-g` if various) is the process group ID, and `user` (`-u` for more than one) is the user name of the process owner.

Let's suppose you have run a process with PID 785, which makes a long scientific operation, and while it is working you want to play a game. You would type:

```
$ renice +15 785
```

In this case your process could potentially take longer to complete but will not take CPU time from other processes.

If you are the system administrator and you see that some user is running too many processes and they use too many system resources, you can change that user's process priority with a single command:

```
# renice +20 -u peter
```

After this, all of `peter`'s processes will have the lowest priority and will not obstruct any other user's processes.

6.4.2. nice

Now that you know that you can change the priority of processes, you may wish to run a command with a defined priority. For this, use the `nice` command.

In this case you need to specify your command as an option to `nice`. By default `nice` sets a priority of 10. The "niceness" range goes from -20 (highest priority) to 19 (lowest). Option `-n` is used to set priority value.

For example, you want to create an ISO image of a Mandrakelinux installation CD-ROM:

```
$ dd if=/dev/cdrom of=~/mdk1.iso
```

On some systems with a standard IDE CD-ROM, the process of copying large volumes of information can use too many system resources. To prevent the copying from blocking all other processes, you can start the process with a lowered priority by using this command:

```
$ nice -n 19 dd if=/dev/cdrom of=~/mdk1.iso
```

and continue with what you were doing.

To change a process' priority you also can use the above described `top` utility. Use the **r** command within `top`'s interface to change the priority of selected process.

Chapter 7. File-Tree Organization

Nowadays, a UNIX system is big, very big. This is especially true of GNU/Linux: the amount of software available would make for an unmanageable system if there weren't any guidelines for the location of files in the tree.

The acknowledged standard is the FHS (*Filesystem Hierarchy Standard*), which was at version 2.3 at press time. The document which describes the standard is available on the Internet in different formats on The Pathname web site (`http://www.pathname.com/fhs/`). This chapter will only provide a brief summary, but it should be enough to show you which directory is likely to contain a given file, or where a given file should be placed.

7.1. Shareable/Unshareable, Static/Variable Data

Data on a UNIX system can be classified according to the following criteria: shareable data may be common to several computers in a network, while unshareable cannot. Static data must not be modified in normal use, while variable data may be. As we explore the tree structure, we'll classify the different directories into each of these categories.

Note that these classifications are only a recommendation. It's not mandatory to follow them, but adopting these guidelines will greatly help you manage your system. Also, bear in mind that the static/variable distinction only applies to general system usage, not its configuration. If you install a program, you'll obviously have to modify "normally" static directories, such as `/usr/`.

7.2. The root Directory: /

The `root` directory contains the entire system hierarchy. It cannot be classified since its subdirectories may or may not be static or shareable. Here is a list of the main directories and subdirectories, with their classifications:

- `/bin/`: essential binary files. It contains the basic commands which will be used by all users and which are necessary for the operation of the system: `ls`, `cp`, `login`, etc. Static, unshareable.
- `/boot/`: contains the files required by the GNU/Linux bootloader (GRUB or LILO for Intel, yaboot for PPC, etc). It may or may not contain the kernel, but if the kernel isn't located in this directory then it must be in the `root` directory. Static, unshareable.
- `/dev/`: system device files (`dev` for *DEVices*). Static, unshareable.
- `/etc/`: contains all configuration files specific to the computer. Static, unshareable.
- `/home/`: where all the personal directories of the system's users are located. This directory may or may not be shared (some large networks make it shareable via NFS). Variable, shareable.
- `/lib/`: it contains libraries which are essential to the system; it also stores kernel modules in the `/lib/modules/KERNEL_VERSION/` subdirectory. All libraries required by the binaries in the `/bin/` and `/sbin/` directories must be located here, together with the `ld.so` linker. Static, unshareable.
- `/mnt/`: directory containing the mount points for temporarily-mounted file systems. Variable, unshareable.
- `/opt/`: holds packages not essential for system operation. It's recommended that static files (binaries, libraries, manual pages, etc.) to be placed in `/opt/package_name` and the specific configuration files in `/etc/opt/`.
- `/root/`: home directory for `root`. Variable, unshareable.
- `/usr/`: explained in more detail in */usr/: The Big One*, page 47. Static, shareable.
- `/sbin/`: contains system binaries essential for system start-up. Most of its files can only be executed by `root`. A normal user may run them, but they won't do anything for a regular user. Static, unshareable.
- `/tmp/`: directory intended to contain temporary files which certain programs may create. Variable, unshareable.
- `/var/`: location for data which may be modified in real time by programs (such as mail servers, audit programs, print servers, etc.). Variable. Its various subdirectories may be shareable or unshareable.

7.3. /usr/: The Big One

The /usr/ directory is the main application-storage directory. The binary files in this directory are not required for system start-up or maintenance, so the /usr/ hierarchy may be, and often is, located on a separate file system. Because of its (usually) large size, /usr/ has its own hierarchy of subdirectories. We will mention just a few:

- /usr/X11R6: the entire X Window System hierarchy. All binaries and libraries required for the operation of X (including the X servers) must be located here. The /usr/X11R6/lib/X11 directory contains all aspects of X's configuration which do not vary from one computer to another. Specific configurations for each computer should go in /etc/X11.
- /usr/bin/: contains the large majority of the system's binaries. **Any** binary program which isn't necessary for the maintenance of the system and isn't a system administration program must be located in this directory. The only exceptions are programs you compile and install yourself, which must be located in /usr/local/.
- /usr/lib/: contains all the necessary libraries to run programs located in /usr/bin/ and /usr/sbin/. There is also a /usr/lib/X11 symbolic link pointing to /usr/X11R6/lib, the directory which contains the X Window System libraries (but only if X is installed).
- /usr/local/: this is where you must install applications you compile from source. The installation program should create the necessary hierarchy: lib/, bin/, etc.
- /usr/share/: this directory contains all architecture-independent data required by applications in /usr/. Among other things, you'll find zone and location information (zoneinfo and locale).

Let's also mention the /usr/share/doc and /usr/share/man directories, which respectively contain application documentation and the system's manual pages.

7.4. /var/: Data Modifiable During Use

The /var directory contains all operative data for programs running on the system. Unlike the working data in /tmp/, this data must be kept intact in the event of a reboot. There are many subdirectories, and some are very useful:

- /var/log/: contains the system's log files.
- /var/spool/: contains the working files of the system's daemons. For example, /var/spool/cups/ contains the print server's working files, while /var/spool/mail/ contains the mail server's working files (for example, all mail arriving on and leaving your system).
- /var/run/: used to keep track of all processes utilized by the system, enabling you to act on them in the event of a system change ***runlevel*** (see "*The Start-Up Files: init sysv*", page 69).

7.5. /etc/: Configuration Files

/etc/ is one of UNIX systems' most essential directories because it contains all the basic system configuration files. **Never** delete it to save space! Likewise, if you want to extend your tree structure over several partitions, remember that /etc/ must not be put on a separate partition: it is needed for system initialization and must be on the root partition at boot time.

Here are some important files:

- passwd and shadow: these are text files which contain all system users and their encrypted passwords. You will only see shadow if shadow passwords are used, which happens to be the default installation option for security reasons.
- inittab: this is the configuration file for init which plays a fundamental role in starting up the system.
- services: this file contains a list of existing network services.
- profile: this is the shell configuration file, although certain shells use other files. For example, bash uses bashrc.

- `crontab`: the configuration file for `cron`, the program responsible for periodic execution of commands.

Certain subdirectories exist for programs which require a large number of configuration files. This applies to the X Window System, for example, which stores all of its configuration files in the `/etc/X11/` directory.

Chapter 8. File Systems and Mount Points

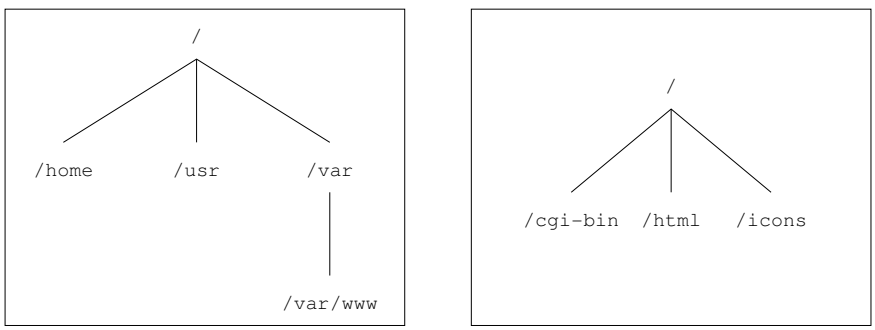
The best way to understand "how it works" is to look at a practical case, which is what we're going to do here. Suppose you just purchased a brand new hard disk with no partitions on it. Your Mandrakelinux partition is completely full, and rather than starting again from scratch, you decide to move a whole section of the tree structure to your new hard disk. Because your new disk has a lot of capacity, you decide to move your biggest directory to it: `/usr`. But first, a bit of theory.

8.1. Principles

Every hard disk is divided into several partitions, and each of these contains a file system. While Windows assigns a letter to each of these file systems (well, actually only to those it recognizes), GNU/Linux has a unique tree structure of files, and each file system is ***mounted*** at one location in that tree structure.

Just as Windows needs a `C:drive`, GNU/Linux must be able to mount the root of its file tree (`/`) on a partition which contains the ***root file system***. Once the root is mounted, you can mount other file systems in the tree structure at various ***mount points*** within the tree. Any directory below the root structure can act as a mount point, and you can mount the same file system several times on different mount points.

This allows great configuration flexibility. For example, if you were to configure a web server, it's fairly common to dedicate an entire partition to the directory which hosts the web server's data. The directory which usually contains the data is `/var/www` and acts as the mounting point for the partition. You can see in figure 8-1 and figure 8-2 how the system looks before and after mounting the file system.



Root file system
(already mounted)

File system containing files
of directory "/var/www"
(not yet mounted)

Figure 8-1. A Not Yet Mounted File System

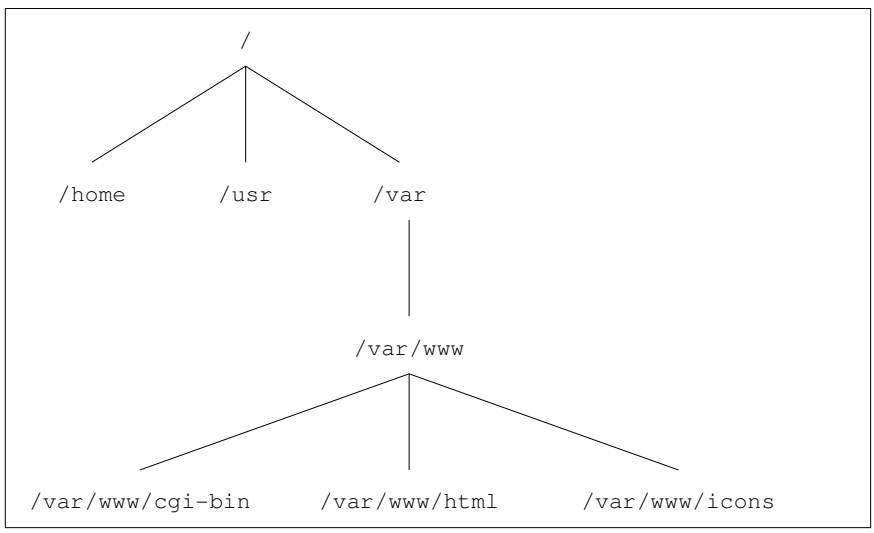


Figure 8-2. File System Is Now Mounted

As you can imagine, this offers a number of advantages: the tree structure will always be the same, whether it's on a single file system or extended over several dozen.[1] This flexibility allows you to move a key part of the tree structure to another partition when space becomes scarce, which is what we are going to do here.

There are two things you need to know about mount points:

1. The directory which acts as a mount point must exist.
2. And this directory **should preferably be empty**: if a directory chosen as a mount point already contains files and subdirectories, these will simply be "hidden" by the newly mounted file system. The files will not be deleted, but they will not be accessible until you free the mount point.

It's actually possible to access the data "hidden" by the newly mounted file system. You simply need to mount the hidden directory with the `--bind` option. For example, if you just mounted a directory in `/hidden/directory/` and want to access its original content in `/new/directory`, you would have to run:

```
mount --bind /hidden/directory/ /new/directory
```

8.2. Partitioning a Hard Disk, Formatting a Partition

There are two things to keep in mind as you read through this section: a hard disk is divided into partitions, and each of these partitions hosts a file system. Your brand new hard disk has neither, so we begin with partitioning. In order to proceed, you must be `root`.

First, you have to know the hard disk's "name" (i.e.: what file designates it). Suppose the new drive is set up as the slave on your primary IDE interface. In that case, it will be known as `/dev/hdb`.[2]. Please refer to the *Starter Guide*'s *Managing Your Partitions* section, which will explain how to partition a disk. DiskDrake will also create the file systems for you, so once the partitioning and file system creation steps are complete, we can proceed.

8.3. The mount and umount Commands

Now that the file system has been created, you can mount the partition. Initially, it will be empty, since the system hasn't had access to the file system for files to have been added to it. The command to mount file systems is `mount` , and its syntax is as follows:

```
mount [options] <-t type> [-o mount options] <device> <mounting point>
```

In this case, we want to temporarily mount our partition on `/mnt` (or any other mount point you have chosen: remember that the mount point must exist). The command for mounting our newly created partition is:

```
$ mount -t ext2 /dev/hdb1 /mnt
```

The `-t` option is used to specify what type of file system the partition is supposed to host. The file systems you will most frequently encounter are ext2FS (the GNU/Linux file system) or ext3FS (an improved version of ext2FS with journaling capabilities), VFAT (for all DOS/Windows partitions: FAT 12, 16 or 32) and ISO9660 (CD-ROM file system). If you don't specify any type, `mount` will try and guess which file system is hosted by the partition by reading the superblock.

The `-o` option is used to specify one or more mounting options. The options appropriate for a particular file system will depend on the file system being used. Refer to the mount(8) man page for more details.

Now that you've mounted your new partition, it's time to copy the entire `/usr` directory onto it:

```
$ (cd /usr && tar cf - .) | (cd /mnt && tar xpvf -)
```

1. GNU/Linux can manage up to 64 simultaneously mounted file systems.
2. Determining the name of a disk is explained in the *Installation Guide*.

Now that the files are copied, we can unmount our partition. To do this, use the `umount` command. The syntax is simple:

```
umount <mount point|device>
```

So, to unmount our new partition, we can type:

```
$ umount /mnt
```

or:

```
$ umount /dev/hdb1
```

Since this partition is going to "become" our `/usr` directory, we need to tell the system. To do this, we edit the `/etc/fstab` file. It makes it possible to automate the mounting of certain file systems, especially at system start-up. It contains a series of lines describing the file systems, their mount points and other options. Here's an example of such a file:

```
/dev/hda1   /           ext2    defaults        1 1
/dev/hda5   /home       ext2    defaults        1 2
/dev/hda6   swap        swap    defaults        0 0
none        /mnt/cdrom  supermount dev=/dev/scd0,fs=udf:iso9660,ro,-- 0 0
none        /mnt/floppy supermount dev=/dev/fd0,fs=ext2:vfat,--,sync,umask=0 0 0
none        /proc       proc    defaults        0 0
none        /dev/pts    devpts  mode=0622       0 0
```

Each line consists of:

- the device hosting the file system;
- the mount point;
- the type of file system;
- the mounting options;
- the `dump` utility backup ***flag***;
- `fsck`'s (*FileSystem CheckK*) checking order.

There is **always** an entry for the root file system. The Swap partitions are special since they're not visible in the tree structure, and the mount point field for those partitions contains the `swap` keyword. As for the `/proc` file system, it will be described in more detail in "*The /proc Filesystem*", page 63. Another special file system is `/dev/pts`.

At this point, we have moved the entire `/usr` hierarchy to `/dev/hdb1` and we want this partition to be mounted as `/usr` at boot time. To accomplish this, add the following entry to the `/etc/fstab` file:

```
/dev/hdb1       /usr        ext2    defaults  1 2
```

Now the partition will be mounted at each boot, and will be checked for errors if necessary.

There are two special options: `noauto` and `user`. The `noauto` option specifies that the file system should not be mounted at start-up, and is mounted only when you tell it to. The `user` option specifies that any user can mount and unmount the file system. These two options are typically used for the CD-ROM and floppy drives. There are other options, and `/etc/fstab` has a `man` page (fstab(5)) you can read for more information.

One advantage of using `/etc/fstab` is that it simplifies the `mount` command syntax. To mount a file system described in the file, you can either reference the mount point or the device. To mount a floppy disk, you can type:

```
$ mount /mnt/floppy
```

or:

```
$ mount /dev/fd0
```

To finish our partition moving example, let's review what we've already done. We copied the `/usr` hierarchy and modified `/etc/fstab` so that the new partition will be mounted at start-up. But for the moment, the old

/usr files are still in their original place on the drive, so we need to delete them to free up space (which was, after all, our initial goal). To do so, you first need to switch to single user mode by issuing the telinit 1 command on the command line.

- Next, we delete all files in the /usr directory. Remember that we are still referring to the "old" directory, since the newer, larger one, is not yet mounted. rm -Rf /usr/*.
- Finally, we mount the new /usr directory: mount /usr/.

And that's it. Now, go back to multi-user mode (telinit 3 for standard text mode or telinit 5 for the X Window System), and if there's no further administrative work left, you should now log off from the root account.

Chapter 9. The Linux File System

Naturally, your GNU/Linux system is contained on your hard disk within a file system. Here, we will discuss the various aspects of file systems available on GNU/Linux, as well as the possibilities they offer.

9.1. Comparison of a Few File Systems

During installation, you can choose different **file systems** for your partitions, so they will be formatted using different algorithms.

Unless you are a specialist, choosing a file system is not obvious. We will take a quick look at a few current file systems, all of which are available with Mandrakelinux.

9.1.1. Different Usable File Systems

9.1.1.1. Ext2

The **Second Extended File System** (its abbreviated form is **Ext2** or simply **ext2**) has been GNU/Linux's default file system for many years. It replaced the **Extended File System** (that's where the "Second" comes from). The "new" file system corrected certain problems and limitations of its predecessor.

Ext2 respects the usual standards for Unix-type file systems. Since its inception, it was destined to evolve while still offering great robustness and good performance.

9.1.1.2. Ext3

Like its name suggests, the **Third Extended File System** is Ext2's successor. It is compatible with the latter but enhanced by incorporating **journaling**.

One of the major flaws of "traditional" file systems like Ext2 is their low tolerance to abrupt system breakdowns (power failure or crashing software). Generally speaking, once the system is restarted, these sorts of events involve a very long examination of the file system's structure and attempts to correct errors, which sometimes result in an extended corruption. This corruption could cause partial or total loss of saved data.

Journaling answers this problem. To simplify, let's say that what we are doing is storing the actions (such as the saving of a file) **before** really doing it. We could compare this functionality to that of a boat captain who uses a log book to note daily events. The result: an always coherent file system. And if problems occur, the verification is very rapid and the eventual repairs, very limited. The time spent in verifying a file system is thus proportional to its actual use and not related to its size.

So, Ext3 offers journal file system technology while keeping Ext2's structure, ensuring excellent compatibility. This makes it very easy to switch from Ext2 to Ext3 and back again.

9.1.1.3. ReiserFS

Unlike Ext3, **ReiserFS** was written from scratch. It is a journalized file system like Ext3, but its internal structure is radically different because it uses binary-tree concepts inspired by database software.

9.1.1.4. JFS

JFS is the journalized file system designed and used by IBM. Proprietary and closed at first, IBM decided to open it to access by the free software movement. Its internal structure is similar to that of ReiserFS.

9.1.1.5. XFS

XFS is the journalized file system designed by SGI and used in ins IRIX operating system. Proprietary and closed at first, SGI decided to open it to access by the free software movement. Its internal structure has lots of different features, such as support for real-time bandwidth, extents, and clustered file systems (but not in the free version).

9.1.2. Differences Between the File Systems

	Ext2	Ext3	ReiserFS	JFS	XFS
Stability	Excellent	Good	Good	Medium	Good
Tools to restore erased files	Yes (complex)	Yes (complex)	No	No	No
Reboot time after crash	Long, even very long	Fast	Very fast	Very fast	Very fast
Status of the data in case of a crash	Generally speaking, good, but high risk of partial or total data loss	Very good	Medium[a]	Very good	Very good
ACL support	Yes	Yes	No	No	Yes
Notes: a. It is possible to improve results on crash recovery by journaling the **data** and not just the **metadata**, adding the option *data=journal* to `/etc/fstab`.					

Table 9-1. File System Characteristics

The maximum size of a file depends on many parameters (e.g. the block size for ext2/ext3), and is likely to evolve depending on the kernel version and architecture. According to the file system limits, the current maximum size is currently near or greater than 2 TeraBytes (TB, 1 TB=1024 GB) and for JFS can go up to 4 PetaBytes (PB, 1 Pb=1024 TB). Unfortunately, these values are also limited to maximum block device size, which in the current `2.4.X` kernel is limited (for `X86` arch only) to 2TB[1] even in RAID mode. In kernel 2.6.X this block device limit could be extended using a kernel compiled with Large Block Device support enabled (CONFIG_LBD=y). For more information, consult Adding Support for Arbitrary File Sizes to the Single UNIX Specification (`http://ftp.sas.com/standards/large.file/x_open.20Mar96.html`), Large File Support in Linux (`http://www.suse.com/~aj/linux_lfs.html`), and Large Block Devices (`http://www.gelato.unsw.edu.au/IA64wiki/LargeBlockDevices`).

9.1.3. And Performance Wise?

It is always very difficult to compare performance between file systems. All tests have their limitations and the results must be interpreted with caution. Nowadays, Ext2 is very mature but its development is slow; Ext3 and ReiserFS are quite mature at this point. New features for ReiserFS are included in ReiserFS4[2]. In the other hand XFS has a lot of features, and as time passes more of the advanced features work better on linux. JFS took a different approach here, and they are integrating on linux feature by feature. This makes the process slower, but they are also finishing with a very clean code base. Comparisons done a couple of months or weeks ago are already too old. Let us not forget that today's material (specially concerning hard drive capacities) has greatly leveraged the differences between them. XFS has the advantage that just now it is the better performer with large streaming files.

1. You may wonder how to achieve such capacities with hard drives that barely store 320-400GB. Using for instance one RAID card with 8 * 250GB drives in RAID-striping, you can achieve 2TB of storage. Combining the storage of several RAID cards using Linux software RAID, or using LVM (logical volume manager) it should be possible to go even beyond (block size permitting) the 2TB limit.
2. At the time of writing, ReiserFS4 was not included in kernel 2.6.X

Each system offers advantages and disadvantages. In fact, it all depends on how you use your machine. A simple desktop machine will be happy with Ext2. For a server, a journalized file system like Ext3 is preferred. ReiserFS, perhaps because of its genesis, is more suited to a database server. JFS is preferred in cases were file system throughput is the main issue. XFS is interesting if you need any of its advanced features.

For "normal" use, the four file systems give approximately the same results. ReiserFS allows you to access small files rapidly, but it is fairly slow in manipulating large files (many megabytes). In most cases, the advantages brought by ReiserFS' journaling capabilities outweigh its drawbacks. Notice that by default ReiserFS is mounted with the `notail` option. That means that there is no optimization for small files and that big files run at normal speed.

9.2. Everything is a File

The *Starter Guide* introduced the file ownership and permissions access concepts, but really understanding the UNIX ***file system*** (and this also applies to Linux' file systems) requires that we redefine the concept of "What is a file.".

Here, "everything" **really** means everything. A hard disk, a partition on a hard disk, a parallel port, a connection to a web site, an Ethernet card: all these are files. Even directories are files. Linux recognizes many types of files in addition to the standard files and directories. Note that by file type here, we do not mean the type of **content** of a file: for GNU/Linux and any UNIX system, a file, whether it be a PNG image, a binary file or whatever, is just a stream of bytes. Differentiating files according to their contents is left to applications.

9.2.1. The Different File Types

If you remember, when you do `ls -l`, the character before the access rights identifies the type of a file. We have already seen two types of files: regular files (`-`) and directories (`d`). You can also find other types if you wander through the file tree and list the contents of directories:

1. ***Character mode files***: these files are either special system files (such as `/dev/null`, which we have already discussed), or peripherals (serial or parallel ports), which share the trait that their contents (if they have any) are not ***buffered*** (meaning they are not kept in memory). Such files are identified by the letter `c`.
2. ***Block mode files***: these files are peripherals, and unlike character files, their contents **are** buffered. For example, some files in this category are: hard disks, partitions on a hard disk, floppy drives, CD-ROM drives and so on. Files `/dev/hda`, `/dev/sda5` are example of block mode files. In `ls -l` output, these are identified by the letter `b`.
3. ***Symbolic links***: these files are very common, and heavily used in the Mandrakelinux system startup procedure (see chapter "*The Start-Up Files: init sysv*", page 69). As their name implies, their purpose is to link files in a symbolic way, which means that they are files whose content is the path to a different file. They may not point to an existing file. They are very frequently called ***"soft links"***, and are identified by an `'l'`.
4. ***Named pipes***: in case you were wondering, yes, these are very similar to pipes used in shell commands, but with the difference that these actually have names. Read on to learn more. They are very rare, however, and it is not likely that you will see one during your journey into the file tree. Just in case you do, the letter identifying them is `p`. To learn more, have a look at *"Anonymous" Pipes and Named Pipes*, page 59.
5. ***Sockets***: this is the file type for all network connections, but only a few of them have names. What's more, there are different types of sockets and only one can be linked, but this is way beyond the scope of this book. Such files are identified by the letter `s`.

Here is a sample of each file:

```
$ ls -l /dev/null /dev/sda  /etc/rc.d/rc3.d/S20random /proc/554/maps \
/tmp/ssh-queen/ssh-510-agent
crw-rw-rw-    1 root     root       1,   3 May  5  1998 /dev/null
brw-rw----    1 root     disk       8,   0 May  5  1998 /dev/sda
lrwxrwxrwx    1 root     root           16 Dec  9 19:12 /etc/rc.d/rc3.d/
  S20random -> ../init.d/random*
pr--r--r--    1 queen  queen         0 Dec 10 20:23 /proc/554/maps|
srwx------    1 queen  queen         0 Dec 10 20:08 /tmp/ssh-queen/
  ssh-510-agent=
```

```
$
```

9.2.2. Inodes

Inodes are, along with the "Everything Is a File" paradigm, a fundamental part of any UNIX file system. The word ***"inode"*** is short for *Information NODE*.

Inodes are stored on disk in an **inode table**. They exist for all types of files which may be stored on a file system, including directories, named pipes, character mode files and so on. Which leads to this other famous sentence: "The inode is the file". Inodes are how UNIX identifies a file in a unique way.

No, you did not misread that: in UNIX, you **do not identify a file by its name**, but by its inode number. [3] The reason for this is that the same file may have several names, or even no name. A file name, in UNIX, is just an entry in a directory inode. Such an entry is called a **link**. Let us look at links in more detail.

9.3. Links

The best way to understand what links are is to look at an example. Let us create a (regular) file:

```
$ pwd
/home/queen/example
   $ ls
   $ touch a
   $ ls -il a
   32555 -rw-rw-r--    1 queen     queen            0 Dec 10 08:12 a
```

The `-i` option of the `ls` command prints the inode number, which is the first field on the output. As you can see, before we created file `a`, there were no files in the directory. The other field of interest is the third one, which is the number of file links (well, inode links, in fact).

The `touch a` command can be separated into two distinct actions:

- creation of an inode, to which the operating system has given the number 32555, and whose type is the one of a regular file;
- and creation of a link to this inode, named `a`, in the current directory, `/home/queen/example`. Therefore, the `/home/queen/example/a` file is a link to the inode numbered 32555, and it is currently the only one: the link counter shows `1`.

But now, if we type:

```
   $ ln a b
   $ ls -il a b
   32555 -rw-rw-r--    2 queen     queen            0 Dec 10 08:12 a
   32555 -rw-rw-r--    2 queen     queen            0 Dec 10 08:12 b
   $
```

we create another link to the same inode. As you can see, we did not create a file named `b`. Instead, we just added another link to the inode numbered 32555 in the same directory, and attributed the name `b` to this new link. You can see on the `ls -l` output that the link counter for the inode is now 2 rather than 1.

Now, if we do:

```
   $ rm a
   $ ls -il b
   32555 -rw-rw-r--    1 queen     queen            0 Dec 10 08:12 b
   $
```

3. Important: note that inode numbers are unique **per file system**, which means that an inode with the same number can exist on another file system. This leads to the difference between on-disk inodes and in-memory inodes. While two on-disk inodes may have the same number if they are on two different file systems, in-memory inodes have a unique number right across the system. One solution to obtain uniqueness, for example, is to hash the on-disk inode number against the block device identifier.

we see that even though we deleted the "original file", the inode still exists. But now, the only link to it is the file named `/home/queen/example/b`.

Therefore, a file in UNIX has no name; instead, it has one or more ***link(s)*** in one or more directory(ies).

Directories themselves are also stored in inodes, their link count coincides with the number of subdirectories within them. This is due to the fact that there are at least two links per directory: the directory itself (`.`) and its parent directory (`..`).

Typical examples of files which are not linked (i.e.: have no name) are network connections; you will never see the file corresponding to your connection to the Mandrakelinux web site (`www.mandrakelinux.com`) in your file tree, no matter which directory you look in. Similarly, when you use a ***pipe*** in the shell, the inode corresponding to the pipe exists, but it is not linked. Other use of inodes without names is temporary files. You create a temporary file, open it, and then remove it. The file exists while it is open, but nobody else can open it (as there is no name for opening it). This way, if the application crashes, the temporary file is removed automatically.

9.4. "Anonymous" Pipes and Named Pipes

Let's get back to the example of pipes, as it is quite interesting and is also a good illustration of the links notion. When you use a pipe in a command line, the shell creates the pipe for you and operates so that the command before the pipe writes to it, while the command after the pipe reads from it. All pipes, whether they be anonymous (like the ones used by the shells) or named (see below) act like FIFOs (*First In, First Out*). We have already seen examples of how to use pipes in the shell, but let's take another look for the sake of our demonstration:

```
$ ls -d /proc/[0-9] | head -5
/proc/1/
/proc/2/
/proc/3/
/proc/4/
/proc/5/
```

One thing that you will not notice in this example (because it happens too fast for one to see) is that writes on pipes are blocking. This means that when the `ls` command writes to the pipe, it is blocked until a process at the other end reads from the pipe. In order to visualize the effect, you can create named pipes, which unlike the pipes used by shells, have names (i.e.: they are linked, whereas shell pipes are not). [4] The command to create a named pipe is `mkfifo`:

```
$ mkfifo a_pipe
$ ls -il
total 0
    169 prw-rw-r--    1 queen     queen        0 Dec 10 14:12 a_pipe|
  #
  # You can see that the link counter is 1, and that the output shows
  # that the file is a pipe ('p').
  #
  # You can also use ln here:
  #
$ ln a_pipe the_same_pipe
$ ls -il
total 0
    169 prw-rw-r--    2 queen     queen        0 Dec 10 15:37 a_pipe|
    169 prw-rw-r--    2 queen     queen        0 Dec 10 15:37 the_same_pipe|
$ ls -d /proc/[0-9] >a_pipe
  #
  # The process is blocked, as there is no reader at the other end.
  # Type C-z to suspend the process...
  #
zsh: 3452 suspended  ls -d /proc/[0-9] > a_pipe
  #
  # ...Then put in into the background:
  #
$ bg
[1]  + continued  ls -d /proc/[0-9] > a_pipe
  #
  # now read from the pipe...
  #
```

4. Other differences exist between the two kinds of pipes, but they are beyond the scope of this book.

```
$ head -5 <the_same_pipe
  #
  # ...the writing process terminates
  #
[1]  + 3452 done       ls -d /proc/[0-9] > a_pipe
/proc/1/
/proc/2/
/proc/3/
/proc/4/
/proc/5/
#
```

Similarly, reads are also blocking. If we execute the above commands in the reverse order, we will see that `head` blocks, waiting for some process to give it something to read:

```
$ head -5 <a_pipe
  #
  # Program blocks, suspend it: C-z
  #
zsh: 741 suspended  head -5 < a_pipe
  #
  # Put it into the background...
  #
$ bg
[1]  + continued  head -5 < a_pipe
  #
  # ...And give it some food :)
  #
$ ls -d /proc/[0-9] >the_same_pipe
$ /proc/1/
/proc/2/
/proc/3/
/proc/4/
/proc/5/
[1]  + 741 done       head -5 < a_pipe
$
```

You can also see an undesired effect in the previous example: the `ls` command has terminated before the `head` command took over. The consequence is that you were immediately returned to the prompt, but `head` executed later and you only saw its output after returning.

9.5. "Special" Files: Character Mode and Block Mode Files

As already stated, such files are either files created by the system or peripherals on your machine. We also mentioned that the contents of block mode character files were buffered, while character mode files were not. In order to illustrate this, insert a floppy into the drive and type the following command twice:

```
$ dd if=/dev/fd0 of=/dev/null
```

You should have observed the following: the first time the command was launched, the entire content of the floppy was read. The second time you executed the command, there was no access to the floppy drive at all. This is because the content of the floppy was buffered the first time you launched the command – and you did not change anything on the floppy between the two instances.

But now, if you want to print a big file this way (yes it will work):

```
$ cat /a/big/printable/file/somewhere >/dev/lp0
```

the command will take as much time, whether you launch it once, twice or fifty times. This is because `/dev/lp0` is a character mode file, and its contents are not buffered.

The fact that block mode files are buffered has a nice side effect: not only are reads buffered, but writes are buffered too. This allows for writes to the disks to be asynchronous: when you write a file on disk, the write operation itself is not immediate. It will only occur when the Linux kernel decides to execute the write to the hardware.

Finally, each special file has a ***major*** and ***minor*** number. On a `ls -l` output, they appear in place of the size, as the size for such files is irrelevant:

```
ls -l /dev/hda /dev/lp0
brw-rw----    1 root     disk       3,   0 May  5  1998 /dev/hda
crw-rw----    1 root     daemon     6,   0 May  5  1998 /dev/lp0
```

Here, the major and minor of `/dev/hda` are 3 and 0, whereas for `/dev/lp0`, they are 6 and 0. Note that these numbers are unique per file category, which means that there can be a character mode file with major 3 and minor 0 (this file actually exists: `/dev/ttyp0`), and similarly, there can be a block mode file with major 6 and minor 0. These numbers exist for a simple reason: it allows the kernel to associate the correct operations to these files (that is, to the peripherals these files refer to): you do not handle a floppy drive the same way as, say, a SCSI hard drive.

9.6. Symbolic Links, Limitation of "Hard" Links

Here we have to face a very common misconception, even among UNIX users, which is mainly due to the fact that links as we have seen them so far (wrongly called "hard" links) are only associated with regular files (and we have seen that it is not the case – since even symbolic links are "linked"). But this requires that we first explain what symbolic links ("soft" links, or even more often "symlinks") are.

Symbolic links are files of a particular type whose sole content is an arbitrary string, which may or may not point to an existing file. When you mention a symbolic link on the command line or in a program, in fact, you access the file it points to, if it exists. For example:

```
$ echo Hello >myfile
$ ln -s myfile mylink
$ ls -il
total 4
    169 -rw-rw-r--    1 queen     queen            6 Dec 10 21:30 myfile
    416 lrwxrwxrwx    1 queen     queen            6 Dec 10 21:30 mylink
-> myfile
$ cat myfile
Hello
$ cat mylink
Hello
```

You can see that the file type for `mylink` is `l`, for symbolic *Link*. The access rights for a symbolic link are not significant: they will always be `rwxrwxrwx`. You can also see that it **is** a different file from `myfile`, as its inode number is different. But it refers to it symbolically, therefore when you type `cat mylink`, you will in fact print the contents of the `myfile` file. To demonstrate that a symbolic link contains an arbitrary string, we can do the following:

```
$ ln -s "I'm no existing file" anotherlink
$ ls -il anotherlink
    418 lrwxrwxrwx    1 queen     queen           20 Dec 10 21:43 anotherlink
-> I'm no existing file
$ cat anotherlink
cat: anotherlink: No such file or directory
$
```

But symbolic links exist because they overcome several limitations encountered by normal ("hard") links:

- You cannot create a link to an inode in a directory which is on a different file system than the said inode. The reason is simple: the link counter is stored in the inode itself, and inodes cannot be shared between file systems. Symlinks allow this;
- You cannot link directories to avoid creating cycles in the file system. But you can make a symlink point to a directory and use it as if it were actually a directory.

Symbolic links are therefore very useful in several circumstances, and very often, people tend to use them to link files together even when a normal link could be used instead. One advantage of normal linking, though, is that you do not lose the file if you delete the "original one".

Lastly, if you observed carefully, you know what the size of a symbolic link is: it is simply the size of the string.

9.7. File Attributes

The same way that FAT has file attributes (archive, system file, invisible), a GNU/Linux file systems has its own, but they are different. We will briefly go over them here for the sake of completeness, but they are very seldom used. However, if you really want a secure system, read on.

There are two commands for manipulating file attributes: `lsattr(1)` and `chattr(1)`. You probably guessed it, `lsattr` *LiSts* attributes, whereas `chattr` *CHanges* them. These attributes can only be set on directories and regular files. The following attributes are possible:

1. `A` (*no Access time*): if a file or directory has this attribute set, whenever it is accessed, either for reading or for writing, its last access time will not be updated. This can be useful, for example, on files or directories which are often accessed for reading, especially since this parameter is the only one which changes on an inode when it is open read-only.
2. `a` (*append only*): if a file has this attribute set and is open for writing, the only operation possible will be to append data to its previous contents. For a directory, this means that you can only add files to it, but not rename or delete any existing file. Only `root` can set or clear this attribute.
3. `d` (*no dump*): `dump (8)` is the standard UNIX utility for backups. It dumps any file system for which the dump counter is 1 in `/etc/fstab` (see chapter "*File Systems and Mount Points*", page 51). But if a file or directory has this attribute set, unlike others, it will not be taken into account when a dump is in progress. Note that for directories, this also includes all subdirectories and files under it.
4. `i` (*immutable*): a file or directory with this attribute set can not be modified at all: it can not be renamed, no further link can be created to it [5] and it cannot be removed. Only `root` can set or clear this attribute. Note that this also prevents changes to access time, therefore you do not need to set the `A` attribute when `i` is set.
5. `s` (*secure deletion*): when a file or directory with this attribute is deleted, the blocks it was occupying on disk are overwritten with zeroes.
6. `S` (*Synchronous mode*): when a file or directory has this attribute set, all modifications on it are synchronous and written to the disk immediately.

For example, you may want to set the `i` attribute on essential system files in order to avoid bad surprises. Also, consider the `A` attribute on man pages: this prevents a lot of disk operations and, in particular, can save some battery life on laptops.

5. Be sure to understand what "adding a link" means, both for a file and a directory **:-)**

Chapter 10. The /proc Filesystem

The /proc file system is specific to GNU/Linux. It is a virtual file system, so the files that you will find in this directory do not actually take up any space on your hard drive. It is a very convenient way to obtain information about the system, especially since most files in this directory are human readable (well, with a little help). Many programs actually gather information from files in /proc, format it in their own way and then display the results. There are a few programs which display information about processes (top, ps and friends) which do exactly that. /proc is also a good source of information about your hardware, and just like the programs which display processes, quite a few programs are just interfaces to the information contained in /proc.

There is also a special subdirectory, /proc/sys. It allows you to display kernel parameters and to change them, with the changes taking effect immediately.

10.1. Information About Processes

If you list the contents of the /proc directory, you will see many directories where the name of the directory is a number. These are the directories containing information on all processes currently running on the system:

```
$ ls -d /proc/[0-9]*
/proc/1/    /proc/302/  /proc/451/  /proc/496/  /proc/556/  /proc/633/
/proc/127/  /proc/317/  /proc/452/  /proc/497/  /proc/557/  /proc/718/
/proc/2/    /proc/339/  /proc/453/  /proc/5/    /proc/558/  /proc/755/
/proc/250/  /proc/385/  /proc/454/  /proc/501/  /proc/559/  /proc/760/
/proc/260/  /proc/4/    /proc/455/  /proc/504/  /proc/565/  /proc/761/
/proc/275/  /proc/402/  /proc/463/  /proc/505/  /proc/569/  /proc/769/
/proc/290/  /proc/433/  /proc/487/  /proc/509/  /proc/594/  /proc/774/
/proc/3/    /proc/450/  /proc/491/  /proc/554/  /proc/595/
```

Note that as a user, you can (logically) only display information related to your own processes, but not those of other users. So, let's be root and see what information is available from process 127:

```
$ su
Password:
$ cd /proc/127
$ ls -l
total 0-9
-r--r--r--    1 root     root            0 Dec 14 19:53 cmdline
lrwx------    1 root     root            0 Dec 14 19:53 cwd -> //
-r--------    1 root     root            0 Dec 14 19:53 environ
lrwx------    1 root     root            0 Dec 14 19:53 exe -> /usr/sbin/apmd*
dr-x------    2 root     root            0 Dec 14 19:53 fd/
pr--r--r--    1 root     root            0 Dec 14 19:53 maps|
-rw-------    1 root     root            0 Dec 14 19:53 mem
lrwx------    1 root     root            0 Dec 14 19:53 root -> //
-r--r--r--    1 root     root            0 Dec 14 19:53 stat
-r--r--r--    1 root     root            0 Dec 14 19:53 statm
-r--r--r--    1 root     root            0 Dec 14 19:53 status
$
```

Each directory contains the same entries. Here is a brief description of some of the entries:

1. cmdline: this (pseudo-)file contains the entire command line used to invoke the process. It is not formatted: there is no space between the program and its arguments, and there is no newline at the end of the line. In order to view it, you can use: perl -ple 's,\00, ,g' cmdline.
2. cwd: this symbolic link points to the current working directory (hence the name) of the process.
3. environ This file contains all the environment variables defined for this process, in the form VARIABLE=value. Similar to cmdline, the output is not formatted at all: no newlines separate the different variables, and there is no newline at the end. One solution to view it: perl -pl -e 's,\00,\n,g' environ.
4. exe: this is a symlink pointing to the executable file corresponding to the process being run.
5. fd: this subdirectory contains the list of file descriptors currently opened by the process. See below.
6. maps: when you print the content of this named pipe (with cat for example), you can see the parts of the process' address space which are currently mapped to a file. From left to right, the fields are: the address space associated to this mapping, the permissions associated to this mapping, the offset from

the beginning of the file where the mapping starts, the major and minor number (in hexadecimal) of the device on which the mapped file is located, the inode number of the file, and finally the name of the file itself. When the device is 0 and there's no inode number or filename, this is an anonymous mapping. See mmap(2).

7. `root`: this is a symbolic link which points to the root directory used by the process. Usually, it will be `/`, but see chroot(2).
8. `status`: this file contains various information about the process: the name of the executable, its current state, its PID and PPID, its real and effective UID and GID, its memory usage, and other information. Note that files `stat` and `statm` are now obsolete. The information they contained is now stored in `status`.

If we list the contents of directory `fd` for process 127, we obtain this:

```
$ ls -l fd
total 0
lrwx------    1 root     root           64 Dec 16 22:04 0 -> /dev/console
l-wx------    1 root     root           64 Dec 16 22:04 1 -> pipe:[128]
l-wx------    1 root     root           64 Dec 16 22:04 2 -> pipe:[129]
l-wx------    1 root     root           64 Dec 16 22:04 21 -> pipe:[130]
lrwx------    1 root     root           64 Dec 16 22:04 3 -> /dev/apm_bios
lr-x------    1 root     root           64 Dec 16 22:04 7 -> pipe:[130]
lrwx------    1 root     root           64 Dec 16 22:04 9 ->
/dev/console
$
```

In fact, this is the list of file descriptors opened by the process. Each opened descriptor is shown by a symbolic link, where the name is the descriptor number, and which points to the file opened by this descriptor[1]. Note the permissions on the symlinks: this is the only place where they make sense, as they represent the permissions with which the file corresponding to the descriptor has been opened.

10.2. Information on The Hardware

Apart from the directories associated to the different processes, `/proc` also contains a myriad of information on the hardware present in your machine. A list of files from the `/proc` directory shows the following:

```
$ ls -d [a-z]*
apm      dma          interrupts  loadavg  mounts      rtc       swaps
bus/     fb           ioports     locks    mtrr        scsi/     sys/
cmdline  filesystems  kcore       meminfo  net/        self/     tty/
cpuinfo  fs/          kmsg        misc     partitions  slabinfo  uptime
devices  ide/         ksyms       modules  pci         stat      version
$
```

For example, if we look at the contents of `/proc/interrupts`, we can see that it contains the list of interrupts currently used by the system, along with the peripheral which uses them. Similarly, `ioports` contains the list of input/output address ranges currently busy, and lastly `dma` does the same for DMA channels. Therefore, in order to chase down a conflict, look at the contents of these three files:

```
$ cat interrupts
           CPU0
  0:     127648          XT-PIC  timer
  1:       5191          XT-PIC  keyboard
  2:          0          XT-PIC  cascade
  5:       1402          XT-PIC  xirc2ps_cs
  8:          1          XT-PIC  rtc
 10:          0          XT-PIC  ESS Solo1
 12:       2631          XT-PIC  PS/2 Mouse
 13:          1          XT-PIC  fpu
 14:      73434          XT-PIC  ide0
 15:      80234          XT-PIC  ide1
NMI:          0
$ cat ioports
0000-001f : dma1
0020-003f : pic1
0040-005f : timer
0060-006f : keyboard
```

1. If you remember what was described in section *Redirections and Pipes*, page 21, you know what descriptors 0, 1 and 2 stand for.

```
0070-007f : rtc
0080-008f : dma page reg
00a0-00bf : pic2
00c0-00df : dma2
00f0-00ff : fpu
0170-0177 : ide1
01f0-01f7 : ide0
0300-030f : xirc2ps_cs
0376-0376 : ide1
03c0-03df : vga+
03f6-03f6 : ide0
03f8-03ff : serial(auto)
1050-1057 : ide0
1058-105f : ide1
1080-108f : ESS Solo1
10c0-10cf : ESS Solo1
10d4-10df : ESS Solo1
10ec-10ef : ESS Solo1
$ cat dma
 4: cascade
$
```

Or, more simply, use the `lsdev` command, which gathers information from these files and sorts them by peripheral, which is undoubtedly more convenient.[2]:

```
$ lsdev
Device            DMA   IRQ  I/O Ports
------------------------------------------------
cascade             4     2
dma                             0080-008f
dma1                            0000-001f
dma2                            00c0-00df
ESS                             1080-108f 10c0-10cf 10d4-10df 10ec-10ef
fpu                          13 00f0-00ff
ide0                         14 01f0-01f7 03f6-03f6 1050-1057
ide1                         15 0170-0177 0376-0376 1058-105f
keyboard                      1 0060-006f
Mouse                        12
pic1                            0020-003f
pic2                            00a0-00bf
rtc                           8 0070-007f
serial                          03f8-03ff
Solo1                        10
timer                         0 0040-005f
vga+                            03c0-03df
xirc2ps_cs                    5 0300-030f
$
```

An exhaustive listing of files would take too long, but here's the description of some of them:

- `cpuinfo`: this file contains, as its name says, information on the processor(s) present in your machine.
- `modules`: this file contains the list of modules currently used by the kernel, along with the usage count for each one. In fact, this is the same information as that reported by the `lsmod` command.
- `meminfo`: this file contains information on memory usage at the time you print its contents. The `free` command. will display the same information in a easier-to-read format.
- `apm`: if you have a laptop, displaying the contents of this file allows you to see the state of your battery. You can see whether the AC is plugged in, the charge level of your battery, and if the APM BIOS of your laptop supports it (unfortunately this is not the case for all), the remaining battery life in minutes. The file isn't very readable by itself, therefore you want to use the `apm` command instead, which gives the same information in a human readable format.

  Note that modern computers now provide ACPI support instead of APM. See below.

- `bus`: this subdirectory contains information on all peripherals found on different buses in your machine. The information is usually not readable, and for the most part it is reformatted with external utilities: `lspcidrake`, `lspnp`, etc.

2. `lsdev` is part of the `procinfo` package.

- `acpi`: Several of the files provided in this directory are interesting especially for laptops, where you can select several power-saving options. Note that it is easier to modify those options through a higher level application , such as the ones included in the `acpid` and `kacpi` packages.

  The most interesting entries are:

  `battery`

  shows how many batteries are in the laptop, and related information as current remaining life, maximum capacity, etc.

  `button`

  Allows you to control actions associated to "special" buttons such as power, sleep, lid, etc.

  `fan`

  Displays the state of the fans on your computer, whether they are running or not, and enables you to start/stop them according to certain criteria. The amount of control of the fans in your machine depends of the motherboard.

  `processor`

  There is one subdirectory for each of the CPUs in your machine. Control options vary from one processor to another. Mobile processors have more features enabled, including:

  - possibility to use several power states, balancing between performance and power consumption.
  - possibility to use clock rate change in order to reduce the amount of CPU power consumption.

  Note that there are several processors that do not offer these possibilities.

  `thermal_zone`

  Information about how hot your system/processor is running.

10.3. The `/proc/sys` Sub-Directory

The role of this subdirectory is to report different kernel parameters, and to allow you to interactively change some of them. As opposed to all other files in `/proc`, some files in this directory can be written to, but only by `root`.

A list of directories and files would take too long to describe, mostly because the content of the directories are system-dependent and that most files will only be useful for very specialized applications. However, here are three common uses of this subdirectory:

1. Allow routing: Even if the default kernel from Mandrakelinux is able to route, you must explicitly allow it to do so. For this, you just have to type the following command as `root`:

   ```
   $ echo 1 >/proc/sys/net/ipv4/ip_forward
   ```

   Replace the 1 by a 0 if you want to forbid routing.

2. Prevent IP spoofing: IP spoofing consists of making one believe that a packet coming from the outside world comes from the interface by which it arrives. This technique is very commonly used by ***crackers*** [3], but you can make the kernel prevent this kind of intrusion. Type:

   ```
   $ echo 1 >/proc/sys/net/ipv4/conf/all/rp_filter
   ```

   and this kind of attack becomes impossible.

3. And not ***hackers***!

3. Increase the size of the table of open files and the inode table: The size of the table of open files and the inode table is dynamic in GNU/Linux. The default values are usually sufficient for normal use, but they may be too conservative if your machine is a huge server (a database server for example). You will know that you need to increase the size of the table if you get messages that processes cannot open any more files because the table is full. If you increase the size of the open file table, then do not forget that the size of the inode table has to be increased as well. These two lines will solve the problem:

```
$ echo 8192 >/proc/sys/fs/file-max
$ echo 16384 >/proc/sys/fs/inode-max
```

These changes will only remain in effect while the system is running. If the system is rebooted, then the values will go back to their defaults. To reset the values to something other than the default at boot time, you can take the commands that you typed at the shell prompt and add them to `/etc/rc.d/rc.local` so that you avoid typing them each time. Another solution is to modify `/etc/sysctl.conf`, see sysctl.conf (5).

Chapter 11. The Start-Up Files: init sysv

The "System V" startup scheme, inherited from AT&T UNIX is one of the UNIX traditional system-startup schemes. This system is responsible for starting or stopping services to bring the system in one of the default system states. Services range here from basic users authentication to local graphical server or Internet services.

The Mandrakelinux tool allowing you to manually start or stop services is `drakxservices`.

11.1. In the Beginning Was init

When the system starts, and after the kernel has configured everything and mounted the root file system, it executes `/sbin/init` [1]. `init` is the father of all of the system's processes and is responsible for taking the system to the desired ***runlevel***. We will look at runlevels later on (see *Runlevels*, page 69).

The `init` configuration file is called `/etc/inittab`. This file has its own manual page (inittab(5)), so we will only document a few of the possible configuration values.

The first line — which should be the focus of your attention — is this one:

```
si::sysinit:/etc/rc.d/rc.sysinit
```

This line tells `init` that `/etc/rc.d/rc.sysinit` is to be run once the system has been initialized (`si` stands for *System Init*). To determine the default runlevel, `init` will then look for the line containing the `initdefault` keyword:

```
id:5:initdefault:
```

In this case, `init` knows that the default runlevel is 5. It also knows that to enter level 5, it must run the following command:

```
l5:5:wait:/etc/rc.d/rc 5
```

As you can see, the syntax for each runlevel is similar.

`init` is also responsible for restarting (`respawn`) some programs which cannot be started by any other process. For example, each of the login programs which run on the six virtual consoles are started by `init`.[2]. The second virtual console is identified this way:

```
2:2345:respawn:/sbin/mingetty tty2
```

11.2. Runlevels

All files related to system startup are located in the `/etc/rc.d` directory. Here is the list of the files:

```
$ ls /etc/rc.d
init.d/  rc0.d/  rc2.d/  rc4.d/  rc6.d/            rc.local*    rc.sysinit*
rc*      rc1.d/  rc3.d/  rc5.d/  rc.alsa_default*  rc.modules*
```

As already stated, `rc.sysinit` is the first file run by the system. It is responsible for setting up the basic machine configuration: keyboard type, configuration of certain devices, file system checking, etc.

Then the `rc` script is run, with the desired runlevel as an argument. As we have seen, the runlevel is a simple integer, and for each runlevel `<x>` defined, there must be a corresponding `rc<x>.d` directory. In a typical Mandrakelinux installation, you might therefore see that that there are six runlevels:

- 0: complete machine stop.

1. Which is why putting `/sbin` on a file system other than the root one would be a very bad idea. The kernel has not mounted any other partitions at this point, and therefore would not be able to find `/sbin/init`.
2. If you do not want six virtual consoles, you may add or remove them by modifying this file. If you wish to increase the number of consoles, you can have up to a maximum of 64. But do not forget that X also runs on a virtual console, so leave at least one console free for X.

- 1: ***single-user*** mode. To be used in the event of major problems or system recovery.
- 2: ***multi-user*** mode, with no network.
- 3: Multi-user mode, with networking
- 4: unused.
- 5: like runlevel 3, but also launches the graphical login interface.
- 6: restart.

Let us take a look at the content of the `rc5.d` directory:

```
$ ls rc5.d
K15postgresql@  K60atd@      S15netfs@   S60lpd@         S90xfs@
K20nfs@         K96pcmcia@   S20random@  S60nfs@         S99linuxconf@
K20rstatd@      S05apmd@     S30syslog@  S66yppasswdd@   S99local@
K20rusersd@     S10network@  S40crond@   S75keytable@
K20rwhod@       S11portmap@  S50inet@    S85gpm@
K30sendmail@    S12ypserv@   S55named@   S85httpd@
K35smb@         S13ypbind@   S55routed@  S85sound@
```

As you can see, all the files in this directory are symbolic links, and they all have a very specific form. Their general form is:

```
<S|K><order><service_name>
```

The `S` means *Start* service, and `K` means *Kill* (stop) service. The scripts are run in ascending numerical order, and if two scripts have the same number, the ascending alphabetical order will apply. We can also see that each symbolic link points to a given script located in the `/etc/rc.d/init.d` directory (other than the `local` script which is responsible for controlling a specific service.)

When the system goes into a given runlevel, it starts by running the `K` links in order: the `rc` command looks at where the link is pointing, then calls up the corresponding script with a single argument: `stop`. It then runs the `S` scripts using the same method, except that the scripts are called with a `start` parameter.

So, without discussing all the scripts, we can see that when the system goes into runlevel 5, it first runs the `K15postgresql` command, (i.e. `/etc/rc.d/init.d/postgresql stop`). Then `K20nfs`, then `K20rstatd`, etc., until it has run the last command. Next, it runs all the `S` scripts: first `S05apmd`, which in turn calls `/etc/rc.d/init.d/apmd start`, and so on.

Armed with this information, you can create your own complete runlevel in a few minutes (using runlevel 4, for instance), or prevent a service from starting or stopping by deleting the corresponding symbolic link. You can also use a number of interface programs to do this, notably drakxservices (see *DrakXServices: Configuring Start-Up Services* in the *Starter Guide*) which uses a graphical program interface, or chkconfig for text-mode configuration.

You can also use the `chkconfig` command to list, add or remove services from a specific runlevel. See chkconfig(8).

Chapter 12. Building and Installing Free Software

We are often asked how to install free software from sources. Compiling software yourself is really easy because most of the steps to follow are the same no matter what the software you are installing is. The aim of this document is to guide the beginner step by step and explain to him the meaning of each move. We assume that the reader has a minimal knowledge of the UNIX system (`ls` or `mkdir` for instance).

This guide is only a guide, not a reference manual. That is why several links are given at the end to answer any remaining questions. This guide can probably be improved, so we appreciate receiving any remarks or corrections on its contents.

12.1. Introduction

What makes the difference between free software and proprietary software is the access to the source code of the software[1]. This means that free software is distributed as archives of source code files. It may be unfamiliar to beginners because users of free software must compile source code for themselves before they can use the software.

There are compiled versions of most of the existing free software. The user in a hurry only has to install these pre-compiled binaries. Some free software is not distributed in this form, or the earlier versions are not distributed in binary form. Furthermore, if you use an exotic operating system or an exotic architecture, a lot of software will not be compiled for you. More importantly, compiling software for yourself allows you to enable only the interesting options or to extend the functionality of the software by adding extensions in order to obtain a program which exactly fits your needs.

12.1.1. Requirements

To build software, you need:

- a computer with a working operating system,
- general knowledge of the operating system you use,
- some space on your disk,
- a compiler (usually for the C language) and an archiver (`tar`),
- some food (in difficult cases, it may last a long time). A real hacker eats pizzas — not quiches.
- something to drink (for the same reason). A real hacker drinks soda — for caffeine.
- the phone number of that techie friend who recompiles his kernel every week,
- specially patience, and a lot of it!

Compiling from source does not generally present a lot of problems, but if you are not used to it, the smallest snag can throw you. The aim of this document is to show you how to escape from such a situation.

12.1.2. Compilation

12.1.2.1. Principle

In order to translate source code into a binary file, a ***compilation*** must be done (usually from C or C++ sources, which are the most widespread languages used by the (UNIX) free software community). Some free software is written in languages which do not require compilation (for instance perl or the shell), but they still require some configuration.

C compilation is logically done by a C compiler, usually `gcc`, the free compiler written by the GNU project (`http://www.gnu.org/`). Compiling a complete software package is a complex task, which goes through the

1. This is not completely true since some proprietary software also provides source code. But unlike what happens with free software, the end user is not allowed to use or modify the code as he wants.

successive compilations of different source files (it is easier for various reasons for the programmer to put the different parts of his work in separate files). In order to make it easier on you, these repetitive operations are handled by a utility named `make`.

12.1.2.2. The four steps of compilation

To understand how compilation works (in order to be able to solve possible problems), you have to know the steps involved. The objective is to little by little convert a text file written in a language that is comprehensible to a trained human being (i.e. C language), into a language that is comprehensible to a machine (or a **very** well trained human being in some cases). `gcc` executes four programs one after the other, each of which carries out one step:

1. `cpp`: The first step consists of replacing directives (***preprocessors***) by pure C instructions. Typically, this means inserting a header (`#include`) or defining a macro (`#define`). At the end of this stage, pure C code has been generated.
2. `cc1`: This step consists of converting C into ***assembly language***. The generated code depends on the target architecture.
3. `as`: This step consists of generating ***object code*** (or ***binary*** code) from the assembly language. At the end of this stage, a `.o` file is generated.
4. `ld`: The last step (***linkage***) links all the object files (`.o`) and the associated libraries together and produces an executable file.

12.1.3. Structure of a distribution

A correctly structured free software distribution always has the same organization:

- An `INSTALL` file, which describes the installation procedure.
- A `README` file, which contains general information related to the program (short description, author, URL where to fetch it, related documentation, useful links, etc). If the `INSTALL` file is missing, the `README` file usually contains a brief installation procedure.
- A `COPYING` file, which contains the license or describes the distribution conditions of the software. Sometimes a `LICENSE` file is used instead, with the same contents.
- A `CONTRIB` or `CREDITS` file, which contains a list of people related to the software (active participation, pertinent comments, third-party programs, etc).
- A `CHANGES` file (or less frequently, a `NEWS` file), which contains recent improvements and bug fixes.
- A `Makefile` file (see the section *Make*, page 77), which controls compilation of the software (it is a necessary file for `make`). If this file does not exist at the beginning, then it is generated by a pre-compilation configuration process.
- Quite often, a `configure` or `Imakefile` file, which allows one to generate a new `Makefile` file customized for a particular system (see *Configuration*, page 74).
- A directory which contains the sources, and where the binary file is usually stored at the end of the compilation. Its name is often `src`.
- A directory which contains the documentation related to the program (usually in `man` or Texinfo format), whose name is often `doc`.
- Sometimes, a directory which contains data specific to the software (typically configuration files, example of produced data, or resources files).

12.2. Decompression

12.2.1. A tar.gz archive

The standard[2] compression format under UNIX systems is the `gzip` format, developed by the GNU project, and is considered as one of the best general compression tools.

`gzip` is often associated with a utility named `tar`. `tar` is a survivor of antediluvian times, when computerists stored their data on tapes. Nowadays, floppy disks and CD-ROM have replaced tapes, but `tar` is still being used to create archives. All the files in a directory can be appended in a single file for instance. This file can then be easily compressed with `gzip`.

This is the reason why much free software is available as `tar` archives, compressed with `gzip`. So, their extensions are `.tar.gz` (or also `.tgz` to shorten).

12.2.2. The use of GNU Tar

To decompress this archive, `gzip` and then `tar` can be used. But the GNU version of `tar` (`gtar`) allows us to use `gzip` ***"on-the-fly"***, and to decompress an archive file without noticing each step (and without the need for the extra disk space).

The use of `tar` follows this format:

```
tar <file options> <.tar.gz file> [files]
```

The `<files>` option is not required. If it is omitted, processing will be made on the whole archive. This argument does not need to be specified to extract the contents of a `.tar.gz` archive.

For instance:

```
$ tar xvfz guile-1.3.tar.gz
-rw-r--r-- 442/1002      10555 1998-10-20 07:31 guile-1.3/Makefile.in
-rw-rw-rw- 442/1002       6668 1998-10-20 06:59 guile-1.3/README
-rw-rw-rw- 442/1002       2283 1998-02-01 22:05 guile-1.3/AUTHORS
-rw-rw-rw- 442/1002      17989 1997-05-27 00:36 guile-1.3/COPYING
-rw-rw-rw- 442/1002      28545 1998-10-20 07:05 guile-1.3/ChangeLog
-rw-rw-rw- 442/1002       9364 1997-10-25 08:34 guile-1.3/INSTALL
-rw-rw-rw- 442/1002       1223 1998-10-20 06:34 guile-1.3/Makefile.am
-rw-rw-rw- 442/1002      98432 1998-10-20 07:30 guile-1.3/NEWS
-rw-rw-rw- 442/1002       1388 1998-10-20 06:19 guile-1.3/THANKS
-rw-rw-rw- 442/1002       1151 1998-08-16 21:45 guile-1.3/TODO
...
```

Among the options of `tar`:

- `v` makes `tar` verbose. This means it will display all the files it finds in the archive on the screen. If this option is omitted, the processing will be silent.
- `f` is a required option. Without it, `tar` tries to use a tape instead of an archive file (i.e., the `/dev/rmt0` device).
- `z` allows you to process a "gziped" archive (with a `.gz` extension). If this option is forgotten, `tar` will produce an error. Conversely, this option must not be used with an uncompressed archive.

`tar` allows you to perform several actions on an archive (extract, read, create, add...). An option defines which action is used:

- `x`: allows you to extract files from the archive.
- `t`: lists the contents of the archive.
- `c`: allows you to create an archive. You may use it to backup your personal files, for instance.
- `r`: allows you to add files at the end of the archive. It cannot be used on an already compressed archive.

2. On GNU/Linux nowadays the standard is the `bzip2` format. `bzip2` is more efficient on text files at the cost of more computing power. Please refer to *Bzip2*, page 73, which deals specifically with this program.

12.2.3. Bzip2

A compression format named bzip2 has already replaced gzip in general use, though some software is still distributed in gzip format, mainly for compatibility reasons with older systems. Almost all free software is now distributed in archives which use the .tar.bz2 extension.

bzip2 is used like gzip by means of the tar command. The only change is to replace the letter z by the letter j. For instance:

```
$ tar xvjf foo.tar.bz2
```

Some distributions may still use the option I instead:

```
$ tar xvfI foo.tar.bz2
```

Another way (which seems to be more portable, but is longer to type!):

```
$ tar --use-compress-program=bzip2 -xvf foo.tar.bz2
```

bzip2 must be installed on the system in a directory included in your PATH environment variable before you run tar.

12.2.4. Just do it!

12.2.4.1. The easiest way

Now that you are ready to decompress the archive, do not forget to do it as administrator (root). You will need to do things that an ordinary user is not allowed to do, and even if you can perform some of them as a regular user, it is simpler to just be root the whole time, even if it might not be very secure.

The first step is to be in the /usr/local/src directory and copy the archive there. You should then always be able to find the archive if you lose the installed software. If you do not have a lot of space on your disk, save the archive on a floppy disk after having installed the software. You can also delete it but be sure that you can find it on the web whenever you need it.

Normally, decompressing a tar archive should create a new directory (you can check that beforehand thanks to the t option). Go then in that directory. You are now ready to proceed to the next step.

12.2.4.2. The safest way

UNIX systems (of which GNU/Linux and FreeBSD are examples) can be secure systems. This means that normal users cannot perform operations which may endanger the system (format a disk, for instance) or alter other users' files. It also immunizes the system against viruses.

On the other hand, root can do everything - even run a malicious program. Having the source code available allows you to examine it for malicious code (viruses or Trojans). It is better to be cautious in this regard[3].

The idea is to create a user dedicated to administration (free or admin for example) by using the adduser command. This user must be allowed to write in the following directories: /usr/local/src, /usr/local/bin and /usr/local/lib, as well as all the sub-trees of /usr/share/man (he may also need to be able to copy files elsewhere). We recommend that you make this user owner of the necessary directories or create a group for him and make the directories writable by the group.

Once these precautions are taken, you can follow the instructions in *The easiest way*, page 74.

3. A proverb from the BSD world says: "Never trust a package you don't have the sources for."

12.3. Configuration

For purely technical interest, the fact that authors create the sources is for the ***porting*** of the software. Free software developed for a UNIX system may be used on all of the existing UNIX systems (whether they are free or proprietary), with few or no changes. This requires configuration of the software just before compiling it.

Several configuration systems exist. You have to use the one the author of the software wants (sometimes, several are needed). Usually, you can:

- Use AutoConf (see *Autoconf*, page 75) if a file named `configure` exists in the parent directory of the distribution.
- Use imake (see *Imake*, page 76) if a file named `Imakefile` exists in the parent directory of the distribution.
- Run a shell ***script*** (for instance `install.sh`) according to the contents of the `INSTALL` file (or the `README` file).

12.3.1. Autoconf

12.3.1.1. Principle

AutoConf is used to correctly configure software. It creates the files required by the compilation (`Makefile` for instance), and sometimes directly changes the sources (for instance by using a `config.h.in` file).

The principle of AutoConf is simple:

- The programmer of the software knows which tests are required to configure his software (eg: "which version of this ***library*** do you use?"). He writes them in a file named `configure.in`, using a precise syntax.
- He executes AutoConf, which generates a configuration script named `configure` from the `configure.in` file. This script makes the tests required when the program is configured.
- The end-user runs the script, and AutoConf configures everything that is needed by the compilation.

12.3.1.2. Example

An example of the use of AutoConf:

```
$ ./configure
loading cache ./config.cache
checking for gcc... gcc
checking whether the C compiler (gcc  ) works... yes
checking whether the C compiler (gcc  ) is a cross-compiler... no
checking whether we are using GNU C... yes
checking whether gcc accepts -g... yes
checking for main in -lX11... yes
checking for main in -lXpm... yes
checking for main in -lguile... yes
checking for main in -lm... yes
checking for main in -lncurses... yes
checking how to run the C preprocessor... gcc -E
checking for X... libraries /usr/X11R6/lib, headers /usr/X11R6/include
checking for ANSI C header files... yes
checking for unistd.h... yes
checking for working const... yes
updating cache ./config.cache
creating ./config.status
creating lib/Makefile
creating src/Makefile
creating Makefile
```

To have better control of what `configure` generates, some options may be added by the way of the command line or environment variables. Example:

```
$ ./configure --with-gcc --prefix=/opt/GNU
```

or (with bash):

```
$ export CC=‘which gcc‘
```

```
$ export CFLAGS=-O2
$ ./configure --with-gcc
```

or:

```
$ CC=gcc CFLAGS=-O2 ./configure
```

12.3.1.3. What if... it does not work?

Typically, it is an error that looks like `configure: error: Cannot find library guile` (most of the errors of the `configure` script look like this).

This means that the `configure` script was not able to find a library (the `guile` library in the example). The principle is that the `configure` script compiles a short test program, which uses this library. If it does not succeed in compiling this program, it will not be able to compile the software. Then an error occurs.

- Look for the reason of the error by looking at the end of the `config.log` file, which contains a track of all the steps of the configuration. The C compiler is clear enough with its error messages. This will usually help you in solving the problem.
- Check that the said library is properly installed. If not, install it (from the sources or a compiled binary file) and run `configure` again. An efficient way to check it is to search for the file that contains the symbols of the library; which is always `lib<name>.so`. For instance,

  ```
  $ find / -name 'libguile*'
  ```

  or else:

  ```
  $ locate libguile
  ```

- Check that the library is accessible by the compiler. That means it is in a directory among: `/usr/lib`, `/lib`, `/usr/X11R6/lib` (or among those specified by the environment variable `LD_LIBRARY_PATH`, explained *What if... it does not work?*, page 78 number 5.b). Check that this file is a library by typing `file libguile.so`.
- Check that the headers corresponding to the library are installed in the right place (usually `/usr/include` or `/usr/local/include` or `/usr/X11R6/include`). If you do not know which headers you need, check that you have installed the development version of the required library (for instance, `libgtk+2.0-devel` instead of `libgtk+2.0`). The development version of the library provides the "include" files necessary for the compilation of software using this library.
- Check that you have enough space on your disk (the `configure` script needs some space for temporary files). Use the command `df -h` to display the partitions of your system, and note the full or nearly full partitions.

If you do not understand the error message stored in the `config.log` file, do not hesitate to ask for help from the free software community (see section *Technical support*, page 83).

Furthermore, check whether `configure` answers by 100% of `No` or whether it answers `No` while you are sure that a library exists. For instance, it would be very strange that there is no `curses` library on your system). In that case, the `LD_LIBRARY_PATH` variable is probably wrong!

12.3.2. Imake

imake allows you to configure free software by creating a `Makefile` file from simple rules. These rules determine which files need to be compiled to build the binary file, and imake generates the corresponding `Makefile`. These rules are specified in a file named `Imakefile`.

The interesting thing about imake is that it uses information which is ***site-dependent*** (architecture-dependent). It is quite handy for applications using X Window System. But imake is also used for many other applications.

The easiest use of imake is to go into the main directory of the decompressed archive, and then to run the `xmkmf` script, which calls the imake program:

```
$ xmkmf -a
$ imake -DUseInstalled -I/usr/X11R6/lib/X11/config
$ make Makefiles
```

If the site is not correctly installed, recompile and install X11R6!

12.3.3. Various shell scripts

Read the `INSTALL` or `README` files for more information. Usually, you have to run a file called `install.sh` or `configure.sh`. Then, either the installation script is non-interactive (and determines itself what it needs) or it asks you information on your system (paths, for instance).

If you cannot manage to determine the file you must run, you can type `./` (under bash), and then press the **TAB** key (tabulation key) twice. bash automatically (in its default configuration) completes with a possible executable file from the directory (and therefore, a possible configuration script). If several files may be executed, it shows you a list. You then only have to choose the right file.

A particular case is the installation of perl modules (but not only). The installation of such modules is made by the execution of a configuration script, which is written in perl. The command to execute is usually:

```
$ perl Makefile.PL
```

12.3.4. Alternatives

Some free software distributions are badly organized, especially during the first stages of development (but the user is warned!). They sometimes require you to change "by hand" some configuration files. Usually, these files are a `Makefile` file (see section *Make*, page 77) and a `config.h` file (this name is only conventional).

We advise against these manipulations except for users who really do know what they are doing. This requires real knowledge and some motivation to succeed, but practice makes perfect.

12.4. Compilation

Now that the software is correctly configured, all that remains is for it to be compiled. This stage is usually easy, and does not pose serious problems.

12.4.1. Make

The favorite tool of the free software community to compile sources is `make`. It has two advantages:

- The developer saves time, because it allows him to efficiently manage the compilation of his project.
- The end-user can compile and install the software in a few command lines, even if he has no previous knowledge of development.

Actions which must be executed to obtain a compiled version of the sources are stored in a file often named `Makefile` or `GNUMakefile`. Actually, when `make` is called, it reads this file – if it exists – in the current directory. If not, the file may be specified by using `make`'s `-f` option.

12.4.2. Rules

`make` operates in accordance with a system of ***dependencies***, so compiling a binary file (" ***target*** ") requires going through several stages ("dependencies"). For instance, to create the (imaginary) `glloq` binary file, the `main.o` and `init.o` object files (intermediate files of the compilation) must be compiled and then linked. These object files are also targets, whose dependencies are their corresponding source files.

This text is only a minimal introduction to survive in the merciless world of `make`. For an exhaustive documentation, refer to *Managing Projects with Make*, 2nd edition, **O'Reilly**, by Andrew Oram and Steve Talbott.

12.4.3. Go, go, go!

Usually, the use of `make` follows several conventions. For instance:

- `make` without argument just executes the compilation of the program, without installation.
- `make install` compiles the program (but not always), and then installs the required files at the right place in the file system. Some files are not always correctly installed (`man`, `info`), they may have to be copied by the user himself. Sometimes, `make install` has to be executed again in sub-directories. Usually, this happens with modules developed by third parties.
- `make clean` clears all the temporary files created by the compilation, and also the executable file in most cases.

The first stage is to compile the program, and therefore to type (imaginary example):

```
$ make
gcc -c glloq.c -o glloq.o
gcc -c init.c -o init.o
gcc -c main.c -o main.o
gcc -lgtk -lgdk -lglib -lXext -lX11 -lm glloq.o init.o main.o -o glloq
```

Excellent, the binary file is correctly compiled. We are ready to go to the next stage, which is the installation of the files of the distribution (binary files, data files, etc). See *Installation*, page 82.

12.4.4. Explanations

If you are curious enough to look in the `Makefile` file, you will find known commands (`rm`, `mv`, `cp`, etc), but also strange strings, looking like `$(CFLAGS)`.

They are ***variables*** which are strings which are usually set at the beginning of the `Makefile` file, and then replaced by the value they are associated with. It is quite useful when you want to use the same compilation options several times in a row.

For instance, to print the string "`foo`" on the screen using `make all`:

```
TEST = foo
all:
 echo $(TEST)
```

Most of the time, the following variables are set:

1. `CC`: This is the compiler. Usually, it is `cc`, which is in most free systems synonymous with `gcc`. When in doubt, put `gcc` here.
2. `LD`: This is the program used to ensure the final compilation stage (see section *The four steps of compilation*, page 72). By default, this is `ld`.
3. `CFLAGS`: These are the additional arguments that are given to the compiler during the first compilation stages. Among them:
   - `-I<path>`: Specifies to the compiler where to search for some additional headers (eg: `-I/usr/X11R6/include` allows inclusion of the header files that are in directory `/usr/X11R6/include`).
   - `-D<symbol>`: Defines an additional symbol, useful for programs whose compilation depends on the defined symbols (ex: use the `string.h` file if `HAVE_STRING_H` is defined).

   There are often compilation lines like:

   ```
   $(CC) $(CFLAGS) -c foo.c -o foo.o
   ```

4. `LDFLAGS` (or `LFLAGS`): These are arguments used during the final compilation stage. Among them:
   - `-L<path>`: Specifies an additional path to search for libraries (eg: `-L/usr/X11R6/lib`).
   - `-l<library>`: Specifies an additional library to use during the final compilation stage.

12.4.5. What if... it does not work?

Do not panic, it can happen to anyone. Among the most common causes:

1. `glloq.c:16: decl.h: No such file or directory`

   The compiler did not manage to find the corresponding header. Yet, the software configuration step should have anticipated this error. Here is how to solve this problem:

   - Check that the header really exists on the disk in one of the following directories: `/usr/include`, `/usr/local/include`, `/usr/X11R6/include` or one of their sub-directories. If not, look for it on the whole disk (with `find` or `locate`), and if you still do not find it, check that you have installed the library corresponding to this header. You can find examples of the `find` and `locate` commands in their respective manual pages.
   - Check that the header is really readable (type `less <path>/<file>.h` to test this)
   - If it is in a directory like `/usr/local/include` or `/usr/X11R6/include`, you sometimes have to add a new argument to the compiler. Open the corresponding `Makefile` (be careful to open the right file, those in the directory where the compilation fails [4]) with your favorite text editor (Emacs, Vi, etc). Look for the faulty line, and add the string `-I<path>` – where `<path>` is the path where the header in question can be found – just after the call of the compiler (`gcc`, or sometimes `$(CC)`). If you do not know where to add this option, add it at the beginning of the file, after `CFLAGS=<something>` or after `CC=<something>`.
   - Launch `make` again, and if it still does not work, check that this option (see the previous point) is added during compilation on the faulty line.
   - If it still does not work, call for help from your local guru or call for help from the free software community to solve your problem (see section *Technical support*, page 83).

2. `glloq.c:28: ‘struct foo’ undeclared (first use this function)`

   The structures are special data types that all programs use. A lot of them are defined by the system in headers. That means the problem is certainly caused by a missing or misused header. The correct procedure for solving the problem is:

   - try to check whether the structure in question is defined by the program or by the system. A solution is to use the command grep in order to see whether the structure is defined in one of the headers.

     For instance, when you are in the root of the distribution:

     ```
     $ find . -name '*.h'| xargs grep 'struct foo' | less
     ```

     Many lines may appear on the screen (each time that a function using this type of structure is defined for instance). If it exists, pick out the line where the structure is defined by looking at the header file obtained by the use of grep.

     The definition of a structure is:

     ```
     struct foo {
         <contents of the structure>
     };
     ```

     Check if it corresponds with what you have. If so, this means that the header is not included in the faulty `.c` file. There are two solutions:

     - add the line `#include "<filename>.h"` at the beginning of the faulty `.c` file.
     - or copy-paste the definition of the structure at the beginning of this file (it is not really neat, but at least it usually works).

   - If not, do the same thing with the system header files (which are usually in directories `/usr/include`, `/usr/X11R6/include`, or `/usr/local/include`). But this time, use the line `#include <<filename>.h>`.

4. Analyze the error message returned by `make`. Normally, the last lines should contain a directory (a message like `make[1]: Leaving directory ‘/home/queen/Project/foo’`). Pick out the one with the highest number. To check that it is the good one, go to that directory and execute `make` again to obtain the same error.

- If this structure still does not exist, try to find out which library (i.e. set of functions put together in a single package) it should be defined in (look in the `INSTALL` or `README` file to see which libraries are used by the program and their required versions). If the version that the program needs is not the one installed on your system, you will need to update this library.
- If it still does not work, check that the program properly works with your architecture (some programs have not been ported yet on all the UNIX systems). Check also that you have correctly configured the program (when `configure` ran, for instance) for your architecture.

3. `parse error`

   This is a problem that is quite complicated to solve, because it often is an error that appears at a certain line, but after the compiler has met it. Sometimes, it is simply a data type that is not defined. If you meet an error message like:

   ```
   main.c:1: parse error before ‘glloq_t
   main.c:1: warning: data definition has no type or storage class
   ```

   then the problem is that the `glloq_t` type is not defined. The solution to solve the problem is more or less the same as that in the previous problem.

   there may be a `parse error` in the old `curses` libraries if my memory serves me right.

4. `no space left on device`

   This problem is easy to solve: there is not enough space on the disk to generate a binary file from the source file. The solution consists of making free space on the partition which contains the install directory (delete temporary files or sources, uninstall any programs you do not use). If you decompressed it in `/tmp`, rather than in `/usr/local/src`, which avoids needlessly saturating the `/tmp` partition. Check whether there are `core` ***files***[5] on your disk. If so, delete them or make them get deleted if they belong to another user.

5. `/usr/bin/ld: cannot open -lglloq: No such file or directory`

   That clearly means that the `ld` program (used by `gcc` during the last compilation stage) does not manage to find a library. To include a library, `ld` searches for a file whose name is in the arguments of type `-l<library>`. This file is `lib<library>.so`. If `ld` does not manage to find it, it produces an error message. To solve the problem, follow the steps below:

   a. Check that the file exists on the hard disk by using the `locate` command. Usually, the graphic libraries can be found in `/usr/X11R6/lib`. For instance:

      ```
      $ locate libglloq
      ```

      If the search is unrewarding, you can make a search with the `find` command (eg: `find /usr -name "libglloq.so*"`). If you still cannot find the library, you will have to install it.

   b. Once the library is located, check that it is accessible by `ld`: the `/etc/ld.so.conf` file specifies where to find these libraries. Add the incriminate directory at the end (you may have to reboot your computer for this to be taken into account). You can also add this directory by changing the contents of the environment variable `LD_LIBRARY_PATH`. For instance, if the directory to add is `/usr/X11R6/lib`, type:

      ```
      export LD_LIBRARY_PATH=$LD_LIBRARY_PATH:/usr/X11R6/lib
      ```

      (if your shell is bash).

   c. If it still does not work, check that the library format is an executable file (or ELF) with the `file` command. If it is a symbolic link, check that the link is good and does not point at an non-existent

5. File generated by the system when a process tries to access a memory location that it is not allowed to. These files are used to analyze the reason of such a behavior to correct the problem.

file (for instance, with `nm libglloq.so`). The permissions may be wrong (if you use an account other than `root` and if the library is protected against reading, for example).

6. `glloq.c(.text+0x34): undefined reference to 'glloq_init'`

   It is a problem of a symbol that was not solved during the last compilation stage. Usually, it is a library problem. There may be several causes:

   - the first thing to do is to find out whether the symbol is **supposed** to be in a library. For instance, if it is a symbol beginning by `gtk`, it belongs to the `gtk` library. If the name of the library is easily identifiable (`frobnicate_foobar`), you may list the symbols of a library with the `nm` command. For example,

     ```
     $ nm libglloq.so
     0000000000109df0 d glloq_message_func
     000000000010a984 b glloq_msg
     0000000000008a58 t glloq_nearest_pow
     0000000000109dd8 d glloq_free_list
     0000000000109cf8 d glloq_mem_chunk
     ```

     Adding the `-o` option to `nm` allows you to print the library name on each line, which makes the search easier. Let's imagine that we are searching for the symbol `bulgroz_max`, a crude solution is to make a search like:

     ```
     $ nm /usr/lib/lib*.so | grep bulgroz_max
     $ nm /usr/X11R6/lib/lib*.so | grep bulgroz_max
     $ nm /usr/local/lib/lib*.so | grep bulgroz_max
     /usr/local/lib/libfrobnicate.so:000000000004d848 T bulgroz_max
     ```

     Wonderful! The symbol `bulgroz_max` is defined in the `frobnicate` library (the capital letter `T` is before its name). Then, you only have to add the string `-lfrobnicate` in the compilation line by editing the `Makefile` file: add it at the end of the line where `LDFLAGS` or `LFGLAGS` (or `CC` at worst) are defined, or on the line corresponding to the creation of the final binary file.

   - the compilation is being made with a version of the library which is not the one allowed for by the software. Read the `README` or `INSTALL` files of the distribution to see which version must be used.
   - not all the object files of the distribution are correctly linked. The file where this function is defined is lacking. Type `nm -o *.o` to see which one it is and add the corresponding `.o` file on the compilation line if it is missing.
   - the problem function or variable may be non-existent. Try to delete it: edit the problem source file (its name is specified at the beginning of the error message). It is a desperate solution whose consequence will certainly be a chaotic execution of the program with a (***segfault*** at startup, etc).

7. `Segmentation fault (core dumped)`

   Sometimes, the compiler hangs immediately and produces this error message. I have no advise except suggesting that you install a more recent version of your compiler.

8. no space on `/tmp`

   Compilation needs temporary workspace during the different stages; if it does not have space, it fails. So, you may have to clean the partition, but be careful some programs being executed (X server, pipes, etc) can hang if some files are deleted. You must know what you are doing! If `/tmp` is part of a partition that does not only contain it (for example the root), search and delete some possible `core` files.

9. `make/configure` in infinite recursion

   It is often a problem of time in your system. Indeed, `make` needs to know the date in the computer and the date of the files it checks. It compares the dates and uses the result to know whether the target is more recent than the dependence.

Some date problems may cause `make` to endlessly build itself (or to build and build again a sub-tree in infinite recursion). In such a case, the use of `touch` (whose use here is to set the files in question to the current time) usually solves the problem.

For instance:

```
$ touch *
```

Or also (cruder, but efficient):

```
$ find . | xargs touch
```

12.5. Installation

12.5.1. With Make

Now that all is compiled, you have to copy the built files to an appropriate place (usually in one of the sub-directories of `/usr/local`).

`make` can usually perform this task. A special target is the target `install`. So, using `make install` carries out the installation of the required files.

Usually, the procedure is described in the `INSTALL` or `README` file. But sometimes, the developer has forgotten to provide one. In that case, you must install everything yourself.

Copy then:

- The executable files (programs) into the `/usr/local/bin` directory.
- The libraries (`lib*.so` files) into the `/usr/local/lib` directory.
- The headers (`*.h` files) into the `/usr/local/include` directory (be careful not to delete the originals).
- The data files usually go in `/usr/local/share`. If you do not know the installation procedure, you can try to run the programs without copying the data files, and to put them at the right place when it asks you for them (in an error message such as `Cannot open /usr/local/share/glloq/data.db` for example).
- The documentation is a little bit different:
  - The `man` files are usually put in one of the sub-directories of `/usr/local/man`. Usually, these files are in `troff` (or `groff`) format, and their extension is a figure. Their name is the name of a command (for instance, `echo.1`). If the figure is `n`, copy the file in `/usr/local/man/man<n>`.
  - The `info` files are put in the directory `/usr/info` or `/usr/local/info`

You are finished! Congratulations! You now are ready to compile an entire operating system!

12.5.2. Problems

If you have just installed free software, GNU tar for instance, and if, when you execute it, another program is started or it does not work like it did when you tested it directly from the `src` directory, it is a `PATH` problem, which finds the programs in a directory before the one where you have installed the new software. Check by executing `type -a <program>`.

The solution is to put the installation directory higher in the `PATH` and/or to delete or rename the files that were executed when they were not asked for, and/or rename your new programs (into `gtar` in this example) so that there is no more confusion.

You can also make an alias if the shell allows it (for instance, say that `tar` means `/usr/local/bin/gtar`).

12.6. Support

12.6.1. Documentation

Several documentation sources:

- HOWTOs, short documents on precise points (usually far from what we need here, but sometimes useful). Look on your disk in `/usr/share/doc/HOWTO` (not always, they are sometimes elsewhere; check that out with the command `locate HOWTO`),
- The manual pages. Type `man <command>` to get documentation on the command `<command>`,
- Specialized literature. Several large publishers have begun publishing books about free systems (especially on GNU/Linux). It is often useful if you are a beginner and if you do not understand all the terms of the present documentation.

12.6.2. Technical support

If you have bought an "official" Mandrakelinux distribution, you can ask the technical support staff for information on your system.

You can also rely on help from the free software community:

- ***newsgroups*** (on Usenet) comp.os.linux.* (`news:comp.os.linux.*`) answer all the questions about GNU/Linux. Newsgroups matching `comp.os.bsd.*` deal with BSD systems. There may be other newsgroups dealing with other UNIX systems. Remember to read them for some time prior to writing to them.
- Several associations or groups of enthusiasts in the free software community offer voluntary support. The best way to find the ones closest to you, is to check out the lists on specialized web sites, or to read the relevant newsgroups for a while.
- Several ***IRC channels*** offer a real time (but blind) assistance by ***gurus***. See for instance the `#linux` channel on most of the IRC network, or `#linuxhelp` on IRCNET.
- As a last resort, ask the developer of the software (if he mentioned his name and his ***email*** address in a file of the distribution) if you are sure that you have found a bug (which may be due only to your architecture, but after all, free software is supposed to be portable).

12.6.3. How to find free software

To find free software, a lot of links may help you:

- the huge FTP site sunsite.unc.edu (`sunsite.unc.edu`) or one of its mirrors
- the following web sites make a catalog of many free software programs which can be used on UNIX platforms (but one can also find proprietary software on these):
  - FreshMeat (`http://www.freshmeat.net/`) is probably the most complete site,
  - SourceForge.net (`http://sourceforge.net/`) is the world's largest Open Source software development web site, with the largest repository of Open Source code and applications available on the Internet.
  - GNU Software (`http://www.gnu.org/software/`) for an exhaustive list of all of GNU software. Of course, all of them are free and most are licensed under the GPL,
- you can also perform a search with a search engine such as Google/ (`http://www.google.com/`) and Lycos/ (`http://www.lycos.com/`) and make a request like: `+<software>+download` or `"download software"`.

12.7. Acknowledgments

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Chapter 13. Compiling and Installing New Kernels

Along with file system mounting and building from sources, compiling the kernel is undoubtedly the subject which causes the most problems for beginners. Compiling a new kernel is not generally necessary, since the kernel installed by Mandrakelinux contains support for a significant number of devices (in fact, more devices than you will ever need or even think of), along with a set of trusted patches and so on. But...

It may be that you want to do it, for no other reason than to see "what it does". Apart from making your PC and your coffee machine work a bit harder than usual, not a lot. The reasons why you should want to compile your own kernel range from deactivating an option to rebuilding a brand new experimental kernel. Anyway, the aim of this chapter is to ensure that your coffee machine still works after compilation.

There are other valid reasons for recompiling the kernel. For example, you have read that the kernel you are using has a security ***bug***, which has been fixed in a more recent version, or that a new kernel includes support for a device you need. Of course, in these cases, you do have the choice of waiting for binary upgrades, but updating the kernel sources and recompiling the new kernel yourself makes for a faster solution.

Whatever you do, stock up with coffee.

13.1. Upgrading a Kernel Using Binary Packages

Before diving deep into kernel compilation from sources, we will detail a simple procedure when you just want/need to update your kernel using binary RPM packages compiled for your version of Mandrakelinux. The example will assume the new kernel is `kernel-2.6.3-5mdk` and the old (current) one is `kernel-2.6.3-1mdk`.

1. **Install the New Kernel.** Issue the command: `urpmi kernel-2.6.3-5mdk` in a terminal window.
2. **Verify it Works.** A new entry will be available in the LILO menu (named something like `263-5`). Reboot your computer and select that entry to boot with the new kernel. Perform all the tests you consider necessary to make sure the new kernel works correctly.
3. **Uninstall the Old Kernel.** Once you are sure the new kernel works in your computer, you can remove the files related to the old kernel. Issue `urpme kernel-2.6.3-1mdk` in a terminal window and edit `/etc/lilo.conf` removing the `263-5` section and issue `lilo -v` to make the new kernel the default one.

13.2. From The Kernel Sources

You can basically get the sources from two places:

1. **Official Mandrake Linux Kernel.** In the `SRPMS` directory of any of the `Cooker` mirrors (`http://www.mandrakelinux.com/en/cookerdevel.php3`), you will find the following packages:

   kernel-2.6.??.?mdk-?-?mdk.src.rpm

   The kernel sources for compiling the kernel used in the distribution. It is highly modified for additional functions.

   kernel2.6-linus-2.6.??-?mdk.src.rpm

   The stock kernel as published by the maintainer of the GNU/Linux kernel.

   If you choose this option (recommended), just download the source RPM, install it (as `root`) and jump to *Configuring The Kernel*, page 86.

2. **The Official Linux Kernel Repository.** The main kernel source host site is ftp.kernel.org (`ftp://ftp.kernel.org`), but there are a large number of mirrors, all named `ftp.xx.kernel.org`, where `xx` represents the ISO country code. Following the official announcement of the availability of the kernel, you should allow at least two hours for all the mirrors to be updated.

   On all of these FTP servers, the kernel sources are in the `/pub/linux/kernel` directory. Next, go to the directory with the series that interests you: it will undoubtedly be `v2.6`. Nothing prevents you from trying the experimental versions or using the old 2.0/2.2/2.4 versions. The file containing the kernel sources is called `linux-<kernel_version>.tar.bz2`, e.g. `linux-2.6.3.tar.bz2`.

You can also apply patches to kernel sources in order to upgrade them incrementally: thus, if you already have kernel sources version 2.6.1 and want to upgrade to kernel 2.6.3, you do not need to download the whole 2.6.3 source, you can simply download the ***patches*** `patch-2.6.2.bz2` and `patch-2.6.3.bz2`. As a general rule, this is a good idea, since sources currently take up dozens of MB.

13.3. Unpacking Sources, Patching the Kernel (if Necessary)

Kernel sources should be placed in `/usr/src`. So you should go into this directory then unpack the sources there:

```
$ cd /usr/src
$ mv linux linux.old
$ tar xjf /path/to/linux-2.6.1.tar.bz2
```

The command `mv linux linux.old` is required: this is because you may already have sources of another version of the kernel. This command will ensure that you do not overwrite them. Once the archive is unpacked, you have a `linux-<version>` directory (where `<version>` is the version of the kernel) with the new kernel's sources. You can make a link (`ln -s linux-<version> linux`) for convenience's sake.

Now, the patches. We will assume that you do want ***to patch*** from version `2.6.1` to `2.6.3` and have downloaded the patches needed to do this: go to the newly created `linux` directory, then apply the patches:

```
$ cd linux
$ bzcat /path/to/patch-2.6.2.bz2 | patch -p1
$ bzcat /path/to/patch-2.6.3.bz2 | patch -p1
$ cd ..
```

Generally speaking, moving from a version `2.6.x` to a version `2.6.y` requires you to apply all the patches numbered `2.6.x+1`, `2.6.x+2`, ..., `2.6.y` in this order. To revert from `2.6.y` to `2.6.x`, repeat exactly the same procedure but applying the patches in reverse order and with option `-R` from `patch` (`R` stands for *Reverse*). So, to go back from kernel `2.6.3` to kernel `2.6.1`, you would do:

```
$ bzcat /path/to/patch-2.6.3.bz2 | patch -p1 -R
$ bzcat /path/to/patch-2.6.2.bz2 | patch -p1 -R
```

If you wish to test if a patch will correctly apply before actually applying it, add the `--dry-run` option to the `patch` command.

Next, for the sake of clarity (and so you know where you are), you can rename `linux` to reflect the kernel version and create a symbolic link:

```
$ mv linux linux-2.6.3
$ ln -s linux-2.6.3 linux
```

It is now time to move on to configuration. For this, you have to be in the source directory:

```
$ cd linux
```

13.4. Configuring The Kernel

To start, go into the `/usr/src/linux` directory.

First, a little trick: you can, if you want, customize the version of your kernel. The kernel version is determined by the four first lines of the `Makefile`:

```
$ head -4 Makefile
VERSION = 2
PATCHLEVEL = 6
SUBLEVEL = 3
EXTRAVERSION = -1mdkcustom
```

Further on in the `Makefile`, you can see that the kernel version is built as:

```
KERNELRELEASE=$(VERSION).$(PATCHLEVEL).$(SUBLEVEL)$(EXTRAVERSION)
```

All you have to do is modify one of these fields in order to change your version. Preferably, you will only change EXTRAVERSION. Say you set it to `-foo`, for example. Your new kernel version will then become 2.6.3-foo. Do not hesitate to change this field each time you recompile a new kernel with different versions, so that you can test different options while keeping the previous versions.

Now, on to configuration. You can choose between:

- `make xconfig` for a graphical interface;
- `make menuconfig` for an interface based on `ncurses`;
- `make config` for the most rudimentary interface, line by line, section by section;
- `make oldconfig` the same as above, but based on your former configuration. See *Saving, Reusing your Kernel Configuration Files*, page 87.

You will go through the configuration section by section, but you can skip sections and jump to the ones that interest you if you are using `menuconfig` or `xconfig`. The options are **y** for Yes (functionality hard-compiled into the kernel), **m** for Module (functionality compiled as a module), or **n** for No (do not include it in the kernel).

Both `make xconfig` and `make menuconfig` have the options bundled in hierarchical groups. For example, `Processor family` goes under `Processor type and features`.

For `xconfig`, the button Main Menu is used to return to the main menu when in a hierarchical group; Next goes to the next group of options; and Prev returns to the previous group. For `menuconfig`, use the `Enter` key to select a section, and switch options with **y**, **m** or **n** to change the options status, or else, press the `Enter` key and make your choice for the multiple choice options. Exit will take you out of a section or out of configuration if you are in the main menu. And there is also Help.

We are not going to enumerate all options here, as there are several hundreds of them. Furthermore, if you have reached this chapter, you probably know what you are doing anyway. So you are left to browse through the kernel configuration and set/unset whichever options you see fit. However, here is some advice to avoid ending up with an unusable kernel:

1. unless you use an initial ramdisk, **never** compile the drivers necessary to mount your root file system (hardware drivers and file-system drivers) as modules! And if you use an initial ramdisk, say `Y` to ext2FS support, as this is the file system used for ramdisks. You will also need the `initrd` support;
2. if you have network cards on your system, compile their drivers as modules. Hence, you can define which card will be the first one, which will be the second, and so on, by putting appropriate aliases in `/etc/modules.conf`. If you compile the drivers into the kernel, the order in which they will be loaded will depend on the linking order, which may not be the order you want;
3. and finally: if you don't know what an option is about, read the help! If the help text still doesn't inspire you, just leave the option as it was. (for `config` and `oldconfig` targets, press the **?** key to access the help).

Et voilà! Configuration is finally over. Save your configuration and quit.

13.5. Saving, Reusing your Kernel Configuration Files

The kernel configuration is saved in the `/usr/src/linux/.config` file. There's a backup for it in `/boot/config-<version>`, it is a good to keep it as a reference. But also save your own configurations for different kernels, as this is just a matter of giving different names to configuration files.

One possibility is to name configuration files after the kernel version. Say you modified your kernel version as shown in *Configuring The Kernel*, page 86, then you can do:

```
$ cp .config /root/config-2.6.3-foo
```

If you decide to upgrade to `2.6.4` (for example), you will be able to reuse this file, as the differences between the configuration of these two kernels will be very small. Just use the backup copy:

```
$ cp /root/config-2.6.3-foo .config
```

But copying the back file does not mean that the kernel is ready to be compiled just yet. You have to invoke `make menuconfig` (or whatever else you chose to use) again, because some files needed in order for the compilation to succeed are created and/or modified by these commands.

However, apart from the chore of going through all the menus again, you could possibly miss some interesting new option(s). You can avoid this by using `make oldconfig`. It has two advantages:

1. it is fast;
2. if a new option appears in the kernel and was not present in your configuration file, it will stop and wait for you to enter your choice.

After you have copied your `.config` to the `root` home, as suggested above, run `make mrproper`. It will ensure that nothing remains from the old configuration and you will get a clean kernel.

Next, time for compilation.

13.6. Compiling Kernel and Modules, Installing the Beast

A small point to begin with: if you are recompiling a kernel with exactly the same version as the one already present on your system, the old modules must be deleted first. For example, if you are recompiling `2.6.3`, you must delete the `/lib/modules/2.6.3` directory.

Compiling the kernel and modules, and then installing modules, is done with the following lines:

```
make clean bzImage modules
make modules_install install
```

A little vocabulary: `bzImage`, `modules`, etc., as well as `oldconfig` and others which we used above, are called **targets**. If you specify several targets to `make` as shown above, they will be executed in the order of appearance. But if one target fails, `make` will not go any further[1].

Let us look at the different targets and see what they do:

- `bzImage`: this builds the kernel. Note that this target is only valid for Intel processors. This target also generates the `System.map` for this kernel. We will see later what this file is used for;
- `modules`: this target will generate modules for the kernel you have just built. If you have chosen not to have modules, this target will do nothing;
- `modules_install`: this will install modules. By default, modules will be installed in the `/lib/modules/<kernel-version>` directory. This target also computes module dependencies (unlike in older kernels);
- `install`: this last target will finally copy the kernel and modules to the right places and modify the boot loader's configurations in order for the new kernel to be available at boot time. Do not use it if you prefer to perform a manual installation as described in *Installing the New Kernel Manually*, page 89.

1. In this case, if the compilation fails, it means that there is a bug in the kernel... If this is the case, please report it!

It is important to respect the target order `modules_install install` so that modules actually get installed first.

At this point, everything is now compiled and correctly installed, ready to be tested! Just reboot your machine and choose the new kernel in the boot menu. Note that the old kernel remains available so that you can use it if you experience problems with the new one. However, you can choose to manually install the kernel and change the boot menus by hand. We will explain that in the next section.

The old `zImage` target is now obsolete, it is deprecated, and you should not use it.

13.7. Installing the New Kernel Manually

The kernel is located in `arch/i386/boot/bzImage` . The standard directory in which kernels are installed is `/boot`. You also need to copy the `System.map` file to ensure that some programs (`top` is just one example) will work correctly. Good practice again: name these files after the kernel version. Let us assume that your kernel version is `2.6.3-foo`. The sequence of commands you will have to type is:

```
$ cp arch/i386/boot/bzImage /boot/vmlinuz-2.6.3-foo
$ cp System.map /boot/System.map-2.6.3-foo
```

Now you need to tell the boot loader about your new kernel. There are two bootloaders: GRUB or LILO. Note that Mandrakelinux is configured with LILO by default.

13.7.1. Updating LILO

The simplest way of updating LILO is to use drakboot (see chapter Change Your Boot-up Configuration in the *Starter Guide*). Alternatively, you can manually edit the configuration file as follows.

The LILO configuration file is `/etc/lilo.conf`. This is what a typical `lilo.conf` looks like:

```
boot=/dev/hda
map=/boot/map
default="linux"
keytable=/boot/es-latin1.klt
prompt
nowarn
timeout=50
message=/boot/message
menu-scheme=wb:bw:wb:bw
image=/boot/vmlinuz
        label="linux"
        root=/dev/hda1
        initrd=/boot/initrd.img
        append="devfs=mount acpi=ht resume=/dev/hda5"
        read-only
other=/dev/fd0
        label="floppy"
        unsafe
```

A `lilo.conf` file consists of a main section, followed by a section for each operating system. In the example of the file above, the main section is made up of the following directives:

```
boot=/dev/hda
map=/boot/map
default="linux"
keytable=/boot/es-latin1.klt
prompt
nowarn
timeout=50
message=/boot/message
menu-scheme=wb:bw:wb:bw
```

The `boot=` directive tells LILO where to install its boot sector; in this case, it is the MBR (*Master Boot Record*) of the first IDE hard disk. If you want to make a LILO floppy disk, simply replace `/dev/hda` with `/dev/fd0`. The `prompt` directive asks LILO to show the menu on start-up. As a timeout is set, LILO will start the default image after 5 seconds (`timeout=50`). If you remove the `timeout` directive , LILO will wait until you have typed something.

Then comes a `linux` section:

```
image=/boot/vmlinuz
        label="linux"
        root=/dev/hda1
        initrd=/boot/initrd.img
        append="devfs=mount acpi=ht resume=/dev/hda5"
        read-only
```

A section to boot a GNU/Linux kernel always starts with an `image=` directive, followed by the full path to a valid GNU/Linux kernel. Like any section, it contains a `label=` directive as a unique identifier, here `linux`. The `root=` directive tells LILO which partition hosts the `root` file system for this kernel. It may be different in your configuration... The `read-only` directive tells LILO that it should mount the root file system as read-only on start-up: if this directive is not there, you will get a warning message. The `append` line specifies options to pass to the kernel during booting.

Then comes the floppy section:

```
other=/dev/fd0
        label="floppy"
        unsafe
```

In fact, a section beginning with `other=` is used by LILO to start any operating system other than GNU/Linux: the argument of this directive is the location of this system's boot sector, and in this case, it is to boot from a floppy disk.

Now, it's time to add a section for our new kernel. You can put this section anywhere after the main section, but do not enclose it within another section. Here is what it should look like:

```
image=/boot/vmlinuz-2.6.3-foo
        label="foo"
        root=/dev/hda1
        read-only
        append="devfs=mount acpi=ht resume=/dev/hda5"
```

Needless to say: adapt the entry to your system's configuration.

So this is what our `lilo.conf` looks like after modification, decorated with a few additional comments (all the lines beginning with `#`), which will be ignored by LILO:

```
#
# Main section
#
boot=/dev/hda
map=/boot/map
install=/boot/boot.b
message=/boot/message
# What should be booted by default. Let's put our own new kernel:
default="foo"
# Show prompt...
prompt
# ... wait 5 seconds
timeout=50
#
# Our new kernel: default image
#
image=/boot/vmlinuz-2.6.3-foo
        label="foo"
        root=/dev/hda1
        read-only
        append="devfs=mount acpi=ht resume=/dev/hda5"
#
# The original kernel
#
image=/boot/vmlinuz
        label="linux"
```

```
        root=/dev/hda1
        read-only
        append="devfs=mount acpi=ht resume=/dev/hda5"
#
# Floppy Section
#
other=/dev/floppy
        label="floppy"
        unsafe
```

This could well be what your `lilo.conf` will look like... but remember, again, adapt it to your own configuration.

Now that the file has been modified appropriately, but unlike GRUB which does not need it, you must tell LILO to change the boot sector:

```
$ lilo
Added foo *
Added linux
Added floppy
$
```

In this way, you can compile as many kernels as you want, by adding as many sections as necessary. All you need to do now is restart your machine to test your new kernel. Notice that if LILO shows any errors during installation, it means that it has changed nothing. LILO only modifies your configuration if it finds no errors in the process.

13.7.2. Updating Grub

Obviously, retain the option of starting your current kernel! The simplest way of updating GRUB is to use drakboot (see chapter Change Your Boot-up Configuration in the *Starter Guide*). Alternatively, you can manually edit the configuration file as follows.

You need to edit the `/boot/grub/menu.lst` file. This is what a typical `menu.lst` looks like, after you have installed your Mandrakelinux distribution and before modification:

```
timeout 5
color black/cyan yellow/cyan
i18n (hd0,4)/boot/grub/messages
keytable (hd0,4)/boot/fr-latin1.klt
default 0

title linux
kernel (hd0,4)/boot/vmlinuz root=/dev/hda5

title failsafe
kernel (hd0,4)/boot/vmlinuz root=/dev/hda5  failsafe

title Windows
root (hd0,0)
makeactive
chainloader  +1

title floppy
root (fd0)
chainloader +1
```

This file is made of two parts: the header with common options (the five first lines), and the images, each one corresponding to a different GNU/Linux kernel or another OS. `timeout 5` defines the time (in seconds) for which GRUB will wait for input before it loads the default image (this is defined by the `default 0` directive in common options, i.e. the first image in this case). The `keytable` directive, if present, defines where to find the keymap for your keyboard. In this example, this is a French layout. If none are present, the keyboard is assumed to be a plain `QWERTY` keyboard. All of the `hd(x,y)` which you see refer to partition number `y` on disk number `x` as seen by the BIOS.

Then come the different images. In this example, four images are defined: `linux`, `failsafe`, `windows`, and `floppy`.

- The `linux` section starts by telling GRUB about the kernel which is to be loaded (`kernel hd(0,4)/boot/vmlinuz`), followed by the options to pass to the kernel. In this case, `root=/dev/hda5` will tell the kernel that the root file system is located on `/dev/hda5`. In fact, `/dev/hda5` is the equivalent of GRUB's `hd(0,4)`, but nothing prevents the kernel from being on a different partition to the one containing the root file system;
- The `failsafe` section is very similar to the previous one, except that we will pass an argument to the kernel (`failsafe`) which tells it to enter "single" or "rescue" mode;
- The `Windows` section tells GRUB to simply load the first partition's boot sector, which probably contains a Windows boot sector;
- The `floppy` section simply boots your system from the floppy disk in the first floppy drive, whatever the system installed on it. It can be a Windows boot disk, or even a GNU/Linux kernel on a floppy;

Depending on the security level you use on your system, some of the entries described here may be absent from your file.

Now to the point. We need to add another section to tell GRUB about our new kernel. In this example, it will be placed before the other entries, but nothing prevents you from putting it somewhere else:

```
title foo
kernel (hd0,4)/boot/vmlinuz-2.6.3-foo root=/dev/hda5
```

Do not forget to adapt the file to your configuration! The GNU/Linux root file system here is `/dev/hda5`, but it can be somewhere else on your system.

And that's it. Unlike LILO, as we will see below, there is nothing else to do. Just restart your computer and your newly defined entry will just appear. Just select it from the menu and your new kernel will boot.

If you compiled your kernel with the framebuffer, you will probably want to use it: in this case, you need to add a directive to the kernel which tells it what resolution you want to start in. The list of modes is available in the `/usr/src/linux/Documentation/fb/vesafb.txt` file (but only in the case of the VESA framebuffer! Otherwise, refer to the corresponding file). For the 800x600 mode in 32 bits[2], the mode number is `0x315`, so you need to add the directive:

```
vga=0x315
```

and your entry now resembles:

```
title foo
kernel (hd0,4)/boot/vmlinuz-2.6.3-foo root=/dev/hda5 vga=0x315
```

For more information, please refer to the info pages about GRUB (`info grub`).

2. 8 bits means 2^8 colors, i.e. 256; 16 bits means 2^{16} colors, i.e. 64k, i.e. 65536; in 24 bits as in 32 bits, color is coded on 24 bits, i.e. 2^{24} possible colors, in other words exactly 16M, or a bit more than 16 million.

Appendix A. Glossary

account
on a UNIX system, the combination of a name, a personal directory, a password and a shell which allows a user to connect to this system.

alias
a mechanism used in a shell in order to make it substitute one string for another before executing the command. You can see all aliases defined in the current session by typing `alias` at the prompt.

APM
Advanced Power Management. A feature used by some BIOSes in order to make the machine enter a standby state after a given period of inactivity. On laptops, APM is also responsible for reporting the battery status and (if supported) the estimated remaining battery life.

ARP
Address Resolution Protocol. The Internet protocol used to dynamically map an Internet address to a physical (hardware) address on a local area network. This is limited to networks that support hardware broadcasting.

ASCII
American Standard Code for Information Interchange. The standard code used for storing characters, including control characters, on a computer. Many 8-bit codes (such as ISO 8859-1, the Linux default character set) contain ASCII as their lower half.
See Also: ISO 8859.

assembly language
is the programming language that is closest to the computer, which is why it's called a "low level" programming language. Assembly has the advantage of speed since assembly programs are written in terms of processor instructions so little or no translation is needed when generating executables. Its main disadvantage is that it is processor (or architecture) dependent. Writing complex programs is very time-consuming as well. So, assembly is the fastest programming language, but it isn't portable between architectures.

ATAPI
("AT Attachment Packet Interface") An extension to the ATA specification ("Advanced Technology Attachment", more commonly known as IDE, *Integrated Drive Electronics*) which provides additional commands to control CD-ROM drives and magnetic tape drives. IDE controllers equipped with this extension are also referred to as EIDE (*Enhanced IDE*) controllers.

ATM
This is an acronym for **Asynchronous Transfer Mode**. An ATM network packages data into standard size blocks (53 bytes: 48 for the data and 5 for the header) that it can be conveyed efficiently from point to point. ATM is a circuit switched packet network technology oriented towards high speed (multi-megabit) optical networks.

atomic
a set of operations is said to be atomic when they execute all at once and cannot be preempted.

background
in shell context, a process is running in the background if you can type commands that are captured by the process while it is running.
See Also: job, foreground.

backup
is a means of saving your important data to a safe medium and location. Backups should be done regularly, especially with more critical information and configuration files (the most important directories to backup are `/etc`, `/home` and `/usr/local`). Traditionally, many people use `tar` with `gzip` or `bzip2` to backup directories and files. You can use these tools or programs like `dump` and `restore`, along with many other free or commercial backup solutions.

batch
is a processing mode where jobs which are submitted to the CPU are executed sequentially until all the jobs have been processed.

beep
is the little noise your computer's speaker emits to warn you of some ambiguous situation when you're using command completion and, for example, there's more than one possible choice for completion. There might be other programs that make beeps to let you know of some particular situation.

beta testing
is the name given to the process of testing the beta version of a program. Programs usually get released in alpha and beta states for testing prior to final release.

binary
in the context of programming, binaries are the compiled, executable code.

bit
stands for *BInary digiT*. A single digit which can take the values 0 or 1, because calculation is done in base two.

block mode files
files whose contents are buffered. All read/write operations for such files go through buffers, which allow for asynchronous writes on the underlying hardware, and for reads, which allows the system to avoid disk access if the data is already in a buffer.
See Also: buffer, buffer cache, character mode files.

boot
the procedure taking place when a computer is switched on, where peripherals are recognized sequentially and where the operating system is loaded into memory.

bootdisk
a bootable floppy disk containing the code necessary to load the operating system from the hard disk (sometimes it is self-sufficient).

bootloader
is a program which starts the operating system. Many bootloaders give you the opportunity to load more than one operating system by allowing you choose between them from a menu. Bootloaders like GRUB and LILO are popular because of this feature and are very useful in dual- or multi-boot systems.

BSD
Berkeley Software Distribution. A UNIX variant developed at the Berkeley University computing department. This version has always been considered more technically advanced than the others, and has brought many innovations to the computing world in general and to UNIX in particular.

buffer
a small portion of memory with a fixed size, which can be associated with a block mode file, a system table, a process and so on. The buffer cache maintains coherency of all buffers.
See Also: buffer cache.

buffer cache
a crucial part of an operating system kernel, it is in charge of keeping all buffers up-to-date, shrinking the cache when needed, clearing unneeded buffers and more.
See Also: buffer.

bug
illogical or incoherent behavior of a program in a special case, or a behavior that does not follow the documentation or accepted standards issued for the program. Often, new features introduce new bugs in a program. Historically, this term comes from the old days of punch cards: a bug (the insect!) slipped into a hole of a punch card and, as a consequence, the program misbehaved. Admiral Grace Hopper, having discovered this, declared "It's a bug!", and since then the term has remained. Note that this is only one of the many stories which attempt to explain the term *bug*.

byte
eight consecutive bits, which when interpreted in base ten result in a number between 0 and 255.
See Also: bit.

case
when taken in the context of strings, the case is the difference between lowercase letters and uppercase (or capital) letters.

CHAP
Challenge-Handshake Authentication Protocol: protocol used by ISPs to authenticate their clients. In this scheme, a value is sent to the client (the machine making the connection), which it uses to calculate a hash based on the value. The client sends the hash back to the server for comparison to the hash calculated by the server. This authentication method is different to PAP in that it re- authenticates on a periodic basis after the initial authentication.
See Also: PAP.

character mode files
files whose content is not buffered. When associated with physical devices, all input/output on these devices is performed immediately. Some special character devices are created by the operating system (`/dev/zero`, `/dev/null` and others). They correspond to data flows.
See Also: block mode files.

CIFS
Common Internet File System The successor to the SMB file system, used on DOS systems.

client
program or computer which periodically connects to another program or computer to give it orders or ask for information. In the case of **peer to peer** systems such as SLIP or PPP the client is taken to be the end that initiates the connection and the remote end receiving the call is designated as the server. It is one of the components of a **client/server system**.

client/server system
system or protocol consisting of a **server** and one or several **clients**.

command line
provided by a shell and which allows the user to type commands directly. Also subject of an eternal "flame war" between its supporters and its detractors.

command mode
under Vi or one of its clones, it is the state of the program in which pressing a key will not insert the character in the file being edited, but instead performs an action specific to the key (unless the clone has re-mappable commands and you have customized your configuration). You may get out of it typing one of the "back to insertion mode" commands: **i**, **I**, **a**, **A**, **s**, **S**, **o**, **O**, **c**, **C**, ...

compilation
is the process of translating source code that is human readable (well, with some training) and that is written in some programming language (C, for example) into a binary file that is machine readable.

completion
the ability of a shell to automatically expand a substring to a filename, user name or other item, as long as there is a match.

compression
is a way to shrink files or decrease the number of characters sent over a communications connection. Some file compression programs include compress, `zip`, `gzip`, and `bzip2`.

console
is the name given to what used to be called terminals. They were the machines (a screen plus a keyboard) connected to one big central mainframe. On PC s, the physical terminal is the keyboard and screen.
See Also: virtual console.

cookies
temporary files written on the local hard disk by a remote web server. It allows for the server to be aware of a user's preferences when this user connects again.

datagram
A datagram is a discrete package of data and headers which contain addresses, which is the basic unit of transmission across an IP network. You might also hear this called a "packet".

dependencies
are the stages of compilation that need to be satisfied before going on to other compilation stages in order to successfully compile a program. This term is also used where one set of programs you wish to install are dependent on other programs which may or may not be installed on your system, in which case you

may get a message telling you that the system needs to "satisfy dependencies" in order to continue the installation.

desktop
If you're using the X Window System, the desktop is the place on the screen where you work and upon which your windows and icons are displayed. It is also called the background, and is usually filled with a simple color, a gradient color or even an image.
See Also: virtual desktops.

DHCP
Dynamic Host Configuration Protocol. A protocol designed for machines on a local network to dynamically get an IP address from a DHCP server.

directory
Part of the file system structure. Files or other directories can be stored within a directory. Sometimes there are sub-directories (or branches) within a directory. This is often referred to as a directory tree. If you want to see what's inside another directory, you will either have to list it or change to it. Files inside a directory are referred to as leaves while sub-directories are referred to as branches. Directories follow the same restrictions as files although the permissions mean different things. The special directories `.` and `..` refer to the directory itself and to the parent directory respectively.

discrete values
are values that are non-continuous. That is, there's some kind of "spacing" between two consecutive values.

distribution
is a term used to distinguish one GNU/Linux manufacturers product from another. A distribution is made up of the core Linux kernel and utilities, as well as installation programs, third-party programs, and sometimes proprietary software.

DLCI
The DLCI is the Data Link Connection Identifier and is used to identify a unique virtual point to point connection via a Frame Relay network. The DLCI's are normally assigned by the Frame Relay network provider.

DMA
Direct Memory Access. A facility used in the PC architecture which allows a peripheral to read or write from main memory without the help of the CPU. PCI peripherals use bus mastering and do not need DMA.

DNS
Domain Name System. The distributed name and address mechanism used in the Internet. This mechanism allows you to map a domain name to an IP address, allowing you to look up a site by domain name without knowing the IP address of the site. DNS also allows reverse lookup, allowing you to obtain machine's IP address from its name.

DPMS
Display Power Management System. Protocol used by all modern monitors to manage power saving features. Monitors supporting these features are commonly called "green" monitors.

echo
occurs when the characters you type in a user name entry field, for example, are shown "as is", instead of showing "*" for each one you type.

editor
is a term typically used for programs that edit text files (aka text editor). The most well-known GNU/Linux editors are the GNU Emacs (Emacs) editor and the UNIX editor Vi.

ELF
Executable and Linking Format. This is the binary format used by most GNU/Linux distributions.

email
stands for Electronic Mail. This is a way to send messages electronically between people on the same network. Similar to regular mail (aka snail mail), email needs a destination and sender address to be

sent properly. The sender must have an address like "sender@senders.domain" and the recipient must have an address like "recipient@recipients.domain." Email is a very fast method of communication and typically only takes a few minutes to reach anyone, regardless of where in the world they are located. In order to write email, you need an email client such as pine or `mutt` which are text-mode clients, or GUI clients such as KMail.

environment
is the execution context of a process. It includes all the information that the operating system needs to manage the process and what the processor needs to execute the process properly.
See Also: process.

environment variables
a part of a process' environment. Environment variables are directly viewable from the shell.
See Also: process.

escape
in the shell context, is the action of surrounding a string between quotes to prevent the shell from interpreting that string. For example, when you need to use spaces in a command line and pipe the results to some other command you have to put the first command between quotes ("escape" the command) otherwise the shell will interpret it incorrectly and it won't work as expected.

ext2
short for the "Extended 2 file system". This is GNU/Linux's native file system and has the characteristics of any UNIX file system: support for special files (character devices, symbolic links, etc), file permissions and ownership, and other features.

FAQ
Frequently Asked Questions. A document containing a series of questions and answers about a specific topic. Historically, FAQs appeared in newsgroups, but this sort of document now appears on various web sites, and even commercial products have FAQs. Generally, they are very good sources of information.

FAT
File Allocation Table. File system used by DOS and Windows.

FDDI
Fiber Distributed Digital Interface. A high-speed network physical layer, which uses optical fiber for communication. Mostly used on large networks, mainly because of its price. It is rarely seen as a means of connection between a PC and a network switch.

FHS
File system Hierarchy Standard. A document containing guidelines for a coherent file tree organization on UNIX systems. Mandrakelinux complies with this standard in most aspects.

FIFO
First In, First Out. A data structure or hardware buffer where items are taken out in the order they were put in. UNIX pipes are the most common examples of FIFO s.

filesystem
scheme used to store files on a physical media (hard drive, floppy) in a consistent manner. Examples of file systems are FAT, GNU/Linux' ext2fs, ISO9660 (used by CD-ROMs) and so on. An example of a virtual filesystem is the `/proc` filesystem.

firewall
a machine or a dedicated piece of hardware that in the topology of a local network is the single connection point to the outside network, and which filters, controls the activity on some ports, or makes sure that only some specific interfaces may have access to the outside world.

flag
is an indicator (usually a bit) that is used to signal some condition to a program. For example, a filesystem has, among others, a flag indicating if it has to be dumped in a backup, so when the flag is active the filesystem gets backed up, and when it's inactive it doesn't.

focus
the state for a window to receive keyboard events (such as key-presses, key-releases and mouse clicks) unless they are trapped by the window manager.

foreground
in shell context, the process in the foreground is the one that is currently running. You have to wait for such a process to finish in order to be able to type commands again.
See Also: job, background.

Frame Relay
Frame Relay is a network technology ideally suited to carrying traffic which is of bursty or sporadic nature. Network costs are reduced by having many Frame Relay customers sharing the same network capacity and relying on them wanting to make use of the network at slightly different times.

framebuffer
projection of a video card's RAM into the machine's address space. This allows for applications to access the video RAM without the chore of having to talk to the card. All high-end graphical workstations use frame buffers.

FTP
File Transfer Protocol. This is the standard Internet protocol used to transfer files from one machine to another.

full-screen
This term is used to refer to applications that take up the entire visible area of your display.

gateway
link connecting two IP networks.

GFDL
The GNU Free Documentation License. The license which applies to all Mandrakelinux documentation.

GIF
Graphics Interchange Format. An image file format, widely used on the web. GIF images may be compressed or animated. Due to copyright problems it is a bad idea to use them, so the recommended solution is to replace them as much as possible by the PNG format.

globbing
in the shell, the ability to group a certain set of filenames with a globbing pattern.
See Also: globbing pattern.

globbing pattern
a string made of normal characters and special characters. Special characters are interpreted and expanded by the shell.

GNU
GNU's Not Unix. The GNU project was initiated by Richard Stallman at the beginning of the 1980s, and aimed at developing a free operating system ("free" as in "free speech"). Currently, all tools are there, except... the kernel. The GNU project kernel, Hurd, is not rock solid yet. Linux borrows, among others, two things from GNU: its C compiler, gcc, and its license, the GPL.
See Also: GPL.

GPL
General Public License. The license of the GNU/Linux kernel, it goes the opposite way of all proprietary licenses in that it applies no restrictions as to copying, modifying and redistributing the software, as long as the source code is made available. The only restriction is that the persons to whom you redistribute it must also benefit from the same rights.

GUI
Graphical User Interface. Interface to a computer consisting of windows with menus, buttons, icons and so on. A great majority of users prefer a GUI to a CLI (*Command Line Interface*) for ease of use, even though the latter is far more versatile.

guru
An expert. Used to qualify someone particularly skilled, but also of valuable help for others.

hardware address
This is a number that uniquely identifies a host in a physical network at the media access layer. Examples of this are **Ethernet Addresses** and **AX.25 Addresses**.

hidden file
is a file which can't be "seen" when doing a `ls` command with no options. Hidden files' filenames begin with a `.` and are used to store the user's personal preferences and configurations for the different programs (s)he uses. For example, `bash`'s command history is saved into `.bash_history`, a hidden file.

home directory
often abbreviated as "home", this is the name for the personal directory of a given user.
See Also: account.

host
refers to a computer and is commonly used when talking about computers that are connected to a network.

HTML
HyperText Markup Language. The language used to create web documents.

HTTP
HyperText Transfer Protocol. The protocol used to connect to web sites and retrieve HTML documents or files.

icon
is a little drawing (normally sized 16x 16, 32x 32, 48x 48 and sometimes 64x 64 pixels) which in a graphical environment represents a document, a file or a program.

IDE
Integrated Drive Electronics. The most widely used bus on today's PC s for hard disks. An IDE bus may contain up to two devices, and the speed of the bus is limited by the device on the bus with the slower command queue (and not the slower transfer rate!).
See Also: ATAPI.

IP masquerading
This is a technique where a firewall is used to hide your computer's true IP address from the outside. Typically, any outside network connections you make through the firewall will inherit the firewall's IP address. This is useful in situations where you may have a fast Internet connection with only one IP address but wish to use more than one computer on your internal network.

inode
entry point leading to the contents of a file on a UNIX-like filesystem. An inode is identified in a unique way by a number, and contains meta-information about the file it refers to, such as its access times, its type, its size, **but not its name!**

insert mode
under Vi or any of its clones, it is the state of the program in which pressing a key will insert that character in the file being edited (except pathological cases like the completion of an abbreviation, right justify at the end of the line, ...). One gets out of it pressing the key **Esc** (or **Ctrl-[**).

Internet
is a huge network that connects computers around the world.

IP address
is a numeric address consisting of four parts which identifies your computer on the Internet. IP addresses are structured in a hierarchical manner, with top level and national domains, domains, sub-domains and each machine's personal address. An IP address will look something like `192.168.0.1`. A machine's personal address can be one of two types: static or dynamic. Static IP addresses are addresses which never change, they are permanently assigned.. Dynamic IP addresses mean that an IP address will change with each new connection to the network. Dial-up and cable modem users typically have dynamic IP addresses while some DSL and other high-speed connections provide static IP addresses.

IRC
Internet Relay Chat. One of the few Internet standards for live speech. It allows for channel creation, private talks and file exchange. It also allows servers to connect to each other, which is why several IRC networks exist today: **Undernet**, **DALnet**, **EFnet** to name a few.

IRC channels
are the "places" inside IRC servers where you can chat with other people. Channels are created in IRC servers and users join those channels so they can communicate with each other. Messages written on one channel are only visible to the people connected to that channel. Two or more users can create a "private" channel so they don't get disturbed by other users. Channel names begin with a #.

ISA
Industry Standard Architecture. The very first bus used on PC s, it is slowly being abandoned in favor of the PCI bus. ISA is still commonly found on SCSI cards supplied with scanners, CD writers and some other older hardware.

ISDN
Integrated Services Digital Network. A set of communication standards for voice, digital network services and video. It has been designed to eventually replace the current phone system, known as PSTN (*Public Switched Telephone Network*) or POTS (*Plain Ole Telephone Service*). ISDN is known as a circuit switched data network.

ISO
International Standards Organization. A group of companies, consultants, universities and other sources which enumerates standards in various disciplines, including computing. The papers describing standards are numbered. The standard number iso9660, for example, describes the file system used on CD-ROMs.

ISO 8859
The ISO 8859 standard includes several 8-bit extensions to the ASCII character set. Especially important is ISO 8859-1, the "Latin Alphabet No. 1", which has become widely implemented and may already be seen as the *de facto* standard ASCII replacement.
ISO 8859-1 supports the following languages: Afrikaans, Basque, Catalan, Danish, Dutch, English, Faroese, Finnish, French, Galician, German, Icelandic, Irish, Italian, Norwegian, Portuguese, Scottish, Spanish, and Swedish.
Note that the ISO 8859-1 characters are also the first 256 characters of ISO 10646 (Unicode). However, it lacks the EURO symbol and does not fully cover Finnish and French. ISO 8859-15 is a modification of ISO 8859-1 to covers these needs.
See Also: ASCII.

ISP
Internet Service Provider. A company which sells Internet access to its customers, either over telephone lines or high-bandwidth circuits such as dedicated T-1 circuits, DSL or cable.

JPEG
Joint Photographic Experts Group. Another very common image file format. JPEG is mostly suited for compressing real-world scenes, and does not work very well on non-realistic images.

job
in a shell context, a job is a process running in the background. You can have several jobs in the same shell and control these jobs independently.
See Also: foreground, background.

kernel
is the core of the operating system. The kernel is responsible for allocating resources and separating processes from each other. It handles all of the low-level operations which allow programs to talk directly to the hardware on your computer, manages the buffer cache and so on.

kill ring
under Emacs, it is the set of text areas cut or copied since the editor was started. The text areas may be recalled to be inserted again, and the structure is ring-like.

LAN
Local Area Network. Generic name given to a network of machines connected to the same physical wire.

launch
is the action of invoking, or starting, a program.

LDP
Linux Documentation Project. A nonprofit organization that maintains GNU/Linux documentation. It's mostly known for documents like HOWTOs, but it also maintains FAQ s, and even a few books.

library
is a collection of procedures and functions in binary form to be used by programmers in their programs (as long as the library's license allows them to do so). The program in charge of loading shared libraries at run time is called the dynamic linker.

link
reference to an inode in a directory, therefore giving a (file) name to the inode. Examples of inodes which don't have a link (and hence have no name) are: anonymous pipes (as used by the shell), sockets (aka network connections), network devices and so on.

linkage
last stage of the compile process, consisting of linking together all object files in order to produce an executable file, and matching unresolved symbols with dynamic libraries (unless a static linkage has been requested, in which case the code of these symbols will be included in the executable).

Linux
is a UNIX-like operating system which runs on a variety of different computers, and is free for anyone to use and modify. Linux (the kernel) was written by Linus Torvalds.

login
connection name for a user on a UNIX system, and the action to connect.

lookup table
is a table that stores corresponding codes (or tags) and their meaning. It is often a data file used by a program to get further information about a particular item.
For example, HardDrake uses such a table to know what a manufacturer's product code means. This is one line from the table, giving information about item `CTL0001`

```
CTL0001 sound   sb      Creative Labs   SB16 \
HAS_OPL3|HAS_MPU401|HAS_DMA16|HAS_JOYSTICK
```

loopback
virtual network interface of a machine to itself, allowing the running programs not to have to take into account the special case where two network entities are in fact the same machine.

major
number specific to the device class.

manual page
a small document containing the definitions of a command and its usage, to be consulted with the `man` command. The first thing one should (learn how to) read when learning about a command you aren't familiar with.

MBR
Master Boot Record. Name given to the first sector of a bootable hard drive. The MBR contains the code used to load the operating system into memory or a bootloader (such as LILO), and the partition table of that hard drive.

MIME
Multipurpose Internet Mail Extensions. A string of the form `type/subtype` describing the contents of a file attached in an e-mail. This allows MIME -aware mail clients to define actions depending on the type of the file.

minor
number identifying the specific device we are talking about.

MPEG
Moving Pictures Experts Group. An ISO committee which generates standards for video and audio compression. MPEG is also the name of their algorithms. Unfortunately, the license for this format is very restrictive, and as a consequence there are still no Open Source MPEG players...

mount point
is the directory where a partition or another device is attached to the GNU/Linux filesystem. For example, your CD-ROM is mounted in the `/mnt/cdrom` directory, from where you can explore the contents of any mounted CDs.

mounted
A device is mounted when it is attached to the GNU/Linux filesystem. When you mount a device you can browse its contents. This term is partly obsolete due to the "supermount" feature, so users do not need to manually mount removable media.
See Also: mount point.

MSS
The Maximum Segment Size (**MSS**) is the largest quantity of data which can be transmitted at one time. If you want to prevent local fragmentation MSS would equal MTU-IP header.

MTU
The Maximum Transmission Unit (**MTU**) is a parameter which determines the largest datagram than can be transmitted by an IP interface without it needing to be broken down into smaller units. The MTU should be larger than the largest datagram you wish to transmit un-fragmented. Note, this only prevents fragmentation locally, some other link in the path may have a smaller MTU and the datagram will be fragmented there. Typical values are 1500 bytes for an Ethernet interface, or 576 bytes for a PPP interface.

multitasking
the ability of an operating system to share CPU time between several processes. At a low level, this is also known as multiprogramming. Switching from one process to another requires that all the current process context be saved and restored when this process runs again. This operation is called a context switch, and on Intel, is done 100 times per second, thereby making it fast enough so that a user has the illusion that the operating system runs several applications at the same time. There are two types of multitasking: in preemptive multitasking the operating system is responsible for taking away the CPU and passing it to another process; cooperative multitasking is where the process itself gives back the CPU. The first variant is obviously the better choice because no program can consume the entire CPU time and block other processes. GNU/Linux performs preemptive multitasking. The policy to select which process should be run, depending on several parameters, is called scheduling.

multiuser
is used to describe an operating system which allows multiple users to log into and use the system at the exact same time, each being able to do their own work independent of other users. A multitasking operating system is required to provide multiuser support. GNU/Linux is both a multitasking and multiuser operating system, as is any UNIX system for that matter.

named pipe
a UNIX pipe which is linked, as opposed to pipes used in shells.
See Also: pipe, link.

naming
a word commonly used in computing for a method to identify objects. You will often hear of "naming conventions" for files, functions in a program and so on.

NCP
NetWare Core Protocol. A protocol defined by **Novell** to access Novell NetWare file and print services.

NFS
Network File System. A network file system created by **Sun Microsystems** in order to share files across a network in a transparent way.

newsgroups
discussion and news areas which can be accessed by a news or USENET client to read and write messages specific to the topic of the newsgroup. For example, the newsgroup `alt.os.linux.mandrake` is an alternate newsgroup (alt) dealing with the Operating System (OS) GNU/Linux, and specifically, Mandrakelinux (mandrake). Newsgroups are broken down in this fashion to make it easier to search for a particular topic.

NIC
Network Interface Controller. An adapter installed in a computer which provides a physical connection to a network, such as an Ethernet card.

NIS
Network Information System. NIS was also known as "Yellow Pages", but **British Telecom** holds a copyright on this name. NIS is a protocol designed by **Sun Microsystems** in order to share common information across a NIS **domain**, which may consist of an entire LAN, or just a part of it. It can export password databases, service databases, groups information and more.

null, character
the character or byte number 0. It is used to mark the end of a string.

object code
is the code generated by the compilation process to be linked with other object codes and libraries to form an executable file. Object code is machine readable.
See Also: compilation, linkage.

on the fly
Something is said to be done "on the fly" when it's done along with something else, without you noticing it or explicitly asking for it.

open source
is the name given to free source code of a program that is made available to the development community and public at large. The theory behind this is that allowing source code to be used and modified by a broader group of programmers will ultimately produce a more useful product for everyone. Some popular open source programs include Apache, sendmail and GNU/Linux.

operating system
is the interface between the applications and the underlying hardware. The tasks for any operating system are primarily to manage all of the machine specific resources. On a GNU/Linux system, this is done by the kernel and loadable modules. Other well-known operating systems include AmigaOS, MacOS, FreeBSD, OS/2, UNIX, Windows NT, and Windows 9x.

owner
in the context of users and their files, the owner of a file is the user who created that file.

owner group
in the context of groups and their files, the owner group of a file is the group to which the user who created that file belongs.

PAP
Password Authentication Protocol. A protocol used by many ISPs to authenticate their clients. In this scheme, the client (you) sends an identifier/password pair to the server, but none of the information is encrypted. See CHAP for the description of a more secure system.
See Also: CHAP.

pager
program displaying a text file one screen at a time, and making it easy to move back and forth and search for strings in this file. We suggest you to use `less`.

password
is a secret word or combination of words or letters which is used to secure something. Passwords are used in conjunction with user logins to multi-user operating systems, web sites, FTP sites, and so forth. Passwords should be hard-to-guess phrases or alphanumeric combinations, and should never be based on common dictionary words. Passwords ensure that other people cannot log into a computer or site with your account.

patch, to patch
file containing a list of corrections to issue to source code in order to add new features, to remove bugs, or to modify it according to one's wishes and needs. The action consisting of the application of these corrections to the archive of source code (aka "patching").

path
is an assignment for files and directories to the filesystem. The different layers of a path are separated by the "slash" or '/' character. There are two types of paths on GNU/Linux systems. The **relative** path is the position of a file or directory in relation to the current directory. The **absolute** path is the position of a file or directory in relation to the root directory.

PCI
Peripheral Components Interconnect. A bus created by **Intel** which today is the standard bus for PC and other architectures. It is the successor to ISA, and it offers numerous services: device identification, configuration information, IRQ sharing, bus mastering and more.

PCMCIA
Personal Computer Memory Card International Association. More and more commonly called "PC Card" for simplicity reasons, this is the standard for external cards attached to a laptop: modems, hard disks, memory cards, Ethernet cards, and more. The acronym is sometimes humorously expanded to *People Cannot Memorize Computer Industry Acronyms*...

pipe
a special UNIX file type. One program writes data into the pipe, and another program reads the data at the other end. UNIX pipes are FIFO s, so the data is read at the other end in the order it was sent. Very widely used with the shell. See also **named pipe**.

pixmap
is an acronym for "pixel map". It's another way of referring to bitmap images.

plugin
add-on program used to display or play some multimedia content found on a web document. It can usually be easily downloaded if your browser is not yet able to display or play that kind of information.

PNG
Portable Network Graphics. Image file format created mainly for web use, it has been designed as a patent-free replacement for GIF and also has some additional features.

PnP
Plug'N'Play. First an add-on for ISA in order to add configuration information for devices, it has become a more widespread term which groups all devices able to report their configuration parameters. All PCI devices are Plug'N'Play.

POP
Post Office Protocol. One common protocol used for retrieving mail from an ISP. See IMAP for an example of another remote-access mail protocol.

porting
one of two ways to run a program on a system it was not originally intended for. For example, to be able to run a Windows-native program under GNU/Linux (natively), it must first be ported to GNU/Linux.

PPP
Point to Point Protocol. This is the protocol used to send data over serial lines. It is commonly used to send IP packets to the Internet, but it can also be used with other protocols such as Novell's IPX protocol.

precedence
dictates the order of evaluation of operands in an expression. For example: If you have `4 + 3 * 2` you get 10 as the result, since the multiplication has higher precedence than the addition. If you want to evaluate the addition first, then you have to add parenthesis like this: `(4 + 3) * 2`. When you do this, you'll get 14 as the result since the parenthesis have higher precedence than the addition and the multiplication, so the operations in parenthesis get evaluated first.

preprocessors
are compilation directives which instruct the compiler to replace those directives for code in the programming language used in the source file. Examples of C 's preprocessors are `#include`, `#define`, etc.

process
in the operating system context, a process is an instance of a program being executed along with its environment.

prompt
in a shell, this is the string before the cursor. When you see it, you can type your commands.

protocol
Protocols organize the communications between different machines across a network, either using hardware or software. They define the format of transferred data, whether one machine controls another, etc. Many well-known protocols include HTTP, FTP, TCP, and UDP.

proxy
a machine which sits between a network and the Internet, whose role is to speed up data transfers for the most widely used protocols (for example, HTTP and FTP). It maintains a cache of previous requests, so a machine which makes a request for something which is already cached will receive it quickly, because it will get the information from the local cache. Proxies are very useful on low bandwidth networks (such as modem connections). Sometimes the proxy is the only machine able to access outside the network.

pull-down menu
is a menu that is "rolled" with a button in some of its corners. When you press that button, the menu "unrolls" itself, showing you the full menu.

quota
is a method for restricting disk usage and limits for users. Administrators can restrict the size of home directories for a user by setting quota limits on specific file systems.

RAID
Redundant Array of Independent Disks. A project initiated at the computing science department of Berkeley University, in which the storage of data is spread across an array of disks using different schemes. At first, this was implemented using floppy drives, which is why the acronym originally stood for *Redundant Array of Inexpensive Disks*.

RAM
Random Access Memory. Term used to identify a computer's main memory. The "Random" here means that any part of the memory can be directly accessed.

read-only mode
for a file means that the file cannot be written to. You can read its contents but you can't modify them.
See Also: read-write mode.

read-write mode
for a file, it means that the file can be written to. You can read its contents and modify them.
See Also: read-only mode.

regular expression
a powerful theoretical tool which is used to search and match text strings. It lets one specify patterns these strings must obey. Many UNIX utilities use it: sed, awk, grep, perl and others.

RFC
Request For Comments. RFC s are the official Internet standard documents, published by the IETF (*Internet Engineering Task Force*). They describe all protocols, their usage, their requirements and so on. When you want to learn how a protocol works, pick up the corresponding RFC.

root
is the superuser of any UNIX system. Typically root (aka the system administrator) is the person responsible for maintaining and supervising the UNIX system. This person also has complete access to everything on the system.

root directory
This is the top level directory of a filesystem. This directory has no parent directory, thus '..' for root points back to itself. The root directory is written as '/'.

root filesystem
This is the top level filesystem. This is the filesystem where GNU/Linux mounts its root directory tree. It is necessary for the root filesystem to reside in a partition of its own, as it is the basis for the whole system. It contains the root directory.

route
Is the path that your datagrams take through the network to reach their destination. It is the path between one machine and another in a network.

RPM
Red Hat Package Manager. A packaging format developed by **Red Hat** in order to create software packages, it is used in many GNU/Linux distributions, including Mandrakelinux.

run level
is a configuration of the system software which only allows certain selected processes to exist. Allowed processes are defined, for each runlevel, in the file `/etc/inittab`. There are eight defined runlevels: 0, 1, 2, 3, 4, 5, 6, S and switching between them can only be achieved by a privileged user by means of executing the commands `init` and `telinit`.

script
shell scripts are sequences of commands to be executed as if they were sequentially entered in the console. shell scripts are UNIX's (somewhat) equivalent of DOS batch files.

SCSI
Small Computers System Interface. A bus with a high throughput designed to allow for several types of peripherals to be connected to it. Unlike IDE, a SCSI bus is not limited by the speed at which the peripherals accept commands. Only high-end machines integrate a SCSI bus directly on the motherboard, therefore most PC s need add-on cards.

security levels
Mandrakelinux's unique feature which allows you to set different levels of restriction according to how secure you want to make your system. There are 6 predefined levels ranging from 0 to 5, where 5 is the tightest security. You can also define your own security level.

segmentation fault
A segmentation fault occurs when a program tries to access memory that is not allocated to it. This generally causes the program to stop immediately.

server
program or computer that provides a feature or service and awaits the connections from **clients** to execute their orders or give them the information they ask. In the case of **peer to peer** systems such as SLIP or PPP, the server is taken to be the end of the link that is called and the end calling is taken to be the client. It is one of the components of a **client/ server system**.

shadow passwords
a password management suite on UNIX systems in which the file containing the encrypted passwords is not world-readable, unlike that usually found with a normal password system. It also offers other features such as password aging.

shell
The shell is the basic interface to the operating system kernel and provides the command line where users enter commands to run programs and system commands. All shells provide a scripting language which can be used to automate tasks or simplify often-used complex tasks. These shell scripts are similar to batch files from the DOS operating system, but are much more powerful. Some example shells are bash, sh, and tcsh.

single user
is used to describe a state of an operating system, or even an operating system itself, that only allows a single user to log into and use the system at any time.

site dependent
means that the information used by programs like imake and `make` to compile some source file depends on the site, the computer architecture, the computer's installed libraries, and so on.

SMB
Server Message Block. Protocol used by Windows machines (9x or NT) for file and printer sharing across a network.
See Also: CIFS.

SMTP
Simple Mail Transfer Protocol. This is the common protocol for transferring email. Mail Transfer Agents such as sendmail or postfix use SMTP. They are sometimes called SMTP servers.

socket
file type corresponding to any network connection.

soft links
See: symbolic links

standard error
the file descriptor number 2, opened by every process, used by convention to print error messages to the terminal screen.
See Also: standard input, standard output.

standard input
the file descriptor number 0, opened by every process, used by convention as the file descriptor from which the process receives data.
See Also: standard error, standard output.

standard output
the file descriptor number 1, opened by every process, used by convention as the file descriptor in which the process prints its output.
See Also: standard error, standard input.

streamer
is a device which takes "streams" (not interrupted or divided in shorter chunks) of characters as its input. A typical streamer is a tape drive.

SVGA
Super Video Graphics Array. The video display standard defined by VESA for the PC architecture. The resolution is 800x 600 x 16 colors.

switch
Switches are used to change the behavior of programs, and are also called command-line options or arguments. To determine if a program has optional switches which may be used, read the `man` pages or try to pass the `--help` switch to the program (i.e.. `program --help`).

symbolic links
are special files, containing nothing but a string which references another file. Any access to them is the same as accessing the file whose name is the referenced string, which may or may not exist, and the path to which can be given in a relative or an absolute way.

target
is the object of compilation, i.e. the binary file to be generated by the compiler.

TCP
Transmission Control Protocol. This is the most common reliable protocol which uses IP to transfer network packets. TCP adds the necessary checks on top of IP to make sure that packets are delivered. Unlike UDP, TCP works in connected mode, which means that two machines must establish a connection before exchanging data.

telnet
creates a connection to a remote host and allows you to log into the machine, provided you have an account. Telnet is the most widely-used method of remote logins, however there are better and more secure alternatives, such as `ssh`.

theme-able
a graphical application is theme-able if it is able to change its appearance in real time. Many window managers are theme-able.

traverse
for a directory on a UNIX system, this means that the user is allowed to go through this directory, and possibly to directories under it. This requires that the user has the execute permission on this directory.

URL
Uniform Resource Locator. A string with a special format used to identify a resource on the Internet in a unique way. The resource can be a file, a server or other item. The syntax for a URL is `protocol://server.name[:port]/path/to/resource`.
When only a machine name is given and the protocol is `http://`, it defaults to retrieving the file `index.html` on the server.

username
is a name (or more generally a word) which identifies a user on a system. Each username is attached to a unique and single UID (user ID)
See Also: login.

variables
are strings which are used in `Makefile` files to be replaced by their value each time they appear. Usually they are set at the beginning of the `Makefile`. They are used to simplify `Makefile` and source files tree management.
More generally, variables in programming are words that refer to other entities (numbers, strings, tables, etc.) that are likely to vary while the program is executing.

verbose
For commands, the verbose mode means that the command reports to standard (or possibly error) output all the actions it performs and the results of those actions. Sometimes, commands have a way to define the "verbosity level", which means that the amount of information that the command will report can be controlled.

VESA
Video Electronics Standards Association. An industry standards association aimed at the PC architecture. For example, it is the author of the SVGA standard.

virtual console
is the name given to what used to be called terminals. On GNU/Linux systems, you have what are called virtual consoles which enable you to use one screen or monitor for many independently running sessions. By default, you have six virtual consoles that can be reached by pressing **ALT-F1** through **ALT-F6**. There is a seventh virtual console, **ALT-F7**, which will permit you to reach a running X Window System. In X, you can reach the text console by pressing **CTRL-ALT-F1** through **CTRL-ALT-F6**.
See Also: console.

virtual desktops
In the X Window System, the window manager may provide you several desktops. This handy feature allows you to organize your windows, avoiding the problem of having dozens of them stacked on top of each other. It works as if you had several screens. You can switch from one virtual desktop to another in a manner which depends on the window manager you're using.
See Also: window manager, desktop.

WAN
Wide Area Network. This network, although similar to a LAN, connects computers on a network which is not physically connected to the same wires and are separated by a greater distance.

wildcard
The '*' and '?' characters are used as wildcard characters and can represent anything. The '*' represents any number of characters, including no characters. The '?' represents exactly one character. Wildcards are often used in regular expressions.

window
In networking, the **window** is the largest amount of data that the receiving end can accept at a given point in time.

window manager
the program responsible for the "look and feel" of a graphical environment, dealing with window bars, frames, buttons, root menus, and some keyboard shortcuts. Without it, it would be hard or impossible to have virtual desktops, to resize windows on the fly, to move them around, ...

workspace switcher
a little applet that allows you to switch between the available virtual desktops.
See Also: virtual desktops.

Index